Individual-based assessment of post-translocation fitness of ungulates: Lessons from the critically endangered Derby eland conservation programme

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Abstract
Translocations have become an essential tool in animal conservation for establishing and maintaining viable populations. Yet, the viability of a population is implicitly based on the individual fitness, that is on the survival and reproduction of individuals. Individual-based assessments of post-translocation fitness are challenging in the wild while conservation breeding programs may provide vital insights. Long-term breeding records of semi-captive (fenced) small population of the Western Derby eland (Taurotragus derbianus derbianus) running in two fenced reserves in Senegal present a case study. This study shows that transport distance and the individual’s age at translocation influence animal post-translocation survival rates and individual reproductive performance. The most critical period for the antelope’s post-translocation survival was the first 2 years following the event, with higher mortalities reported after long-distance transport in an ecologically novel environment. The first successful calving of translocated females was postponed by 1 year, but the life-long reproductive performance was not affected. However, higher calf survival in a habitat similar to that in the wild suggests a non-negligible effect of the habitat on individual fitness, thus crucial to conservation decisions on translocating threatened species.

KEYWORDS
antelope, conservation translocation, Derby eland, large mammal, endangered species, post-release survival, post-translocation monitoring, reproductive performance, semi-captive breeding management, wildlife management

1 | INTRODUCTION

Translocations have become an integral part of species conservation and metapopulation management, and contribute to the long-term survival of species that face diverse challenges connected to small population sizes and limited available space, either in the wild or in captive and semi-captive breeding programs (Ogden et al., 2020; Redford et al., 2012; Xia et al., 2014). Animal conservation translocations, that is the intentional movement of wildlife for conservation purposes (IUCN/SSC, 2013), have the ultimate goal the species...
recovery, contributing thereby to the restoration of ecosystem functions (Armstrong & Seddon, 2008). The primary focus of translocation literature has been therefore on viable populations, using the post-release survival, mortality, and population growth rates as proxies of translocation success/failure (e.g., Berger-Tal et al., 2020; Bubac et al., 2019; Morris et al., 2021). However, the viability of a population is implicitly based on the individual fitness, that is on the survival and reproduction of individuals that were transported. Translocations are challenging events for the animals, “a severe test for individuals” (Letty et al., 2007), whatever the species, due to their invasive nature, during which the animals can face chemical immobilization, handling, all sorts of discomfort (e.g., physical, thermal, and noise), and then they are subjected to other disturbances from the novel environment, that is the habitat, distribution and quantity of key resources, inter- and intra-species (social) interactions (Letty et al., 2007; Pohl et al., 2021; Teixeira et al., 2007). These translocation-related disturbances may induce adverse stress; acute stress that is often induced rapidly, during the capture and transport, and chronic stress that develops subsequently and persists over the long term (Dickens et al., 2010). Both, short- and long-term stresses have negative biological consequences for individuals, for example, poor physical condition and decreased reproductive performance, and make thus the translocated animals vulnerable to factors that directly contribute to translocation failure (Dickens et al., 2010).

To promote translocation success, there are decisions on translocation tactics (Batson et al., 2015) to be taken at the pre-translocation phase level, for example, decisions on immobilization chemicals and doses, immobilization techniques such as darting, net-gunning, and clover trapping, or on length of handling (Burroughs et al., 2012; Casady & Allen, 2013; DelGiudice et al., 2001); decisions on the release site, for instance in regard to predation risk for the translocated animals at the new site (Edwards et al., 2019; Matson et al., 2004; Rominger et al., 2004) and in regard to the quality habitats and resources (Clapp et al., 2014; Scillitani et al., 2013), and decisions regarding the social structure of the translocated animals in relation to social functionality (Franks et al., 2020; Goldenberg et al., 2019).

