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Reproduction of translocated *Geochelone platynota* (Testudines: Testudinidae) at two wildlife sanctuaries in Myanmar

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Translocations (defined as the human mediated movement of organisms from one area with release into another area; IUCN 2013) – often undertaken in combination with captive-breeding and head-starting of juveniles – are playing an increasingly important role in the conservation of tortoises and freshwater turtles (Burke 2015, Stanford et al. 2018). In many cases, translocation may be the only remaining option for reestablishing extirpated populations (Stofer 1999, Marsh & Trenham 2001). This is especially true for species that survive only in captivity and translocating captive-bred offspring is the sole remaining pathway available to restore ecologically functional wild populations (e.g., Zhou et al. 2008, Weissenbacher et al. 2015).

There is no standardized definition of success when translocating wildlife because of varying time scales and differences in life history traits among target organisms (Seddon 1999, Germano et al. 2014, Miller et al. 2014, Burke 2015). However, a translocation can ultimately be considered successful only when a viable, self-sustaining population becomes established in the wild (Griffith et al. 1989, Dodd & Seigel 1991). As a first step towards achieving this objective, translocated individuals must demonstrate competency in the wild, such that they survive, grow, and reproduce (Alberts 2007, Roe et al. 2015). Common demographic indicators of near-term success include positive survival rates and reproduction of founder females (Armstrong & Seddon 2008, Ewen et al. 2014, Miller et al. 2014, Elsey et al. 2015).

The Burmese Star Tortoise (*Geochelone platynota* Blyth, 1863) is endemic to the Dry Zone of central Myanmar (Platt et al. 2011), listed as Critically Endangered on the IUCN Redlist (Praschag et al. 2020), and considered among the 25 most endangered chelonians in the world (Stanford et al. 2018). This perilous conservation situation was brought about by widespread and long-term habitat loss to agriculture, chronic subsistence harvesting by rural Burmese, and rampant over-collecting to meet commercial demands from food and traditional medicine markets in China and more recently (post 2000), the high-end international pet trade (Platt et al. 2011, Platt & Platt 2020). By the early 2000s, viable wild populations of *G. platynota* could no longer be found, even within the national protected area system (Platt et al. 2011). Assurance colonies (captive-breeding groups) were established in Myanmar at about the same time to, 1) ensure the biological survival of *G. platynota* and 2) produce offspring for head-starting and eventual translocation to protected habitat (Platt et al. 2017), and as a result, 1000–2000 neonates are now being produced annually (Platt & Platt 2020). Head-started *G. platynota* in the assurance colonies typically attain sexual maturity when 5–6 years-old at a carapace length of about 200 mm, with males being somewhat smaller than females (Platt et al. unpubl. data). Clutch size among captive *G. platynota* averages 4 eggs (range = 1–6) and females deposit 1–6 clutches each year (Platt et al. 2011 and unpubl. data). In accordance with a national conservation action plan (Platt et al. 2014), we began releasing captive-bred and head-started *G. platynota* into the wild at Minzontaung (MWS; 2260 ha) and Shwe Settaw (SSWS; 45,167 ha) wildlife sanctuaries in 2014 and 2017,

Table 1. Evidence of reproduction among translocated *Geochelone platynota* found at Minzontaung and Shwe Settaw wildlife sanctuaries in central Myanmar (2014–2020).

Location	Year	Evidence of reproduction
Minzontaung Wildlife Sanctuary	2014	Female observed nesting (20 December)
	2015	Successful nest with eggshells
	2017	29 living neonates, remains of one dead neonate
	2018	10 neonates; successful nest with eggshells
	2019	14 juvenile tortoises, including nine neonates and five larger juveniles (1–3 years-old); successful nest with eggshells
	2020	Five neonates
Shwe Settaw Wildlife Sanctuary	2017	Female nesting in pre-release acclimation pen (16 April)
	2018	10 neonates
	2019	Three neonates
	2020	Four neonates

respectively (site descriptions in Platt et al. 2001, 2003). To date (November 2021), 2800 tortoises (MWS = 1050; SSWS = 1750) have been successfully translocated from the assurance colonies into the wild (Platt & Platt 2020, Platt et al. unpubl. data). We here report evidence that successful reproduction by translocated *G. platynota* is now occurring at both wildlife sanctuaries.

