

# LONESOME GEORGE: THE LEGACY

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Fig. 1. Lonesome George. Photo by Godfrey Merlen.

On 24th June 2012, the world lost its most famous conservation icon. This charismatic chelonian named Lonesome George was the last known living Galapagos giant tortoise from Pinta Island (*Chelonoidis nigra abingdoni*) (Fig. 1). Throughout his 40 year captive life, he acted as a poignant reminder of the extent and severity of human impacts on the natural world and genuinely touched the hearts of many tourists who were lucky enough to pay him a visit in his corral. Although the hopes of George reproducing are over, the legacy of this individual tortoise has the ability to continue to make a real difference in the world of conservation both in Galapagos and globally.



loss of George, it is now assumed that five of the original sub-species have become extinct.

The discovery of a solitary tortoise on Pinta Island back in 1971 by a snail biologist, Jozsef Vagvolgyi, was something of a surprise as the population was thought to be long extinct. The last recorded sighting of a tortoise on Pinta had been in 1906 by the California Academy of Science who promptly took the tortoises they found to preserve in a museum. In March 1972, the lonely tortoise nicknamed 'Solitario Jorge' (Lonesome George) was taken back to the Charles Darwin Research Station where the race began to find another Pinta tortoise to breed with him to bring this sub-species back from the very brink of extinction. George was introduced to several females of different species over the years, including one human, Sveva Grigioni, a Swiss student charged with the task of extracting a semen sample, but none of these ventures was successful before his unexpected demise at the age of about 100 (not particularly old for a Galapagos giant tortoise).

But does the story of the Pinta Island tortoise end with George? A new chapter is just beginning to unfold on a volcano in the north of Isabela Island...

### **The story of Wolf Volcano**

Less than six months after George's death, a research group including the Galapagos National Park and Yale University reported that the genetic legacy of the Pinta tortoises may live on somewhere on a volcano in the north of Isabela. After years of effort to persuade him to reproduce with different sub-species and a worldwide appeal to zoos to check their giant tortoise collections, it is a cruel irony that perhaps there may be tortoises possessing relics of George's genes in existence on a different island in the Archipelago.

This seminal research trip had been inspired by an earlier expedition that had identified a high incidence of giant tortoise hybrids on Wolf Volcano, Isabela. In total, the team took blood samples from 1,669 tortoises, estimated to be 20% of the population, and worked to ascertain their parenthood and genetic origin. A total of 17 individuals sampled on this ground-breaking trip shared genetic ancestry with George. Of these, 13 were likely to have a Pinta tortoise grandparent with four likely to have a purebred Pinta as a parent – an extremely unexpected find. These individuals, and any more that may be discovered with the sampling of the remaining population, have the potential to become integral to captive breeding strategies aiming to conserve the unique genes from this sub-species (Edwards *et al.* 2013). Another expedition to continue the sampling is likely to commence at the end of this year.

Earlier in 2012, it was reported that genes from the extinct Floreana Island tortoise (*Chelonoidis nigra elephantopus*) had been discovered in hybrid

tortoises also from Wolf Volcano (Garrick *et al.* 2012). This was a species thought to have been wiped out over 150 years ago, just after Charles Darwin's famous visit in 1835. As 30 of the 84 individuals with Floreana ancestry were estimated to be less than 15 years old, there is a good chance that this purebred parent could still be alive and reproductively active. These findings suggest that a viable population may be established *ex situ* to attempt the recovery of the Floreana species via captive breeding (Garrick *et al.* 2012). The tortoises of Wolf Volcano appear to be harbouring a genetic goldmine.

Paradoxically, it is two previous conservation crimes that may have inadvertently aided the preservation of these Galapagos giant tortoise sub-species. Firstly, the early explorers that extracted many tortoise specimens for international collections have provided an essential DNA archive of extinct lineages that are now essential for identifying genetic signatures of animals such as the Floreana tortoise (Poulakakis *et al.* 2008; Russello *et al.* 2010). The most likely reason for the collection of multiple tortoise sub-species on Wolf Volcano was the very people that had played such a big part in the original decimation of the tortoise populations, the pirates and whalers – both directly via poaching and also by the introduction of invasive mammals (the effects of which are very much still evident today). The north of Isabela constituted an important docking area and thus a popular spot for a tortoise clean out, where they had a habit of throwing previously collected, unwanted giant tortoises overboard after restocking their supplies. The lucky ones that had survived were washed up to shore on their new island.

### **The long road to reintroduction**

When a wild population becomes so decimated that it is unlikely to remain self-sustaining, a last resort to avoid absolute extinction is often to gather the remaining individuals to found captive breeding programmes for eventual reintroduction. The success of these initiatives depends on several factors – if the species can successfully breed in captivity with adequate genetic diversity, if there is sound understanding about the ecological interactions of a species and if the major threat that caused the original population decline can be managed and/or eradicated in the natural environment (Milinkovich *et al.* 2004).