The selection of individuals for translocation is usually based on a conservation breeding management plan (Ogden et al., 2020) which considers the genetic and demographic parameters necessary for the species' viable population and social behavior. In large polygynous ungulate species, the social groups in the wild are composed of more females compared to the number of males, however, the decision on the group composition for the translocation follows the specific purpose of the intervention (e.g., reintroduction vs. reinforcement). Yet, the decision on the age of individuals for translocation can be critical. Age is, specifically in large mammals, strongly correlated with body size (Gloneková et al., 2016) which may contribute to better survival due to better movement and dispersal (e.g., Calenge et al., 2005), access to resources, and social ranking abilities (Letty et al., 2007; Vymyslická Jůnková et al., 2015). On the other hand, a higher age may limit the abilities of individual animals to cope with the novel environment, in terms of habitat- or predator-related factors (Matson et al., 2004), intra-specific interactions (Brett, 1998; Scillitani et al., 2013), and other pressures, for instance, the parasitical load at the release site (Slotta-Bachmayr et al., 2004). Younger individuals, despite being less experienced, may be more likely to cope with novel environments, specifically when transferred at the age of natural dispersal (Letty et al., 2007).

In terms of individual fitness, the decision relies on the choice of individuals, which is not solely those that comply with the translocation goals and conservation breeding management, but also those that, coping with stress, can go through the translocation process at best and have enough phenotypic plasticity to survive in the release environment (Letty et al., 2007; Teixeira et al., 2007). In the case of conservation interventions on threatened species, the individual approach may be impossible, due to constraints in an a priori selection of individuals from a small source population offering limited options, and in a posteriori difficulties of long-term monitoring of individual-based survival and reproduction success in the wild. The individual post-translocation survival rate, reproduction performance, and juvenile survival are rarely mentioned in studies evaluating conservation translocations, especially in mammals (Berger-Tal et al., 2020; Bubac et al., 2019), to confirm the effectiveness of the intervention. These parameters may be, however, provided by conservation breeding programs that have detailed population records (e.g., Brandlová et al., 2018; Ogden et al., 2020), perform translocation interventions among breeding facilities, and offer thus the possibility of assessing diverse effects of translocation on survival and reproduction performance at the individual level. The post-release monitoring at the individual animal level may become a powerful source of information and experience that create critical learning for further conservation endeavors and that enable to control of individual characteristics of animals best suitable to cope with the translocation process.

To assess the influence of translocation on post-translocation survival and fitness at an individual level, we took advantage of long-term conservation breeding
records of the Western Derby eland (*Taurotragus derbianus derbianus*), as a model species. Western Derby eland is a critically endangered antelope with its conservation breeding program running in Senegal in two fenced nature reserves located in different types of savanna ecosystems. The conservation breeding management for this species involved short- and long-distance translocations of breeding individuals to ensure the long-term viability of the semi-captive (fenced) small population (Kubátová et al., 2020).

To examine the influence of the translocation events on animals’ subsequent survival rate and reproductive performance, we compared the differences in the survival rate of individuals after translocation with that of non-translocated individuals. We assumed that a long transport to a novel environment would have a more negative impact on short-term individual survival and reproductive performance than a short transport within the same environment, and we predicted the best survival rates and fitness performances for individuals not involved in the translocation process at all. Then, we expected younger animals to be more adaptable, that is less affected by the novel environment, social structure and capture/handling and transport processes. Finally, we assessed the suitability of habitats at two translocation sites with regard to individual survival and consequent fitness by comparing the survival rates of calves born in the two different habitats, that is semi-arid savanna and sub-humid woodland savanna in the Bandia and Fathala reserve, respectively. Based on the natal habitat preference induction hypothesis predicting an individual’s preference for native habitats (Stamps & Swaisgood, 2007), we could expect no difference in calf survival in the two reserves. However, we rather hypothesized that the WDE calves would have higher survival in the habitat similar to that in the species’ natural distribution range, that is in the Fathala reserve, where the animals maximize their fitness (Fretwell, 1972).

2 | METHODS

2.1 | Study sites

The semi-captive Western Derby eland (*Taurotragus derbianus derbianus*) population is hosted by two fenced nature reserves in Senegal, unconnected with the WDE native distribution range in Senegal (Figure 1).

