ESSAY 5.1. SEYCHELLES AMPHIBIANS

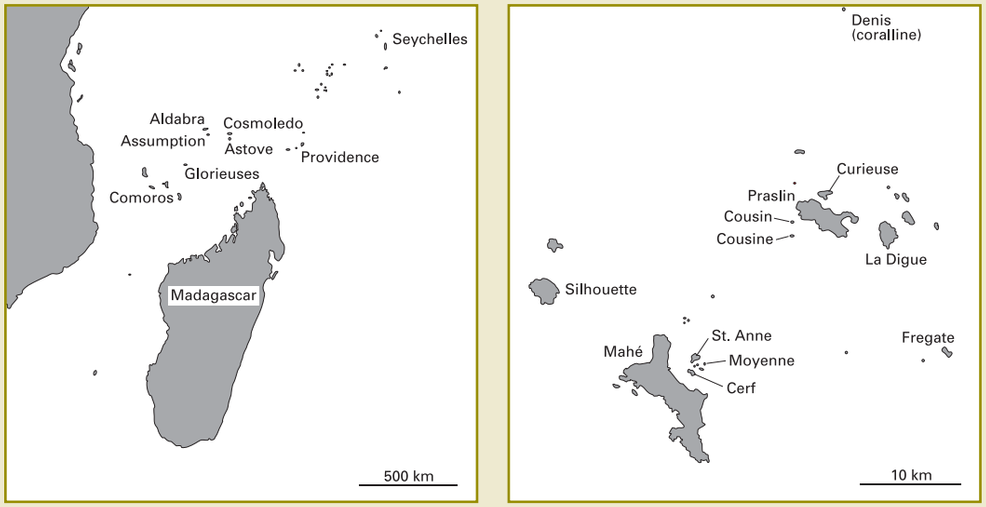

Figure 1. *Map of the Seychelles Islands.*

Due to their permeable skin few amphibians are able to tolerate dry or salty conditions, a characteristic that has prevented most species from colonising oceanic islands. The most diverse oceanic island amphibian fauna is found in the Seychelles, an archipelago of about 115 granitic and coralline islands in the Indian Ocean, some 1,600km east of mainland Africa, and northeast of the island of Madagascar (Figure 1). Eleven native amphibian species have been recorded from the Seychelles islands, comprising both recent colonists and ancient endemics. Recent colonization by one species, the Mascarene Grass Frog *Ptychadena mascariensis* (LC), is probably the result of human introduction (Vences *et al.* 2004) in the 1800s, whilst the endemic Seychelles Treefrog *Tachycnemis seychellensis* (LC) is believed to be descended from a natural colonist from Madagascar (Vences *et al.* 2003). The remaining species are all ancient endemics that have probably existed on the island since their isolation from the Indian landmass some 65 million years ago. These species comprise the endemic frog family Sooglossidae and seven species of burrowing caecilians (Order Gymnophiona).

Sooglossidae are an exceptional family in several respects. Four species are currently recognized in two genera, although recent morphological and molecular data suggests that a further three species remain to be described and that the genera need to be redefined. They are all small frogs, with Gardiner's Frog *Sooglossus gardineri* (VU) among several species up for contention as the world's smallest frog (with adults being as small as 9mm in length). All sooglossids are found in the damp forests of the two highest islands, Mahé and Silhouette. These habitats have only seasonal or fast-flowing stems, and the sooglossids have abandoned the normal frog life-cycle in favour of terrestrial development. The Seychelles Frog *Sooglossus sechellensis* (VU) lays its eggs on land and the female carries the tadpoles until they develop into frogs. *Sooglossus gardineri* is even more specialized, with the male guarding terrestrial eggs that hatch into 3-mm long froglets; the entire tadpole stage is passed within the egg. Thomasset's Seychelles Frog *Nesomantis thomasseti* (VU) has recently been discovered to have a very similar breeding strategy, but nothing is known of the reproductive behaviour of the Seychelles Palm Frog *S. pipilodryas* (VU). This latter species is the most recently described of the Seychelles amphibian species, having been discovered in 2000 (Gerlach and Willi 2002). It lives in the axils of endemic palms where it lay protected from discovery by the dense spines of the palm leaves. It is the only arboreal sooglossid, the other species all being associated with crevices in boulder fields or the leaf-litter and root-mat of the forest floor.

The caecilian fauna of the Seychelles islands comprises six species in three endemic genera. Not surprisingly, and as with caecilians in general (see Essay 1.3), these are the least well known of all Seychelles amphibians. Their burrowing habits make them difficult to locate and study. For most species, their distributions are reasonably well defined and there are some observations of breeding habits. Different species appear to show the full range of reproductive strategies, form aquatic larvae, thorough to terrestrial larvae and direct development. The limited ecological data available indicate that *Grandisonia alternans* (LC) is a widespread species occurring in all habitats and *Hypogeophis rostratus* (LC) is a similar generalist, although more associated with lowland habitats. In contrast, *Praslina cooperi* (VU) and some of the small *Grandisonia* species appear to be specialists of the high forest. Current research into this group is attempting to develop monitoring methods and to identify aspects of their ecology that are of importance to their conservation.