Ecosystem level recovery of disturbed habitats is the first step towards successful reintroduction programmes. Historically, Galapagos vegetation has suffered three main threats including direct habitat destruction (e.g. land transformation for agriculture), exploitation of certain species (e.g. for timber) and, potentially the most severe, via the impacts of introduced species (Tye 2006). Endemic and native vegetation in Galapagos are subject to two lines of attack from invasive species, namely predation (herbivory)

and competition. A perfect example of this is the introduction of 'mora', a Himalayan raspberry that was introduced for agriculture. It is incredibly invasive, producing seed densities of up to 7,000 per square metre presenting significant management challenges (Gardener *et al.* 2010). To seriously address habitat restoration, four major steps have been identified: i) identification and understanding of the threat, ii) removal or reduction of the threat, iii) monitoring of the effects following threat removal, iv) further intervention strategies if required (Tye 2006).

The most common habitat restoration requirement preceding tortoise reintroduction is the eradication of introduced mammals that either compete for food resources (e.g. goats, donkeys) or prey on tortoise eggs and hatchlings (e.g. rats, cats, pigs). Once some of these issues have been addressed at the ecosystem level, reintroduction has a much improved chance of success.

In 2004, a programme to eradicate goats on Pinta Island was hugely successful, providing the first steps toward restoring the island to a more natural state. In 2009, the beginning of a reintroduction programme was initiated by the Galapagos National Park, the Charles Darwin Foundation and the Max Planck Institute (described in more detail in Abigail Rowley's article in *Testudo* Vol. 7, No. 4). As it was looking unlikely that George would successfully breed and as the researchers on Wolf Volcano were yet to reveal their genetic treasure, it was decided that the closest known sub-species should be released – the Espanola tortoise (*Chelonoidis nigra hoodensis*). In order not to compromise any potential future repatriation of tortoises with Pinta heritage, the initial 39 individuals released were sterilised. As the first chelonian coloniser of Pinta Island was likely to have originated from Espanola, some researchers believe that the reintroduction of reproductive Espanola tortoises would be an acceptable alternative if it proves too difficult to establish a breeding population from the newly discovered Pinta hybrids (Nicholls 2012). To gain a greater understanding of their movements and ecological significance, the sterilised founders were tagged with GPS receivers to gain an important insight into tortoise life history and how newly introduced animals manage to establish themselves in the recovering landscape.

### **Breeding success**

Perhaps the best example of a successful breeding programme and reintroduction in Galapagos was the work undertaken to reintroduce a viable giant tortoise population on Espanola Island. After extensive exploitation from the infamous pirates and whalers that frequented Galapagos in the 17th and 18th centuries, the population of the Espanola tortoise (*Chelonoidis nigra hoodensis*) was decimated to just 14 individuals (two males and 12

females). As an emergency conservation measure in the mid-1960s, these remaining individuals were collected and relocated to the breeding centre of the Galapagos National Park and newly formed Charles Darwin Foundation on Santa Cruz Island. These tortoises were set to become pioneer individuals for the establishment of a captive population that would eventually produce offspring for reintroduction onto Espanola Island (over 2,000 offspring have now been produced). During their leave of absence from Espanola, an extensive goat eradication programme took place permitting the first stages of vegetation recovery ready for reintroduction.

### **Understanding the ecosystem engineers**

Galapagos giant tortoises provide essential ecosystem services as top herbivores, seed dispersers and mechanical landscape shapers. The terrestrial ecosystems of Galapagos developed with saurochory (seed dispersal by reptiles) playing an essential role in vegetation dispersal, in addition to the physical impacts of a 400kg reptilian tank browsing through undergrowth. This implies that reintroducing tortoises to their original habitat has the ability to positively affect the wider ecosystem and play an important role in further habitat restoration and ecological resilience (an essential factor for adapting to climatic changes). An example of this mutualism is seen between the giant tortoises on Espanola and a particular species of tree-like cactus (*Opuntia megasperma*) that was almost wiped out by the introduced goats. Tortoises and a whole suite of other animals including lava lizards, Darwin's finches and mockingbirds depend on *Opuntia* cacti as a source of food and shade from the equatorial sun. In return, tortoises are key seed dispersers regularly moving large quantities of seeds over considerable distances (Blake *et al.* 2012; Gibbs *et al.* 2008).