The Bandia Reserve, situated 65 km south-east of Dakar, Senegal (14°35’S, 17°00’W) (Figure 1), is a fenced wildlife sanctuary (3500 ha) managed for tourism and wildlife conservation. The Bandia Reserve receives

![Image](image-url)
350–550 mm of rainfall and its ecosystem is classified as semi-arid Sahelo-Sudanian savanna (Figure 2), dominated by baobab trees (*Adansonia digitata*), various species of acacia (*Acacia* spp., *Faidherbia albida*), and *Balanites aegyptiaca*. The reserve hosts large mammal species, both native and non-native to Senegal, introduced for tourism reasons, for example, African buffalo (*Syncerus caffer brachyceros*), roan antelope (*Hippotragus equinus koba*), giraffe (*Giraffa camelopardalis giraffa*), greater kudu (*Tragelaphus strepsiceros*), impala (*Aepyceros melampus*), common eland (*Taurotragus oryx*), and white rhino (*Ceratotherium simum simum*).

The Fathala Wildlife Reserve is the fenced area of the Fathala Forest, and the main terrestrial part of the Delta du Saloum National Park, situated on the west coast of Senegal (13°39’N, 16°30’W, Figure 1). The reserve is also managed for tourism and wildlife conservation. The Fathala Reserve receives 800–1050 mm of rainfall and, similar to NKNP (the original home of WDE), its ecosystem belongs to the subhumid Sudano-Guinean savannah (Figure 3), with predominantly *Acacia macrostachya*, *Combretum* spp., *Daniellia oliveri*, *Piliostigma thonningii*, *Terminalia avicennoides*, *T. macroptera*, and *Andropogon gayanus* grass. Large mammal species in this reserve are both native and non-native to Senegal, introduced there for tourism reasons, for example, African buffalo, roan antelope, giraffe, white rhino, defassa waterbuck (*Kobus ellipsiprymnus defassa*), bushbuck (*Tragelaphus scriptus*), and warthog (*Phacochoerus africanus*).

### 2.2 Model species and conservation breeding program

The Derby eland (*Taurotragus derbianus*) is a large gregarious browsing antelope (Hejcmanová et al., 2019) inhabiting the strip of woody West African savannah vegetation from Senegal to Sudan; however, their population numbers have decreased over its entire distribution range, and thus it is currently listed as vulnerable...
(IUCN SSC Antelope Specialist Group, 2017). The Western subspecies, *T. d. derbianus*, hereafter abbreviated as WDE, is listed as critically endangered, with the last remaining population currently limited to the Niokolo Koba National Park (NKNP) in southeast Senegal. Here, the WDE population is estimated to not exceed more than 200 mature individuals (Gueye et al., 2021).

The WDE conservation programme started in 2000, through the translocation of nine individuals (one male and eight females) from the NKNP to the Bandia Reserve in the western part of Senegal (Figure 4). Later that year, three females died (Akakpo et al., 2004) and the remaining six wild-born individuals (one male and five females) became the founders of the semi-captive breeding program.

**FIGURE 3** Various types of habitat in the Fathala reserve. Photo credit: Zuzana Holubová

**FIGURE 4** Reproductive herd of the Western Derby eland in the semi-captive breeding program in the Bandia reserve.
The conservation breeding management is based on the individual identification of each animal in the semi-captive population. The individual identification of the animals in the Bandia reserve, and later in the Fathala reserve, has been regularly performed based on the unique patterns of the white stripes on their flanks (Koláčková et al., 2011), while kinship was determined through direct observations of suckling, and molecular genetic analyses were used to complete the pedigrees and any missing paternity information (Kubátová et al., 2020; Zemanová et al., 2015). The mean lifespan of WDE calculated from pedigree data was 6.7 years for males (maximum age 14 years) and 7.2 years for females (maximum age 16 years). This information is presented in the WDE studbook, which has been published annually since 2008 (available at https://www.derbianus.cz/en/plemenna-kniha/).