To briefly summarize our methods, we employed a soft-release strategy (sensu Knox & Monks 2014) to translocate tortoises (Platt & Platt 2020). Groups of 100–150 tortoises (sex ratio ca. 1:1) aged 3–5 years-old were confined at the release site in acclimation pens encompassing 1-ha of natural habitat for 12 months before being allowed to self-liberate through holes cut in the perimeter fences. We placed tortoises in the pens during mid-dry season (January or February) and initiated release at the same time the following year. We attached very high frequency (VHF) radio transmitters (Holohil® Ri2b) to 20–30 tortoises (body mass ≥ 500 g) in each release cohort to monitor dispersal and survival. Transmitters (15 g) were encased in epoxy and the combined weight of this package was approximately 25 g or ≤ 5.0% of body mass. We attempted to physically relocate these tortoises at least 1–2 times monthly (more if possible) and continued monitoring for the life of the transmitter batteries (18–24 months). Because poaching for the high-end, albeit illegal international pet market remains the single greatest threat to translocated *G. platynota*, intensive law enforcement patrols are regularly conducted in both wildlife sanctuaries by locally–recruited Community Guards working together with Forest Department rangers (Platt & Platt 2020).

We considered observations of egg-laying, old nests containing eggshells, and encounters with juvenile tortoises to be evidence of successful reproduction by translocated *G. platynota* (Figs 1a–c). We follow Morafka (1994) and refer to tortoises < 1 year-old as neonates, and individuals 1–2 years-old and 2–3 years-old as 1 and 2 year-olds, respectively. Our assessment of age was based on counts of plastral annuli and comparisons of body size with known-age individuals in the assurance colonies. In late 2017 we initiated an egg translocation program at MWS whereby recently deposited clutches from the assurance colony were reburied in the wild to incubate under natural conditions, and upon hatching, the neonates dispersed into the surrounding habitat. Because we were unable to distinguish these neonates from those produced by translocated females, after the 2017–2018 reproductive season we considered only those juveniles found > 1 km from the area where clutches were buried to be the progeny of translocated females. This distance was selected based on our experience with radio-tracking older translocated tortoises, which rarely move > 1 km from the release site. We therefore assumed it highly unlikely that hatchlings and juvenile tortoises would be capable of dispersing > 1 km from the hatching area.

We found evidence of successful reproduction by translocated female *G. platynota* at both Minzontaung and Shwe Settaw wildlife sanctuaries (Table 1). Our observations largely resulted from chance encounters that occurred as we monitored released tortoises or were engaged in other routine tasks. Government-mandated COVID-19 restrictions severely curtailed our monitoring efforts in 2020, which may in part be responsible for fewer opportunistic encounters during that year. At MWS, we found a nesting female tortoise, 59 juveniles (including the remains of a dead neonate), and three old nests, while at SSWS we observed a female nesting in an acclimation pen prior to release and encountered 17 neonates. On occasion, we also encountered females at MWS with a thick layer of soil caked on the plastron and adhering to the posterior-most rim of the carapace suggesting these individuals had recently excavated a nest and deposited eggs (Figs 2a–b). In the assurance colonies, similar accumulations of soil are present on females immediately post-nesting and often persist > 1 day (Swann Htet Naing Aung, pers. obs.).

We encountered juvenile tortoises from 2017–2020 at MWS and 2018–2020 at SSWS (Table 1). Numerous other juveniles (> 30) have been found at MWS after the 2017–

2018 nesting season, but because of our inability to reliably distinguish the progeny of translocated females from neonates that emerged from translocated clutches these tortoises are not included in our tally. The majority (89.4%) of our encounters with juvenile tortoises at both wildlife sanctuaries occurred from June through September, a period coinciding with the annual monsoonal rains (Fig. 3). This is not unexpected because neonate *G. platynota* in the assurance colonies typically emerge from the nest at this time (Platt et al. 2017), rainfall is known to stimulate movements among terrestrial chelonians (Stickel 1950, Christiansen et al. 1985, Dodd 2017), and tortoise activity in arid habitats often peaks during wet periods (Ernst & Lovich 2009).

