Successful translocations of the Hermann's Tortoise (*Testudo hermanni hermanni*) offer promising approach to restore populations after fire

BRIEF 35

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Natural habitats of the Mediterranean basin host a rich fauna of endemic reptiles, notably the Hermann's Tortoise (*Testudo hermanni*; Fig. 1). This species is an emblematic medium size tortoise (adult carapace length [CL] ~210 mm), but it is also one of the most threatened reptiles in Western Europe (van Dijk et al. 2004). In continental France, remaining populations of the western subspecies (*T. h. hermanni*) subsist in a single region where they are exposed to drastic habitat loss and fragmentation caused by urbanization, forest exploitation, and fires (Bertolero et al. 2011). Unfortunately, this situation reflects the decline of this subspecies throughout its distribution range (and of chelonians worldwide). Natural habitats are subjected to intensive anthropogenic pressures due to rapidly increasing population growth and infrastructure sprawl.

In 2009, the classification of 5,276 previously unprotected hectares as a national natural reserve was the first practical advance for the conservation of the Hermann's Tortoise (Livoreil 2009). The presence of tortoise populations was used as a fulcrum to reach this objective, which provides a striking example of the usefulness of popular species to protect habitats. However, most natural areas favorable to tortoises are threatened by land development. Despite legal requirements to offset negative impacts during land development, many tortoise populations are severely impacted.

Further, large areas of favorable habitats are regularly destroyed by fires, especially protected areas that shelter large tortoise populations. For example, 600 hectares were devastated by a fire in Port-Cros National Park in summer 2017. The last population of tortoises living in the coastline was ravaged (90% mortality estimated; XXX, pers. obs.). Repeated fires push populations toward extinction (Couturier et al. 2011). Current fragmentation of habitats (e.g., impassable highways) prevents natural population recovery through dispersal and immigration from neighboring populations. Peripheral and isolated populations with low density are particularly fragile. Multiple threats pose insurmountable problems for tortoises. Indeed, their long life expectancy is also associated with slow movements (hence, limited escape ability) and slow pace of life (hence, limited population growth). Practical responses are required to bolster residual populations.

Before destructive land management, translocation seems to be the last solution to rescue individuals. This approach may appear futile, but in long lived animals like tortoises, each individual has an important conservation value. Rescued individuals can be used to reinforce other populations or repopulate favorable areas, or they can be placed back in their home habitat after the completion of land management. Reinforcing populations impacted by fires with rescued tortoises is an obvious option with a huge potential, especially considering the vast land areas that are also coveted by property developers. In addition, each year, numerous tortoises are injured or killed by dogs, accidentally hit by public and work vehicles, or illegally collected. Many illegally collected tortoises are brought to rescue centers (e.g., SOPTOM), which provides a pool of candidates for conservation translocations, possibly supplemented by injured individuals following healing (Gagno et al. 2013). Successful translocations have been performed in Desert Tortoises in the USA (Field et al. 2007), but questions about the method remain (Germano et al. 2015). For instance, translocation may trigger homing behaviors, and individuals undertaking hazardous movements (e.g., crossing road or obstacles) may suffer from stress. Introduced tortoises may perturb resident ones, hampering population recovery. Further experiments in diverse species and contexts, accompanied by accurate assessments, are thus urgently needed. Here, we describe a series of three experiments to evaluate translocation in Hermann's Tortoises (Fig. 2).

Fig. 1. An adult Hermann's Tortoise (*Testudo hermanni hermanni*) in its natural habitat. Photo by Franck Bonin.