The conservation breeding program, therefore, started in the Bandia reserve where wild-born individuals were placed in a separate breeding enclosure of ca 150 ha with natural vegetation, provisioned with water and supplementary feeding on daily basis. The first WDE calves were born in 2002, and a total of 184 calves have been born within the WDE conservation programme since, until June 30, 2020. The WDE breeding management is based on a minimal kinship principle, using translocations within the Bandia reserve and between Bandia and Fathala reserves as an integral part of the plan. In the Bandia reserve, the animals were divided into four herds over the last 18 years of breeding; specifically, there were two reproductive herds in separate enclosures of 100–200 ha, one reproductive herd in the open space (2000 ha) mixed with other species, and one bachelor herd in a separate enclosure of 150 ha (Brandlová et al., 2018). The Fathala Wildlife Reserve hosts two reproductive herds of WDE, one in a separate enclosure of 160 ha and one in the open reserve space of 1800 ha, mixed with other species (Brandlová et al., 2018). From January to June, the animals are supplementarily fed with peanut hay, livestock pellets, and pods of Faidherbia albida in both reserves; this supplementary feeding is also a crucial part of post-translocation management practices (Vymyslická Jůnková et al., 2015).

Altogether, the number of individuals in the semi-captive WDE population increased from 6 founders in 2000 to 127 individuals by 2018, being separated into five breeding and one bachelor herd in two fenced wildlife reserves as a result of more than 100 translocations realized over the last two decades (Brandlová et al., 2018).

### 2.3 Translocations used for population management

In 2006, nine males were selected for the pilot translocation operation from Bandia to Fathala Reserve, about 220 km south. The aims of this pilot translocation were to create a new geographically separated group, to verify the ability of the WDE to thrive in the Fathala Reserve, and to establish good practices for the translocation process. Due to the low number of founders and the limited area of distribution of the WDE population, conservation management has further used a series of translocations aimed at increasing the number of sites where the WDE are bred in semi-captivity to minimize the risk of stochastic events (such as a disease outbreak and bushfire), prevent genetic issues expected in small populations (reduce inbreeding, minimize mean kinship, and balance founder contributions), and to ensure the appropriate demographic composition of the herds (Brandlová et al., 2018; Koláčková et al., 2011) in order to maintain the population viable in the long term, serving as insurance population and potential source of animals for reintroduction/reinforcement. From 2006 to 2017, a total of eight translocation operations were realized and involved 99 chemically immobilized WDEs transported for either short or long distances (see below and Table 1), plus a further 32 individuals which walked to different enclosures within the Bandia and Fathala reserves by themselves, lured by the pods of Faidherbia albida (excluded from analyses).

#### 2.4 Translocation process

To fulfill the abovementioned conservation goals, the animals were individually selected for the translocations according to genetic parameters obtained from their pedigrees (inbreeding coefficient, mean kinship) with the aid of PMX software (Ballou et al., 2019). We preferentially selected young animals (between 1 and 2 years of age) because of their appropriate size and weight; older individuals were proven to be logistically complicated and more expensive to immobilize, as shown during the pilot

| Year | SHORT | LONG |
|------|-------|------|
| 2006 | 1,3   | 9,0  |
| 2008 | 3,0   | 4,5  |
| 2009 | 1,9   | 4,2  |
| 2011 | 5,3   | 2,2  |
| 2012 | 18,0  | 0,0  |
| 2014 | 7,10  | 0,0  |
| 2017 | 7,5   | 0,0  |
translocation in 2006 (Antonínová et al., 2006). We also considered the condition and health status of the individuals during the preselection process.

