

The conservation of the world's most threatened tortoise: the ploughshare tortoise (*Astrochelys yniphora*) of Madagascar

Ryan Walker^{1,2}, Richard Lewis³, Angelo Mandimbihasina³, Eric Goode⁴, Paul Gibbons⁴, Andrea Currylow⁵ and Lance Woolaver³

¹Nautilus Ecology, Oak House, Pond Lane, Greetham, Rutland, LE15 7NW, UK

²Department of Environment, Earth and Ecosystems, The Open University, Milton Keynes, MK7 6AA, UK. Email: ryan@nautilusecology.org

³Durrell Wildlife Conservation Trust (DWCT), Lot II Y 49 J Ampasanimalo, BP 8511, 101 Antananarivo, Madagascar

⁴Turtle Conservancy, 49 Bleecker Street, Suite 601, New York, NY 10012, USA

⁵Integrative and Evolutionary Biology, University of Southern California, 3616 Trousdale Parkway, AHF 107, Los Angeles, CA 90089, USA

Introduction

The Critically Endangered ploughshare tortoise (*Astrochelys yniphora*) is Madagascar's largest, rarest and most threatened of the island's four endemic tortoises (Fig. 1) (Mandimbihasina & Currylow 2014). Madagascar supports two genera of endemic tortoises. One is the *Astrochelys* genus, of which the radiated tortoise (*A. radiata*), endemic to the southern dry forests of Madagascar, is the ploughshare's sister species. The other genus, *Pyxis*, supports two of the smallest species in the world: the spider tortoise (*P. arachnoides*), often sympatric in its range with *A. radiata*, and the flat tailed tortoise (*P. planicauda*), endemic to isolated parts of the western dry forests within the Kirindy region.

The ploughshare tortoise inhabits a number of isolated pockets of dry bamboo forest, palm savannah and thick scrub within the Baly Bay region of northwest Madagascar (Juvik *et al.* 1981). The bamboo forest is a fire-dependant transitional habitat. The species inhabits a region that is considered to be one of the driest within Madagascar (Mandimbihasina & Woolaver 2014).



Fig. 1. A large male ploughshare tortoise in the Cap Sada region of Baly Bay National Park. Photo by A. Currylow.

Conservation status

The ploughshare tortoise has been legally protected within Madagascar since 1960; however, enforcement is difficult (Pedrono 2008). International trade in the species is banned and the species is listed as Critically Endangered by the IUCN Red List for Threatened Species. The species has always been considered rare, even when the first specimens were collected by the early naturalist Voeltzkow in the Cap Sada region (Curl *et al.* 1985). This scarcity is most likely the result of many centuries of exploitation by sailors and there are no anecdotal records or sub-fossil records outside of the Baly Bay region, suggesting the species may have always had a very restricted range (Mandimbihasina & Woolaver 2014).

Currently, five remaining fragmented sub-populations of tortoises exist within Baly Bay National Park, divided by the Bay of Baly and the Andranomavo River into east and west populations (Fig. 2). There are three sub-populations inhabiting patches of habitat in the west: Ambatomainity-Andranolava (10,644 ha.), Betainalika (2,908 ha.) and the reintroduced subpopulation of captive-bred animals within Beaboaly (1,400 ha.) (Mandimbihasina & Woolaver 2014). The two eastern sub-populations consist of habitat fragments in Cap Sada and Beheta, with no natural gene flow between the east and west populations (Mandimbihasina *et al.*, in prep).