Half of Seychelles amphibians are threatened due to their naturally restricted ranges and deteriorating habitats (five species are categorised as Least Concern, 5 Vulnerable and one Endangered). The sooglossid frogs and the caecilian *Praslina cooperi* have particularly restricted ranges, being associated only with the damper rain-forests. Habitat deterioration is a significant threat to the caecilian *Grandisonia brevis* (EN), which has a restricted range and occurs in habitats that are suffering from ongoing invasion by alien plant species. In addition, there is some suggestion that changes in rainfall patterns may have impacts on some species, which may result from mid-year declines in rainfall restricting the activity and distribution of the rain-forest specialists (Gerlach 2000). Losses of several areas of marsh habitats have probably caused population declines in some species, such as another caecilian *Grandisonia alternans* (Gerlach 2000).

There have been a number of successful conservation programmes in Seychelles, concentrating mainly on birds. Critically Endangered species have been rescued from extinction by limited habitat management, but mostly by inter-island transfers. These programmes have been to the benefit of species such as the Seychelles Magpie-robin *Copsychus seychellarum* and the Seychelles White-eye *Zosterops modesta*. Such options are not available for the amphibians due to their close dependence on their high forest or marsh-land habitats. Consequently, preservation of their habitat is essential; most species are present in protected areas, although habitat management is still required to control the spread of invasive plant species. The island with the highest diversity of amphibians (Silhouette) is currently unprotected and designation of this island as a national park would significantly enhance amphibian conservation in Seychelles.

To date, there has been no evidence of any sudden amphibian decline in Seychelles, although the potential impact of an invasion by chytridiomycosis would be considerable. Monitoring programmes are in place for the frogs, and are being developed for the caecilians. Updates on research and conservation progress can be found at http://members.aol.com/jstgerlach/herps.htm

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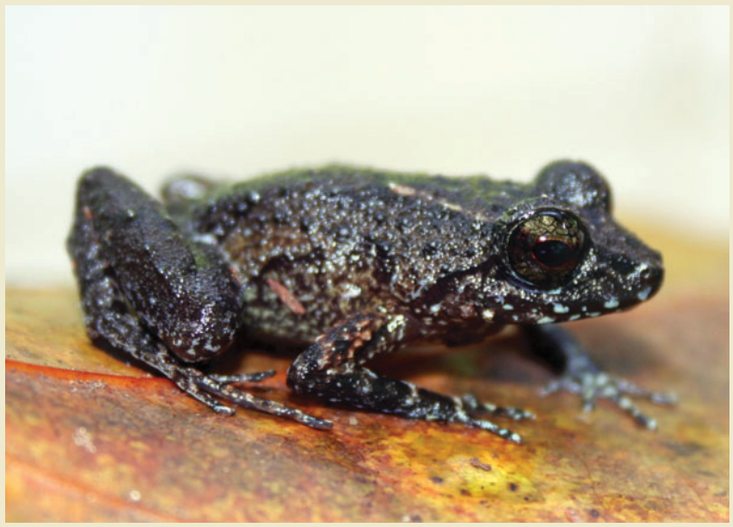

Nesomantis thomasseti *(Vulnerable) is restricted to Mahé and Silhouette Islands in the Seychelles, and has been recorded from the Morne Seychellois National Park.* © *Naomi Doak*

ESSAY 5.2. THE ENDEMIC AND THREATENED AMPHIBIANS OF MADAGASCAR

Separated from mainland Africa by a sea channel of about 300km, the biodiversity of Madagascar has experienced a distinct evolutionary trajectory that has resulted in a very high degree of endemism in both its fauna and flora. Among the vertebrates, the amphibians of this large island (around 580,000km^2, the fourth in the world for size) are currently represented by more than 230 frog species[1], a number that is still preliminary and tentative, since many more remain to be discovered or are awaiting description (see Essay 1.1) (Figure 1).

Remarkably, out of the entire amphibian fauna, only two species, the adaptable and widely distributed *Ptychadena mascareniensis*, which is present also in mainland Africa, and *Hoplobatrachus tigerinus*, introduced to Madagascar from southern Asia, are not considered to be endemic. Interestingly, recent molecular studies have shown that the *P. mascareniensis* populations from Madagascar are already sufficiently differentiated from those from mainland Africa, and likely represent a different species (Vences *et al.* 2003, 2004).