The translocations involving chemical immobilization were performed between 2006 and 2017. The herds containing the selected individuals were lured to open sites and fed by Faidherbia albida pods. The selected individuals were then darted using a PneuDart gun. For the immobilizations, we used a combination of etorphine (M99, Immobilon) and xylazine, with diprenorphine (Reviron) as the antidote. In 2017, the combination of medetomidine, acepromazine, azaperone, alvegesic acid (butorfanol), narkamon (ketamine), and xylazine was used together with revertor, divascol, and naltrexon as the antidote (for the dosages see Stoklasová et al., 2021). All animals were further treated with Selevit, Norocillin, Noromectin, and Hepagen. After being immobilized, animals were arranged into the sternal position, provided with earplugs and eye covers, cooled with water, then moved onto the transport sheet and loaded onto the open 4 WD pick-up Toyota Hilux. The duration of immobilization was less than 30 min from darting to revival.

The transportations of WDEs were performed differently according to the distance between the capture and release destinations. Short translocations (“SHORT”) involved transporting animals to a different enclosure within the same reserve for a maximum distance of 3 km, and the whole transport was performed using only the 4 WD pick-up. The animal was put on the ground, an antidote was administered, and the animal walked directly away. Long translocations (“LONG”) involved first transportation on the open 4 WD pick-up to a truck, where animals were then loaded individually into two separate compartments without crates, and then the antidote was applied. The animals were transported from Bandia to Fathala for another 5–10 h, and released directly to the selected enclosure (the doors of the truck were opened and the animal walked away). Two individuals died during the translocation process, one because of suffocation during anesthesia, and one due to a direct attack from another herd member during ataxia. We reported no other injuries during the transport and release events.

2.5 | Statistical analyses

Based on the studbook data, we first created a list of all the WDEs within the breeding program with recorded individual life histories, including their birth date and location, kinship information, translocation events (if any), and date of death (if relevant). Regarding the type of translocation event, we distinguished between three groups: “LONG” (n = 32), “SHORT” (n = 67), and “NONE” (n = 80); thus, those animals that were not translocated at all (NONE) were used as a control group (Table TABLE S1).

The Kaplan–Meier survival analysis (Scheiner & Gurevitch, 2001) was used to estimate the groups’ median lifetime and to analyze the overall survival curve for all three groups. Then, the Kaplan–Meier survival analysis was applied to the translocated animal data to estimate the differences in survival curves between the animals translocated for either short or long distances. Multivariate Cox proportional hazard regression (Scheiner & Gurevitch, 2001) was applied to test the effects of the sex and age of the animal at the transport event on its survival. The tested variable in all analyses was “time after translocation event”. The “censored” variable indicates that the animal is still alive.

Reproductive performance was analyzed by comparison of the number of offspring produced by females during their lifetime, according to whether she was translocated for either a LONG or SHORT distance, or not translocated at all (NONE)—mostly being females older than 2 years. We also compared the age at first calving (response variable) for the translocated (LONG, SHORT) and non-translocated (NONE) females (predictor), using GLM models in the TIBCO Statistica Software (Version 13.5) (Table S2).

The survival of calves born in the two reserves was analyzed using the Kaplan–Meier survival analysis, followed by Multivariate Cox proportional hazard regression, to test separately for differences of survival between the two reserves and between male and female calves.

3 | RESULTS

3.1 | Individual post-translocation survival

The median survival time since the translocation event was 3.5 years (min = 1.3 months, max = 11.2 years) for animals translocated over LONG distances, 5.1 years (min = 0 month, max = 10.9 years) for animals transported over SHORT distances, and 2.1 years (min = 0.5 month, max = 11.7 years) for animals that were not translocated (NONE). The estimated survival time was not significantly different among the treatment groups (chi-sq = 5.21, df = 2, p = .073). The highest mortality rate was recorded during the first 2 years following the LONG translocation events, specifically 25% in the first year and 7% in the second year after translocation, while a 12% and 9% mortality rate was reported within
the first 2 years for SHORT and NONE, respectively (Figure 5).

For translocated animals, the age of the animals had a significant effect on their survival after translocation (chi-sq = 4.29, df = 1, p = .038); the older the animal at the time of transport, the longer the survival time after transport (regression coeff. = 0.35). On the other hand, there was no difference in the survival time between males and females (Cox’s $F_{[28,56]} = 1.26, p = .227$).

