Short Communication

The St Lucia whiptail lizard *Cnemidophorus vanzoi*: a conservation dilemma?

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Abstract Uncertainties in species definitions can have important consequences for biodiversity conservation because taxonomic rank is used as a criterion to assess the conservation priorities of threatened organisms. The Vulnerable St Lucia whiptail lizard *Cnemidophorus vanzoi*, considered a single species, is the sole representative of its genus in the Caribbean region, found on Maria Major and Maria Minor islands off the coast of St Lucia. However, a recent study revealed significant morphological and phylogenetic differences between the two populations and recommended they should be managed as two separate entities. We surveyed the two populations and estimated them to comprise 1,985 and 29 individuals on Maria Major and Minor, respectively. The Maria Minor population is currently at a critically low level and consequently highly susceptible to demographic and genetic stochasticity and catastrophic events, in particular the colonization of invasive mammalian predators. If our goal is to conserve biodiversity and evolutionary potential we face a dilemma in formulating the optimum strategy for the management of these two threatened populations on the species boundary. We discuss some potential management options but also raise this issue for discussion in the conservation biology community.

Keywords Caribbean, *Cnemidophorus vanzoi*, cryptic species, distance sampling, islands, speciation, St Lucia whiptail lizard, translocation.

The prioritizing of species for conservation management relies on species definitions and lists, which conservation biologists tend to perceive as accurate measures of biodiversity. Uncertainties in species definitions can therefore have negative impacts on biodiversity conservation because taxonomic rank is an important criterion in assessing the conservation priority of an endangered organism (Goldstein *et al*., 2000). When cryptic evolutionary partitions are discovered in threatened species these findings are heralded as a positive step in the conservation process (Karl & Bowen, 1999). Taxonomic uncertainty is, however, a consequence of evolution and the very nature of a classification into units called species defies the dynamic nature of evolutionary processes. For species management to be more efficient, therefore, the difference between units for taxonomy and units for species conservation should be recognized and their definitions decoupled (Mace, 2004).

The St Lucia whiptail lizard *Cnemidophorus vanzoi* (Baskin & Williams, 1966), considered a single species, was until recently found only on two neighbouring small islets, the Maria Islands, *c*. 1 km off the south-east coast of St Lucia (Fig. 1; Dickinson & Fa, 2000). The 10.6 ha Maria Major is heavily vegetated with dry scrub woodland and large stands of cacti. The adjacent Maria Minor (1.6 ha) consists largely of open grassland with an area of scrub woodland of <0.5 ha. Both islands are uninhabited and were designated as a nature reserve in 1982. The whiptail lizard is the sole representative of its genus in the Caribbean (Swartz & Henderson, 1991) and is categorized as Vulnerable on the IUCN Red List (IUCN, 2006). In 1995, 42 animals were translocated from Maria Major to another St Lucia islet, Praslin Island, to found a third population and thus increase the species' distribution (Dickinson & Fa, 2000). The 1.1 ha Praslin Island, which had been recently cleared of rats *Rattus rattus* (Johnston *et al*., 1994), is thought not to have supported the species in recent times. By 1998 the population had grown to *c*. 155 (Dickinson & Fa, 2000). Following the release, mean effective population size