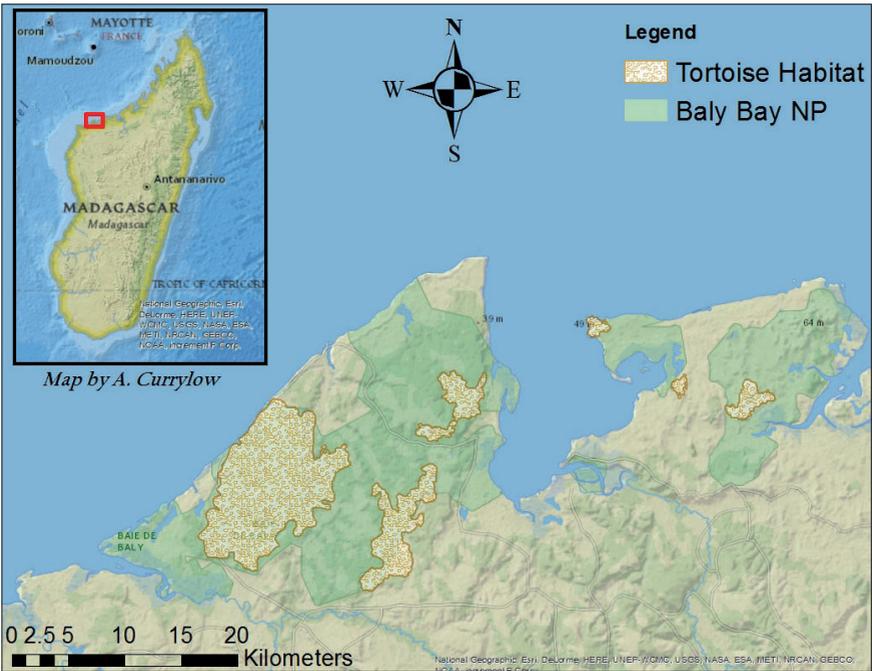


Fig. 2. Current ploughshare tortoise (*Astrochelys yniphora*) habitat and range within Baly Bay National Park.

The most recent population estimate for the species stems from a distance sampling study, suggesting a population of 950 ± 375 adults and subadults (>20cm carapace length) (Mandimbihasina *et al.*, in prep). However, this recent estimate does not account for the presumed substantial losses due to poaching since 2010 (Currylow *et al.*, in prep.). Recorded densities of this species since research has been carried out have been extremely low, particularly in the western subpopulations with densities from 0.02 to 0.06 subadults/adults per ha. (Mandimbihasina & Woolaver 2014). The highest recorded densities were recorded by Pedrono (2008) from the Ambatomainty region (0.71 animals per ha.) and at Cap Sada (0.55 animals per ha.).

Threats

Historically the ploughshare tortoise has always been exploited at some level for commercial trade, mostly as a protein resource by passing sailors during the 19th century (Vaillant & Grandidier 1910; Mandimbihasina & Woolaver 2014). In recent times the consumption of tortoises by local communities has largely been considered taboo and is not considered a threat to the species (DWCT, unpublished data). Anthropogenic bush fires, often started

to improve grazing habitat for livestock, were considered a significant threat but have been mitigated somewhat due to efforts by Madagascar National Parks (MNP), the Durrell Wildlife Conservation Trust (DWCT) and local communities to manage fires, through the implementation of fire-breaks (Mandimbihasina & Woolaver 2014). Invasive species such as rats (*Rattus rattus*), Indian palm civets (*Viverricula indica*) and bush pigs (*Potamochoerus larvatus*) are thought to be a predation risk to hatchling and juvenile tortoises. Pedrono *et al.* (2001) documented a predation rate of 2.8% by bush pigs on ploughshare nests.

The most serious current threat facing the ploughshare tortoise comes from the international pet trade. The number of confiscated poached wild animals has steadily increased within the last 15 years (Mandimbihasina & Woolaver 2014). The demand for this trade stems primarily from the emerging economies within Asia (Table 1; Kiester *et al.* 2013). However, it is anticipated that a proposed mine adjacent to the Baly Bay National Park could result in the final death knell to the species' survival in the wild, unless all efforts are made by conservation organisations, government and the mine itself to mitigate impacts. Mine infrastructure including a port and access roads could allow for greater access to the area by traffickers and provide an easy route for the illegal theft of animals from the country (Mandimbihasina & Woolaver 2014). In addition, the influx of people to staff the mine will put added pressures upon the National Park, and there is also a risk that some parts of the park could be declassified to make way for access roads from the mine to the port.

Table 1. *Ex situ* ploughshare tortoises illegally held or offered for sale 2008-11. Reproduced from Kiester *et al.* (2013).