### 3.2 Individual post-translocation reproductive performance

Sixty females born in the Bandia and Fathala reserves reached reproductive age (i.e., >2 years) during the study. Of those females, 39 individuals (65%) reproduced at least once during the study period. The maximum number of offspring produced per lifetime by a female born in the reserves was nine calves.

The mean number of offspring per female (all females included) was $2.6 \pm 2.7$ and did not significantly differ among LONG, SHORT, and NONE translocated individuals ($H_{[2,60]} = 0.60, p = .74$) or between the reserves ($U = 109, Z = 0.074, p = .94$).

The mean number of offspring produced per reproducing female, that is, within the group of 39 females, was $3.9 \pm 2.3$, and did not differ among LONG, SHORT, and NONE ($H_{[2,39]} = 3.66, p = .16$).

The age at first reproduction was 1101 days (median; min 751—max 2203 days) for non-translocated females, while transported females reproduced at the age of 1432 days (median; min 1013—max 2594 days), which is significantly later (Mann–Whitney $U = 104, p = .039$). The age at first reproduction was 1378 days (median, $n = 20$) for SHORT, and 1538 days (median, $n = 5$) for LONG, transportation events.

The age at first reproduction did not significantly differ for females born in Bandia and Fathala ($U = 31, Z = -1.19, p = .24$).

### 3.3 Calf survival

There was a total of 147 and 32 calves born in the Bandia and Fathala reserves, respectively. The estimated survival of calves was significantly higher in the Fathala reserve compared to Bandia (Cox’s $F_{[6,110]} = 4.55, p < .001$). The three calf mortalities, out of 32 born calves in the Fathala reserve, occurred within 2 months after birth, representing an overall mortality rate of 10%. The mortality rate of calves born in the Bandia reserve was 11% during the first year of life, and 3.5% in the second year of life (Figure 6). There was no difference in the survival rate of male and female calves (tested for Bandia reserve only: Cox’s $F_{[46,50]} = 1.26, p = .21$).

### 4 DISCUSSION

The post-translocation survival of individuals reflects many aspects and effects of the translocation event, some
of which are possible to disentangle while the others are overlapped and to understand them, more elements appear to be assessed complementarily. The individual-based post-translocation monitoring of WDE in two fenced reserves enabled us to assess the effects of the interventions, by focusing on both, the preparatory phase, specifically the selection of individuals for transport to create new breeding groups, and on the distance of transport on the animals’ survival and reproduction.

4.1 Individual post-translocation survival

The survival time of WDE individuals which, in the case of WDE, represents the length of life was not affected by translocations and was similar to the animals that did not undergo any intervention. This indicates that the management of animals within this conservation program is set up correctly to sustain the semi-captive population of the threatened antelope and is able to support adequately also the animals that are subjected to demanding interventions.

There were, however, differences in the mortality rates that were especially higher within the two first years after LONG translocation. Mortalities during and after translocations are related to the process of restraint, handling, transport itself, and the adaptation of the translocated animals to the novel environment as there are risks for animals to be injured or not supporting the acute stress (Teixeira et al., 2007). Our findings showed a relatively low ratio of direct mortalities (<2%) related to animal restraint, that is, immobilization, and no mortalities related to handling and transport, which is also not common in ungulate translocations (Breed et al., 2019). We acknowledge this is due to the high quality of veterinary procedures and drugs that increase the success of translocations (Fahlman, 2008), together with the skills and experience of the wildlife veterinarian, a well-trained local translocation team, and good seasonal and temperature conditions (Fennessy et al., 2020). Nevertheless, mortalities recorded after translocation indicate the impact of the translocation process.