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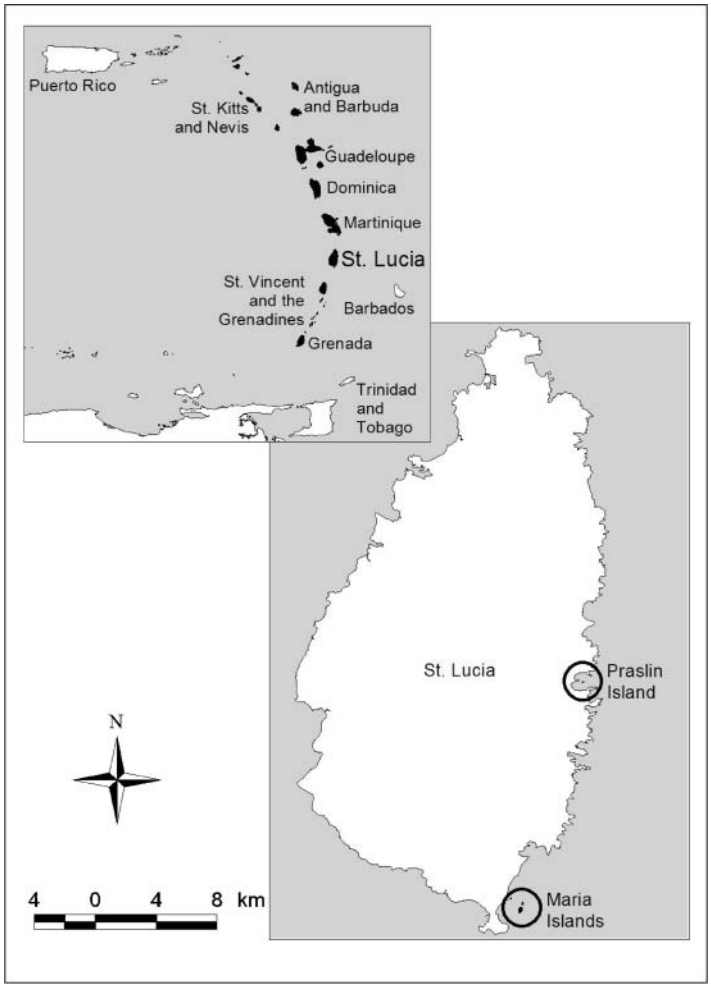

Fig. 1 The location of St. Lucia within the West Indies island group (top map) and the islands containing whiptail lizard populations examined in this study (bottom map).

estimated using molecular genetic approaches increased by two- and 10-fold, respectively, after 2.5 and 7 years (Funk *et al*., in press). The translocation of lizards on Praslin Island was therefore considered successful (Dickinson & Fa, 2000). Only three, or possibly four, more of the St Lucia offshore islets are considered suitable translocation sites for whiptail lizards (M. Morton, pers. comm.), of which two have recently been restored through the eradication of rats in readiness for future translocations.

Morphological measurements and genetic analysis have shown there are significant differences between the Maria Major and Minor populations, and long historical isolation appears to have led to the differential accumulation of mutations in both, although the exact time of divergence is impossible to estimate (Funk & Fa, 2006). Additionally, there are significant differences in body size and general form between the two populations. According to the phylogenetic species concept and Moritz's Evolutionary Significant Unit criteria (Moritz, 1994) the two lizard populations can be considered separate entities. However, these two concepts tend to *a priori* identify separate entities in situations where only two isolated and small populations of one species exist (Funk & Fa, 2006). An alternative approach is Crandall *et al*.'s (2000) broader categorization of population distinctiveness, based on ecological and genetic exchangeability. Although it remains unclear whether the observed morphological differences are inheritable, ecological and genetic data indicate that the populations are on differing evolutionary trajectories.

Here we report estimates of abundance of the whiptail lizard populations from recent surveys to evaluate their conservation status and devise a strategy for conservation management. Abundance on each island was estimated by line transect surveys using distance sampling (Buckland *et al*., 2001) during January-February 2005. On Maria Major and Minor randomly positioned grids of 20 and 11 parallel line transects, respectively, were established across the islands. The survey design on Praslin Island was identical to that used by Dickinson & Fa (2000). Line transects were surveyed for whiptail lizards and

perpendicular distances, between the transect (marked with twine) and the position of lizards when first encountered, were measured. Density was estimated using *Distance 4.0* (Thomas *et al*., 2003). All suitable models recommended by Buckland *et al*. (2001) were considered and for each the detection probability histogram and goodness of fit test statistics were examined. On the basis of the lowest Akaike's Information Criterion value, the uniform key function model, with one cosine adjustment term, was chosen to fit the detection functions for Maria Major and Praslin, and the hazard rate model for Maria Minor.