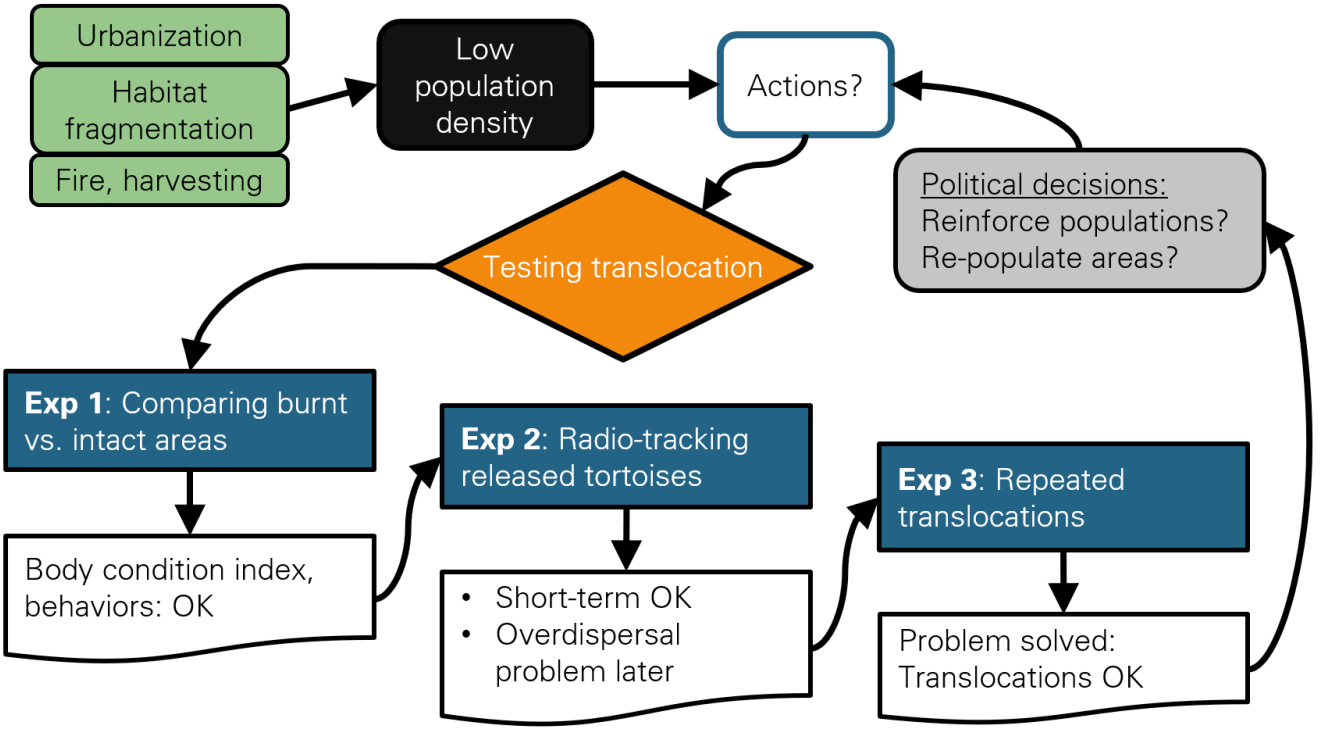

Fig. 2. Experimental flowchart illustrating translocation. Populations threatened by urbanization, fire, or habitat fragmentation (green rectangles) are declining. Translocation represents an option to reinforce populations, but this approach must be tested (orange diamond). Three successive complementary experiments (blue rectangles) were performed. The outcomes (white boxes) showed that translocation was eventually successful and is a potential tool to curb the decline of this species, but enacting translocations depends on political decisions (gray rectangle).

Is translocation suitable to restore Hermann's Tortoise populations affected by fire?

The first step in translocating tortoises was to examine if burnt habitats were still suitable. To tackle this issue, we compared annual fluctuations of body condition (an integrative proxy of how individuals cope with environment) of tortoises that survived a strong fire to nearby tortoises living in unburned habitat (2003–2009). Strong fires devastated thousands of hectares of natural habitats in 2003; landscape and vegetation were still markedly degraded six years later. Mean body condition fluctuated over time, likely due to varying climatic and trophic conditions, but body condition did not differ between burnt and intact habitats (Lecq et al. 2014). This suggests that depopulated burnt areas provide adequate amounts of food resources and suitable shelters, and thus are likely appropriate for population-augmentation programs.

Experimental assessment of translocation success

We evaluated experimental translocations in 2013. Within the framework of the first National Action Plan of the species (2009–2014), and thanks to a LIFE program (EU's funding instrument for the environment), we released 2 groups of 12 translocated adult tortoises in the field. The 165-ha release site was within the core of the species' distribution. The host population was affected by a devastating fire in 1978 and still had a density approximately 50% lower than unaffected areas (population recovery is a very slow process). The site was considered favorable: complex habitat provided abundant food and shelter. The 24 candidates were selected from a pool of rescued individuals housed in a center dedicated to tortoise conservation (SOPTOM). All individuals were screened to ensure a lack of infectious disease. We opted for hard-releasing because this method drastically reduces logistical constraints compared to soft-releases (i.e., animals are temporarily penned in acclimation enclosures). Hard releases may represent the most challenging situation for tortoises, but if successful, the need to test other options would be relaxed.