Our observation of a nesting female *G. platynota* and three old nests (with eggshells) at MWS compliment an earlier description of nesting at SSWS (Platt et al. 2001). To our knowledge, these are the only observations of nesting by *G. platynota* in the wild. The nesting female and old nests that we found at MWS all occurred in thorn-scrub

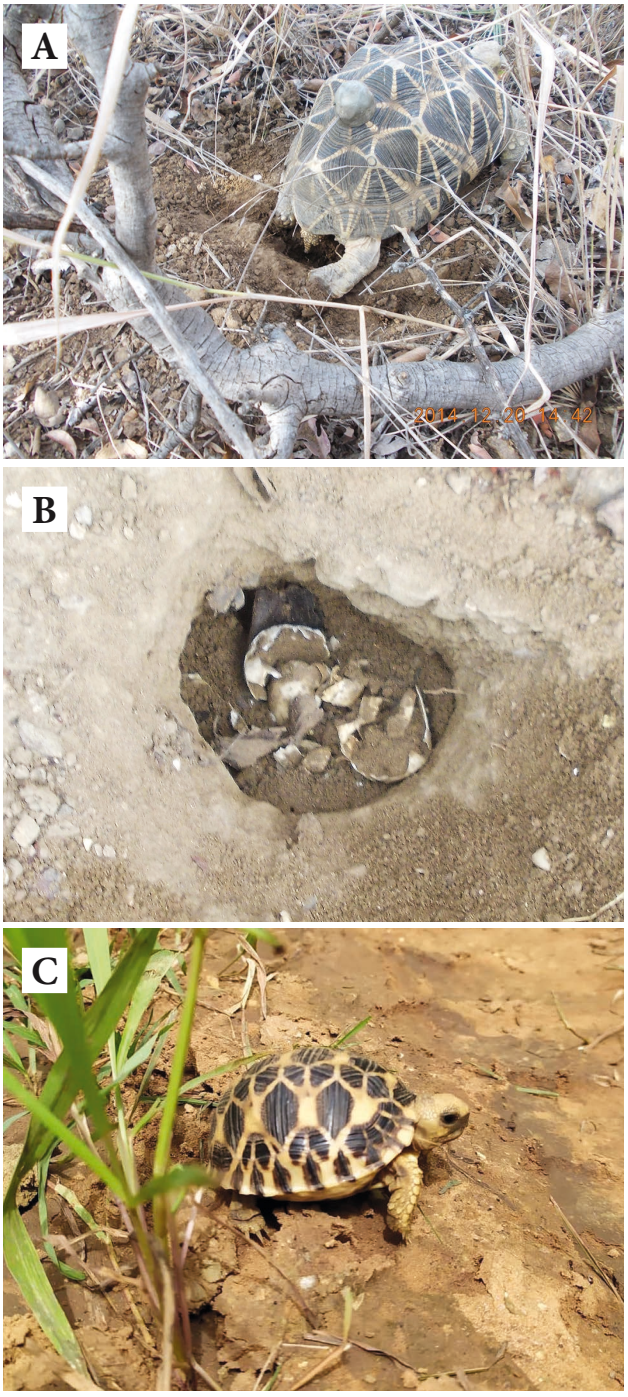

Figure 1. Evidence of successful reproduction by translocated *Geochelone platynota* at Minzontaung and Shwe Settaw wildlife sanctuaries included observations of nesting females (A), old nests containing eggshells (B), and juveniles (C). Photos: Me Me Soe (A), Swan Htet Naing Aung (B, C).