The most critical period for the post-translocation survival of the WDE was the first 2 years following the event which corresponds with findings across species (Bubac et al., 2019). Higher mortality rates in individuals after longer translocation distances may be attributed to the extended time spent in isolation and physical disturbance during the long-distance transport events and we could expect short-term acute stress (Dickens et al., 2010; Teixeira et al., 2007). However, the animals were released directly to their final environment (new enclosures) without acclimatization pens (see, e.g., Daily et al., 2022) and showed no visible signs of stress when walking out of the truck. Yet, other factors, most likely novel ecological and social environments accounted for chronic stress, hence higher mortalities (Dickens et al., 2010). First of all, the animals experienced a substantial change in habitat. They were translocated to an ecosystem of sub-humid...
Sudano-Guinean savanna (Něžerková-Hejmanová et al., 2005) which is ecologically similar to the species’ native environment, but substantially distinct from the place of birth of the respective translocated individuals, that is, the semi-arid Sudano-Sahelian savanna (Hejmanová, Hejman, Camara, & Antonínová, 2010). The animals thus had to cope not only with the translocation stress and their new social group, but also with the novel environment, including a new vegetation structure and hence food resources, including different (anti)nutritive chemical compounds (Hejmanová et al., 2019), various physical barriers, potentially new pathogens and parasites. For example, the denser vegetation structure with robust, tufted, and up to 3-m tall, grasses (Andropogon gayanus and Schizachyrium sanguineum) and hidden fallen wood material may induce injuries which, together with a more humid environment, support exuberant infestations of ticks and/or other pathogens. Even if the habitat in the Fathala reserve corresponds to the habitat in the Niokolo Koba national park in South-East Senegal where the WDE naturally occurs, it may still be suboptimal. Yet, since the wild population monitoring and abundance estimates started being conducted in the 1960’s, the WDE population appears stable, but very low and geographically restricted (Gueye et al., 2021). The WDE is at the westernmost boundary of the Derby eland distribution (IUCN SSC Antelope Specialist Group, 2017) which suggests that the WDE could be qualified as a “refugee species”, that is a species confined to suboptimal habitats, with consequences of decreased fitness and density, and attendant conservation risks (Kerley et al., 2012). In the case of WDE, the habitat may lack some of the key features present in the core area of the species distribution, for instance, natural mineral licks or Isoberlinia doka dominated vegetation type widely mentioned as key resources for Derby eland (Kingdon, 2015).

Facing a novel environment may be severe for certain individuals. The individual-based approach presents possibilities to select animals with specific personality traits (e.g., boldness, aggressiveness, and sociability) coping with novel environment in different ways, and thereby to increase post-release survival. Diverse personalities entail the behavioral diversity (de Azevedo & Young, 2021), which is as important as genetic diversity in the establishment of viable populations (Cordero-Rivera, 2017; Wolf & Weissing, 2012). Even though such selections are vital, and decisively affect survival and reproductive rates (de Azevedo & Young, 2021; Tetzlaff et al., 2019), they are not always possible, especially in the case of species at the brink of extinction, because the source population is low, and may not provide a high diversity in behaviors and personalities anymore. In this case, and in the case of the WDE semi-captive population, the genetic diversity and selection based on kinship and pedigree become a priority (Kubátová et al., 2020).

The age of individuals at the transport event was the next vital decision factor regarding post-translocation survival, regardless of sex. The older WDE individuals showed longer survival times than younger ones, which is relevant only for the age range studied (1–2 years), when the animals were translocated. Some of the yearlings showed visibly deteriorated body conditions after transport. Even though they are no longer directly dependent on their mothers, as they were weaned at approximately 6 months of age (Hejmanová et al., 2011), it may be crucial for them to remain in their natal social group until they reach sexual maturity, that is, at approximately 2 years of age (Brandlová et al., 2013), and not be separated earlier. Additionally, younger animals tend to have lower positions in the hierarchy, and therefore delayed or prevented access to supplementary food by others (Výmyslická Jůnková et al., 2015), hence resulting in a lower body condition. Animals older than 2 years of age were not transported, due to their size and logistic constraints, including increased costs for veterinary intervention. In addition, females older than 2 years might experience abortions during translocations in the case of a potential pregnancy (cf. the use of anti-pregnancy treatment in Dorj & Namkhai, 2013), and males older than 2 years might elicit agonistic conflict with other adult males at the release site. Therefore, by selecting individuals within the given age range, we prevented potential losses of valuable specimens. Sex of the animal itself does not most likely play a strong role in post-translocation survival of gregarious species with a fission-fusion system (for WDE see, Gueye et al., 2021), because the post-translocation behavior of males and females, specifically movements and dispersal (Mertes et al., 2019), can be similar.