Country	Number	Source
Singapore	10	Private communication
Thailand	80	NantarikaChansue internet and market surveys
China	112	Internet and market surveys
Indonesia	6	Internet and market surveys
Philippines	6	Internet and market surveys
Italy	2	Private communication
Germany	2	Private communication

Conservation strategies

Since the early 1980s DWCT and partners have been instrumental in the conservation of the ploughshare tortoise. Conservation efforts combined *in situ* and *ex situ* strategies. The DWCT has managed a captive breeding facility in Madagascar that started with a founding population of 18 individuals confiscated in 1986 and 1991 (Reid 1995). The captive population has produced 688 tortoises to date. Apart from the breeding population in Madagascar, six institutions in the US and Europe officially hold captive populations, derived from confiscated animals, although most are not yet of breeding age (Goetz 2015). A total of 101 captive-bred tortoises from the DWCT facility have been released, between 2006 and 2015, to recolonise an extirpated population in the Beaboaly area of Baly Bay (Mandimbihasina & Woolaver 2014). The reintroduction has been regarded as a success due to the establishment of home ranges at the releases site, a low mortality rate of the released animals (2/101) and the discovery of 22 hatchlings from these released animals since 2012.

Complementary to the captive-breeding and reintroduction, DWCT has been involved in a long-term intensive programme of community engagement to protect ploughshare tortoises since 1986. This has included working with Madagascar National Parks to create Baly Baly National Park, supporting local communities to develop community associations and improving the livelihoods of local communities through development projects. Since 2009 the engagement work has increased in scope to employ 28 local people as teams of park 'rangers' who patrol daily with permanent field camps in ploughshare habitat in an effort to combat the increased poaching effort (Keister *et al.* 2013). However, it has been an uphill battle due to the challenges of patrolling large areas of remote habitat and of ensuring rapid response by enforcement agencies with very limited capacity and infrastructure.

In addition to long-term population monitoring of the wild sub-populations, DWCT has worked in collaboration with national and expatriate PhD and Masters students. Most recently, a PhD candidate from the University of Southern California (USC), supported by the Turtle Conservancy (TC) and DWCT, has been engaged in a wide scale radio-tracking programme. The constant presence of field workers and local field patrols radio-tracking in the wild subpopulations is thought to aid in deterring poachers, but it has only managed to slow down poachers and change their behaviour. Complementary to the radio-tracking, field teams have been engraving wild and captive tortoises in order to devalue them for the international pet market. DWCT and TC developed a methodology in 2009 to deface the tortoises by engraving carapaces (Goetz *et al.* 2014) with large identification numbers (Fig. 3). Sixty-two wild tortoises and all 101 of the reintroduced

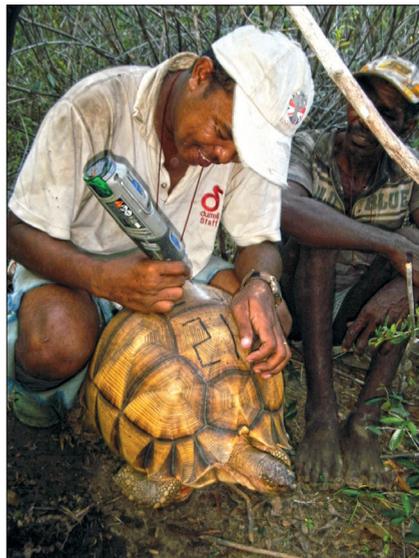


Fig. 3. A. Currylow (left) and A. Mandimbiasina (right) engraving the identification number into the carapace of a mature ploughshare tortoise. Photos by A. Currylow.

animals have been engraved since early 2012 (Fig. 4). The power tools used to engrave the large specimens will not work upon smaller juveniles and hatchlings (<200mm) due to the soft nature of the carapace and plastron of these animals, therefore an alternative method had to be developed for these smaller tortoises, which are often favoured by poachers and smugglers over the larger animals.