From 1998 to 2005 the density of the Praslin Island population increased from 140.9 to 304.9 lizards ha^{-1} (Table 1). The Maria Major population was at a lower density than Praslin in 2005 but because of the island's larger size was the most numerous of the three populations. The Maria Minor population had the lowest estimated density and population. We assume that the marked difference in habitat between Maria Minor and Major is the cause of the large disparity in density. The mainly open grassland of Maria Minor probably has a much lower carrying capacity for whiptail lizards than the dry scrub woodland and cactus vegetation of Maria Major. We have no evidence that any historical anthropogenic effects have resulted in habitat changes on Maria Minor and therefore we consider it probable that the size of this population has always been small. Nevertheless, this population is currently at a critically low level and would be defined as Critically Endangered as it is estimated to be <50 mature individuals (IUCN, 2001). This small population size makes it highly susceptible to demographic and genetic stochasticity and catastrophic events such as hurricanes or fire. However, colonization by invasive mammals from St Lucia may represent the greatest risk to the long-term survival of both the Maria Minor and Major populations. Boats regularly visit Maria Major, and have facilitated the colonization of islands by *Rattus* spp. in other regions (Thorsen *et al*., 2000). Rats can cross relatively large stretches of open sea (Russell *et al*., 2005) and therefore could swim the 100 m stretch of water between Maria Major and Minor.

Table 1 Number of observations, and density and population estimates of whiptail lizards on Maria Major, Minor and Praslin islands in 2005.

Island	Number of observations	Density (lizards ha^{-1})	Population (95% confidence interval)
Maria Major	104	194.6	1,985 (1,449–2,719)
Maria Minor	105	18.1	29 (16–52)
Praslin	105	304.9	335 (249–452)

If our goal is to maximize the probability of the long-term persistence of these restricted range small populations, further management of the whiptail lizards should be considered. Permanent poison bait stations would reduce the risk of successful colonization by rats and therefore should be implemented and maintained on the Maria Islands. However, rats invading islands have been shown to persist for long periods despite intensive efforts to eliminate them (e.g. Russell *et al*., 2005). Translocation of a number of whiptail individuals from each population to the newly restored rat-free islands to found new populations would greatly reduce the risk of these two forms being extirpated. This is most pressing for the Maria Minor form, which is of a higher conservation priority because of its very small population size. However there are a number of potential issues associated with such an intervention.

Firstly, although genetic differentiation between the two island forms at microsatellite loci strongly indicates Evolutionary Significant Units, differences in body size do not necessarily demonstrate ecological non-exchangeability. Ideally, evidence for a heritable basis of these differences in morphological traits is ideally required to assess the relative strength of evidence for population and species status and to decide on management strategies (Crandall *et al*., 2000). Pending evidence for heritability of morphological traits, management options would be the treatment as distinct species or as a single population (cases 2 & 8 in Crandall *et al*., 2002, respectively). The experimental measurement of heritability would inform management decisions, but the Maria Minor population could go extinct before this could be achieved. To not forfeit the evolutionary potential of the two distinct populations, the individuals of the Maria Major and Minor forms should not be mixed at this stage. Other studies have also emphasized the importance of managing populations independently, once evolutionary divergence has been verified, so that genetic homogenization can be avoided during relocation programmes (Ficetola & De Bernadi, 2005).

Secondly, because the Maria Minor population is so small removing a few individuals for translocation could have deleterious demographic and genetic effects for the source population. One solution could be to increase the growth rate of the Maria Minor population artificially before a translocation, through food provisioning, head-starting juveniles or habitat management. However, such intensive management would require significant resources. Finally, we have no data on the historical distribution or presence of the whiptail lizard on mainland St Lucia or its offshore islets other than the Maria Islands. Consequently, it is impossible to definitively identify potential translocation sites within its

former range. Furthermore, and perhaps most crucially, both populations are likely to have become genetically distinct whilst present on these small islands and may therefore fully occupy their historical ranges, excluding the translocated population on Praslin Island (Funk & Fa, 2006).

In summary, we face a dilemma that although we perceive there to be a high anthropogenic threat to the persistence of these small populations of whiptail lizards through rat invasion, there is a strong argument for non-intervention other than implementing a monitoring programme and maintaining poison bait stations. Our aim is to provide the Government of St Lucia with the best advice possible so that an effective conservation management plan for these populations can be implemented. We raise this issue for discussion in the conservation biology community and invite comments and suggestions.

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Biographical sketches

Richard Young has broad research interests in population ecology, specializing in animal abundance estimation, and currently works on a number of projects monitoring threatened species in Madagascar and the Caribbean.

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