### 4.2 Individual post-translocation reproductive performance and calf survival

In the long-term, WDE females in both reserves reproduced, regardless of being translocated or not, having offspring annually since they reached sexual maturity. Nonetheless, the individual reproductive performance was affected by translocations, because they are highly stressful operations for animals, and substantially affect the individual’s body condition (Breed et al., 2019; Dickens et al., 2010). Translocations were conducted in the middle of the dry season, after the offspring of that year was born and a new breeding season was emerging. Females that were transported, specifically over long distances, showed postponed reproduction by one breeding
season. This indicates that translocations of females may negatively affect their reproductive performance in terms of the decreased probability of giving birth in the year following the translocation event, either because the female’s chance for conception decreases due to the change of breeding males within the breeding season, or the embryo is aborted in the early stage of development because of the use of immobilization drugs and/or the stress related to the transport itself (Dickens et al., 2010; Letty et al., 2007; Teixeira et al., 2007). We highlight that the timing was carefully planned, considering other options which would be out of the middle of the dry season that overlaps with the breeding season. Earlier translocations (i.e., in the wet season) are logistically more complicated due to the difficult accessibility of some areas, and can also be challenging for the animals in a novel environment while postponing translocations into the advanced dry season would result in two other issues, namely, high temperatures that can result in overheating (hyperthermia) during immobilization, and place further risk on pregnant females. Therefore, in this context, postponing the reproduction of females by 1 year is lower risk, and supports better animal welfare and effective conservation.

From the perspective of calf survival, calves born in Fathala had significantly higher survival rates than those born in Bandia reserve during the first year of life, as we expected. The animals in both reserves are in large fenced enclosures without predators and supplied with water and supplementary feeding during the dry season but in ecologically different habitats. Together with findings that the environment did not affect the age at first reproduction of the females born there, nor the total number of offspring produced per female, we may infer that the habitat in the Fathala reserve had a neutral or positive impact on WDE individual fitness.

5 | CONCLUSION

The post-translocation long-term survival and breeding performance of animal species are essential to confirm the success of a translocation event. Post-translocation and post-release monitoring are critical to detect potential constraints and formulate scenarios for adaptive post-translocation management.

Our findings highlight that knowing the individual’s life history, which allows for selection of the appropriate age and sex, and adequate timing of the translocation operation, may facilitate beneficial outcomes for species conservation. Our findings further demonstrate the importance of the timing of translocation operations regarding animal breeding, which may impact subsequent breeding success in the long term. Post-translocation monitoring proved to be the most effective when performed for a minimum of 2 years, as this represents the most sensitive period for the animals in coping with the novel environment, and thus proves the ecological resilience of the surviving translocated individuals. Last but not least, our findings suggest that individual fitness, measured by the survival of offspring at the site, is higher in habitats similar to those in the wild.

AUTHOR CONTRIBUTIONS
Karolina Brandlová and Pavla Hejcmanová contributed to the study and manuscript equally. Karolina Brandlová and Pavla Hejcmanová conceived the study, collected and analyzed data, and wrote the paper.

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CONFLICTS OF INTEREST
The authors declare no competing financial interests.

DATA AVAILABILITY STATEMENT
The datasets generated and analyzed during this study are included in this published article as supplementary information files.

ETHICS STATEMENT
The translocation process was performed within the frame of the Western Derby eland conservation programme with the approval of Senegalese conservation authorities, namely the Directorate of National Parks of Senegal under the Ministry of Environment and Sustainable Development of Senegal, and within the framework of agreements between the Czech and Senegalese Ministries of Environment.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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