More extensive research is needed to understand the dynamics of seed dispersal to determine effectiveness, differential germination success (with or without a tortoise conduit) and the general demography of vegetation in order to further shed light on the giant tortoise's role in habitat restoration. In order to successfully reintroduce a species, relatively simple life history information is required such as the drivers for migration and food selection and environmental preferences (Blake *et al.* 2012; Sadeghayobi *et al.* 2011). The Galapagos Conservation Trust has supported the work of the Galapagos Giant Tortoise Monitoring Program since its inception and the study now includes 46 tagged tortoises on three islands: Santa Cruz, Isabela and Espanola. The GPS data collected to date is providing fascinating results on tortoise movements and migration and is providing essential data that will feed into management recommendations to the Galapagos National Park. This data can be viewed via an open source online database containing all kinds of animal tracking data from around the world ([www.movebank.org](http://www.movebank.org)).

## **Supplementing the study: a new project focus**

This ongoing monitoring study provides the perfect opportunity for supplementary work with giant tortoises out in the field. A new focus for our project supported by the BCG is the provision of ambient environmental sensors to enhance the information collected from the tagged tortoises. This project will bring together the Giant Tortoise Monitoring Programme (Max Planck Institute for Ornithology), the Zoological Society of London (ZSL), BCG and GCT in an exciting new inter-institutional partnership to maximise the impact on the conservation of Galapagos giant tortoises. With the support of BCG and ZSL, we want to source and provide sensors to provide important supporting data to the study in addition to giving an important insight into the lives of wild tortoises and their environmental preferences, such as temperature, humidity and UV. Whilst enhancing the understanding of the ecology of the tortoises, an essential factor for reintroduction, this information will help to advise the captive breeding programme in London Zoo so that artificial conditions can reflect those naturally experienced by wild tortoises. Many questions remain outstanding: do they show different preferences for environmental conditions at certain life stages? Are there seasonal effects that influence breeding success?

This project partnership will also open other avenues of data sharing that will ultimately benefit both wild Galapagos giant tortoises and our captive populations, such as the measurement of hormone levels in wild tortoises as a guide for parameters for captive individuals and the testing *in situ* of internal sensors in a zoo setting to assess thermoregulation activity – it is much easier to track down tortoise excrement in a defined cage area than in natural island habitat with very dense vegetation!

## **A sustainable future**

A key question that must be addressed in conservation is that of sustainability. Not only for the techniques employed, i.e. considering ecosystem level management as opposed to species-specific initiatives, but also for the longevity of programmes that often span decades. At GCT we believe that an essential component in providing a sustainable future for Galapagos is the involvement of the local community in the work undertaken. The engagement of students both locally and internationally is another key component of ensuring environmental stewardship in our future conservation ambassadors. Via the networks of our project partners, we hope to recruit school groups to get involved in tortoise themed activities.

## **The legacy of George...**

So after 40 years of being a world famous tourist attraction with the most poignant of conservation messages, George was found dead by his long-



Fig. 3. Lonesome George's memorial plaque. Photo by Galapagos Conservation Trust.

term keeper Fausto Llerena. A necropsy declared that he probably died of natural causes. As soon as was possible, skin cells were taken and frozen for the potential future culture of stem or sex cells. His preserved remains are currently in the USA awaiting the attention of expert taxidermists from the New York Museum of Natural History who are restoring him to be displayed in a dedicated museum back in his Galapagos home to continue to inspire tourists with his message (Nicholls 2012). A plaque in his memory is currently on display (Fig. 3).

These new discoveries demonstrate without dispute the requirement for ongoing research into this 'living laboratory' and the unique flora and fauna that inhabit Galapagos. The continued support from the BCG is enabling us to continue working towards the ongoing conservation of these species that are so significant to both the Galapagos ecosystems and also to a global audience for their conservation messages. The cooperation between organisations working to conserve the future of the Galapagos giant tortoises is the greatest way to continue the legacy of George. It is only by working together to improve our knowledge of tortoise ecology, genetics, captive breeding and habitat restoration that any meaningful long-term conservation strategies can be put in place. Simultaneously, it is equally important to communicate to as wide an audience as possible, educating students both in Galapagos and internationally about the plight of these incredible animals and the wider conservation messages of Galapagos.



Worries of retaining sufficient genetic information breeding from such a small founder population were highlighted by Milinkovitch *et al.* in 2004 arising from unequal reproductive success of the initial breeders. A more recent analysis has shown that breeding *in situ* is successful and the establishment of several captive breeding groups in which individuals could be circulated would create a better degree of genetic diversity (Milinkovitch *et al.* 2013). This reintroduction programme is one of the best global examples of saving a critically endangered population and has provided a unique example for genetic studies and molecular analysis of captive populations. The lessons from this island will be invaluable for the future repopulation of Galapagos Islands such as Pinta and Floreana and also for other reintroduction programmes around the world.

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