Tattooing identification numbers on the plastron of smaller animals (<200mm) with identification numbers was developed by the veterinary team at TC (Fig. 5) and trialled on young animals in the captive population. However, two years after the trial in 2012, the numbers tattooed on these tortoises had faded due to the growth of new keratin. The TC-DCWT team are continuing to develop more permanent methods of marking young animals.

Conservation organisations, Madagascar National Parks and the local communities of Baly Bay have invested large amounts of effort and resources in the protection of this iconic species since the mid 1980s. There is no question that the conservation status of this species would be in a far worse state without this effort. However, the ploughshare tortoise is still in a critical situation due to impacts of the illegal international pet trade and the potential impact of the new mine, which unless mitigated could spell the final extirpation of this species from the wild.



Fig. 5. Tattooed juvenile ploughshare tortoise. Photo by R. Walker.

References

- Curl, D.A., Scoones, I.C., Guy, M.K. & Rakotoarisoa, G. (1985). The Madagascar tortoise *Geochelone yniphora*: current status and distribution. *Biological Conservation* 35: 35-54.
- Currylow, A., Mandimbihasana, A., Woolaver, L., Gibbons, P., Kiester, A.R. & Stanford, C. (2013). The Ploughshare Problem: 2013 Field Report for *Astrochelys yniphora* in Madagascar. In: Walde, A.D., Riedle, J.D., Walton, E.M. & Currylow, A. (eds). 11th Annual Symposium on the Conservation and Biology of Tortoises and Freshwater Turtles. Joint Annual Meeting of the Turtle Survival Alliance and IUCN Tortoise & Freshwater Turtle Specialist Group, Saint Louis, MO.
- Goetz, M. (2015). EAZA-EEP for the Ploughshare tortoise *Astrochelys yniphora* 1st edition (to end January 2015). Durrell Wildlife Conservation Trust, Jersey.
- Goetz, M., Woolaver, L. & Routh, A. (2014). Ploughshare tortoise captive management protocols, 1st edition. Durrell Wildlife Conservation Trust, Jersey.
- Juvik, J.O., Andrianarivo, A.J. & Blanc, C.P. (1981). The ecology and status of *Geochelone yniphora*: a critically endangered tortoise in northwest Madagascar. *Biological Conservation* 19: 297-316.
- Kiester, R., Mandimbihasana, A.R., Lewis, R.E., Goode, E.V., Juvik, J.O., Young, R. & Blanck, T. (2013). Conservation of the angonoka (ploughshare tortoise) *Astrochelys yniphora*. *Chelonian Research Monographs* 6. doi 10.33854/crm.6.a26p162.
- Mandimbihasana, A.R. & Currylow, A.F.T. (2014). New data on the naturally-occurring maximum sizes attained by Ploughshare Tortoises (*Astrochelys yniphora*). *Herpetology Notes* 7: 685-688.
- Mandimbihasana, A. & Woolaver, L. (2014). The Ploughshare tortoise *Astrochelys yniphora*. In: *Tortoises of the Indian Ocean* (ed. Gerlach, J.). Siri Scientific Press, UK, pp. 277-296.
- Mandimbihasana, A., Young, R., Woolaver, L.G. & Lewis, R. (in prep). Current status of the critically endangered ploughshare tortoise: density and population size.
- Pedrono, M. (2008). *The Tortoises and Turtles of Madagascar*. Natural History Publications (Borneo), Kota Kinabalu, Malaysia. 147 pp.
- Pedrono, M., Smith, L.L., Sarovy, A., Bourou, R. & Tiandray, H. (2001). Reproductive ecology of the ploughshare tortoise (*Geochelone yniphora*). *Journal of Herpetology* 35: 151-156.
- Reid, D. (1995). Observations on hatchling and juvenile captive bred Angonoka *Geochelone yniphora* in Madagascar. *Dodo* 31: 112-119.
- Vaillant, L. & Grandidier, G. (1910). Histoire naturelle des reptiles, Première Partie: Crocodiles et tortues. In: Grandidier, A. & Grandidier, G. (eds). *Histoire Physique Naturelle et Politique de Madagascar*, Paris Hachette, 17: 1-86.