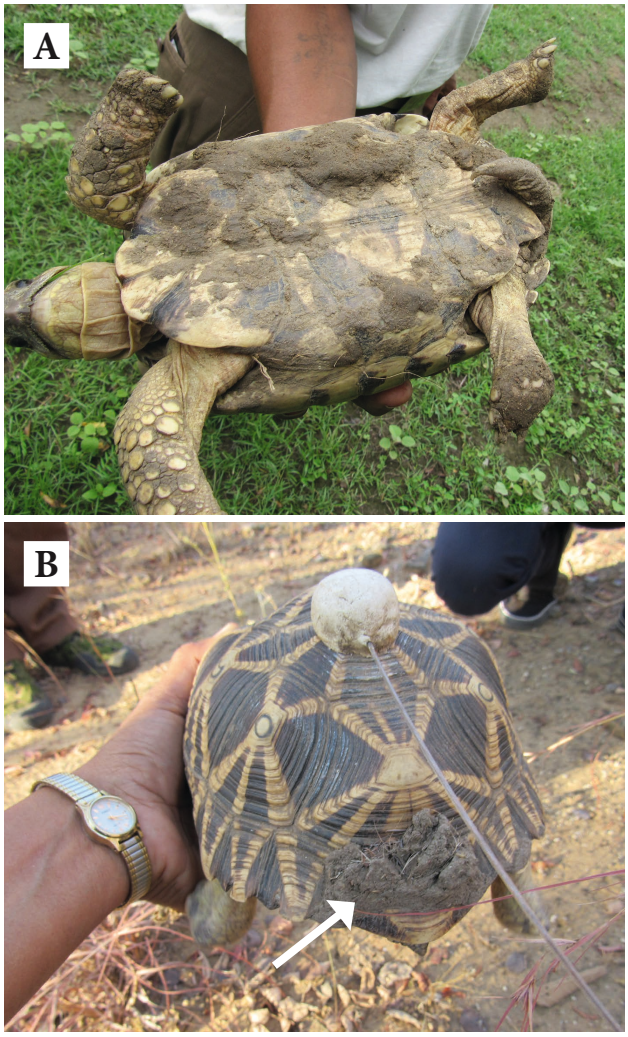

Figure 2. Translocated female *Geochelone platynota* found at Minzontaung Wildlife Sanctuary with soil caked on the plastron (A) and adhering to the posterior carapace (white arrow) (B) suggesting these tortoises had recently nested. Photos: Me Me Soe.

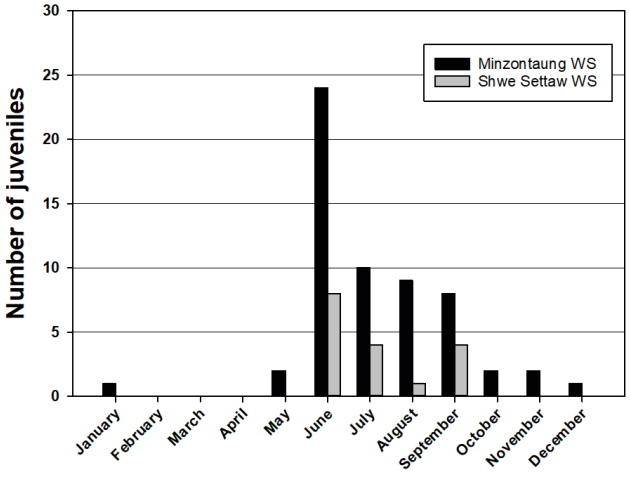

Figure 3. Juvenile *Geochelone platynota* found each month at Minzontaung and Shwe Settaw wildlife sanctuaries (2017–2020).

thickets rather than the scattered patches of open grassland that characterize the habitat in this wildlife sanctuary (see Platt et al. 2003). Likewise, the nest site (with neonates) described by Platt et al. (2001) at SSWS occurred within *Tectona hamiltoniana* forest. This small sample of observations suggests that female *G. platynota* are likely to nest in scrub or forest rather than in more open habitats. This finding is also consistent with our preliminary results from translocated nests; hatching success in those clutches we buried in open grassland was greatly reduced in comparison to clutches incubated beneath a scrub forest canopy (Platt et al. unpubl. data).

In conclusion, our observations at MWS and SSWS demonstrate that captive-bred and head-started *G. platynota* are capable of successfully producing offspring after being translocated into the wild, and moreover, reproduction among translocated females has been occurring every year since the tortoises were released into the wild. Although reproduction alone does not guarantee the long-term success of translocation projects (Dodd & Seigel 1991, Bertolero & Oro 2009), the production of offspring by founder females is an important milestone on the continuum of success towards a self-sustaining, viable, reestablished wild population (Miller et al. 2014). Whether or not offspring recruitment at either wildlife sanctuary is sufficient to offset the assumed high rates of juvenile mortality (Germano 1994, but see Pike et al. 2008 for an alternate view) remains to be determined. Because *G. platynota* is a long-lived species with delayed sexual maturity and relatively low fecundity, several decades will likely be required to restore viable wild populations in Myanmar.

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