We compared two batches of adult tortoises: one released (n = 12) in spring during the main activity season versus another (n = 12) released shortly before hibernation. This second release presumably limited post-release activity and thus over-dispersal. Indeed, the period of immobility during winter may increase site fidelity through acclimation to novel habitat (Attum and Cutshall 2015). Several tortoises from the host population (n = 23) were also monitored prior to, and then in parallel to translocations, to obtain comparative data and to assess their responses to the new entrants. We intensively radio-tracked all individuals for three years, usually daily.

We first aimed to obtain a rapid assessment during the critical post-release period of three months. Behavioral and eco-physiological analyses revealed no difference between translocated and resident groups. Body condition of all tortoises increased rapidly in spring, indicating that translocated tortoises found suitable trophic resources and adapted well to their novel

environment (Lepeigneul et al. 2014).

The next crucial question was to identify the exact timing and location of settlement, if any. Intensive long-term radio-tracking provided sufficient precision for this endeavor (Pille et al. 2018). Translocated tortoises first dispersed 500 m to 3000 m away from the release site in random directions. Most individuals settled during the first year after release; others did so the second year. Autumn-released tortoises exhibited a marked dispersal phase after hibernation. Thus, it might be better to translocate tortoises at the beginning of the active season when environmental conditions are the most favorable in terms of food and thermal resource availability. Mean annual survival rate (> 85%) was relatively low for translocated tortoises but remained within the range of the species (Pille et al. 2018). Importantly, almost all deaths were due to predation and occurred during dispersal. Regular observations of courtship and mating between translocated and resident tortoises were particularly encouraging.

This second experiment showed that post-release dispersal is likely the main problem to consider during translocations. Consequently, release sites must be large enough and/or surrounded by secondary host areas to limit the mortality associated with hazardous dispersal (Pille et al. 2018). Yet, this perilous dispersal phase imposes strong practical constraints.

Mitigating post-release dispersal complications

In 2017, we used 10 tortoises from different ages (including juveniles < 8 years old) that were rescued before land management and represented suitable candidates to reinforce (e.g., repopulate) degraded populations. They were screened for infectious disease and to certify that they belonged to the local subspecies; they were subsequently involved in a third experiment (XXX, pers. obs.) in a relatively small (50 ha) area. In this site, the resident population has been affected by intensive timber harvesting (many tortoises were killed by work vehicles). Experimental individuals were hard-released in spring 2017 and intensively radio-tracked for 1–2 years. Following translocation, many tortoises left the small area, and hence did not settle as expected. To overcome this strong post-release dispersal, we replaced each tortoise that ventured > 1 km away from the boundary of the protected area back at its initial release point. We repeated this action two times in case of failure. More than two-thirds of the released individuals eventually settled into the targeted area. Fifteen months later, the very high survival rate (100%) of the translocated tortoises that settled in their novel habitat, and thus that remained in the protected area, suggests that repeated translocation to the initial point of release was successful.

Perspectives

Our empirical investigations and complementary experiments suggest that translocations are an effective management strategy to stem the decline of threatened Hermann's Tortoises. However, these results should not be used to justify further loss of natural habitats. Conversely, the large pools of Hermann's Tortoises held in captivity provide abundant suitable candidates for reintroduction into sites where the species has disappeared, thereby providing a means to upgrade the conservation status of the targeted zones. Each year, hundreds of tortoises are confiscated by environmental authorities, and genetic analyses indicate that many likely originate from wild populations. Instead of keeping these individuals in enclosures, we can use them to reinforce fragile populations and to promote the protection of important habitats. Further projects should focus on juveniles, which are insufficiently studied. Practical actions favoring shelter availability (i.e., thick bushes, rocky areas) might be crucial to buffer the effects of climatic changes by providing a wide range of thermal niches (Robinson et al. 2013). This is likely important for small individuals that are sensitive to climatic conditions and highly exposed to wild and feral predators, especially increasingly frequent wild-boar outbreaks. Overall, translocation of tortoises of different age classes, notably juveniles released in a substantial number (e.g., ≥ 100) from conservation breeding centers, represents a promising strategy to restore populations (e.g., after fire) and their environment.

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