Malagasy amphibians are represented by four families of frogs (Gymnophiones and Urodeles being absent): Mantellidae, Microhylidae, Hyperoliidae, and Ranidae[2], with ranids being represented only by the aforementioned non-endemic *Ptychadena mascareniensis* and *Hoplobatrachus tigerinus* (Glaw and Vences 1994). Mantellidae is the most speciose group and is endemic to Madagascar and the Comoro Islands. This family includes the highly diverse genus *Mantidactylus* (with nearly 90 species), the well-known genus *Mantella*

(15 species), *Boophis* (53 species), *Aglyptodactylus* (3 species), and the monospecific genus *Laliostoma*. At the time of writing, *Mantidactylus* has been split into several genera (Glaw and Vences 2006), which differ significantly in aspects of morphology, life history and distribution: *Wakea, Blommersia, Guibemantis, Spinomantis, Gephyromantis, Boehmantis,* and *Mantidactylus*. As a general trait, *Mantidactylus* (sensu lato) and the closely related *Mantella* show peculiar reproductive features, such as the absence of amplexus and of nuptial pads in males, with eggs laid outside water, and the presence (in most species) of femoral glands, which are glandular structures on the inside of the thighs, and related to reproductive behaviour. They also exhibit a variety of life history traits, with species adapted to terrestrial, aquatic, and arboreal habitats (Andreone and Luiselli 2003). The diurnal *Mantella* species are characterized mainly by their bright aposematic colouration, small size, and accumulations of alkaloids in the skin. The *Mantella* species are, therefore, toxic, and are apparently rarely predated upon by other species, a situation similar in many respects to that of the Neotropical dendrobatid frogs (Clark *et al.* 2005).

In contrast to these frogs, amphibians in the genus *Boophis* are mainly arboreal species, breed in water, and have a typical larval development. Egg-laying usually occurs in streams, except for some species that reproduce in lentic waters (Aprea *et al.* 2004; Glaw and Vences 2006). Two further genera, *Aglyptodactylus* and *Laliostoma,* are mainly terrestrial and breed in temporary ponds, often breeding explosively during which time they form large aggregations. The genus *Aglyptodactylus* is also peculiar in having the males that assume a somehow bright yellow colouration during the breeding season (Glaw and Vences 1994, 2006).

Microhylidae are represented by 10 genera and more than 50 species with a diverse life history. The cophyline microhylids (belonging to the genera *Cophyla, Platypelis, Anodonthyla, Plethodontohyla, Madecassophryne, Rhombophryne,* and *Stumpffia*) are closely tied to rainforest habitats and have a reproduction that is characterized by the presence of parental care (for example, both the parents, or at least one of them, remain with the tadpoles during their development) and non-feeding tadpoles (Andreone *et al.* 2004). The genera *Dyscophus, Paradoxophyla,* and *Scaphiophryne* are different in this habitat preference, living mainly in open areas, but sometimes in arid and sub-arid conditions (Andreone *et al.* 2006a). Most of them are mainly terrestrial, although some species, such as *S. gottlebei* are partly rupicolous and able to climb vertical walls within the narrow canyons of the Isalo Massif (Andreone *et al.* 2005a). In particular, *Scaphiophryne* species have tadpoles that are largely filter feeding, with some peculiar specializations (see Mercurio and Andreone 2005).

The Malagasy Hyperoliidae includes the single endemic genus *Heterixalus* comprising eleven species, which inhabit grasslands and forest edges. They are quite similar in habitat preferences and general behaviour to other hyperoliids from mainland Africa (Glaw and Vences 1994).

Nine species of Malagasy frogs have been categorized as Critically Endangered according to the IUCN Red List Categories and Criteria, namely: *Mantella aurantiaca, M. cowani, M. expectata, M. milotympanum, M. viridis, Scaphiophryne gottlebei, Mantidactylus pauliani, Boophis williamsi,* and *Stumpffia helenae* (Andreone *et al.* 2005b). A further 21 species were classed as Endangered and 25 as Vulnerable. In general, the main threat affecting the local amphibian fauna is the high rate of forest loss (just less than 1% per annum; Harper *et al.* 2007) (Figure 2). The different life history traits of the amphibians are consequently mirrored by their differential ecological sensitivity and conservation needs (Andreone and Luiselli 2003). In fact, most of the Malagasy frogs inhabit the eastern rainforest, an ecosystem that allowed the rapid diversification of some groups, such as *Boophis, Mantidactylus* (sensu lato), and cophyline microhylids. The original eastern rainforest block is now severely fragmented due to deforestation, and this fragmentation has often resulted in high levels of threats among the native amphibian fauna (Figure 3). However, in some cases this loss in amphibian species richness is not immediately evident, because species have differing sensitivities to habitat alterations (Andreone *et al.* 2005b).

In addition to the threat of habitat loss, some species (e.g. those belonging to *Mantella, Scaphiophryne,* and *Dyscophus*) have been highly sought after for the international pet trade due to their biological peculiarities and remarkable colouration (Raxworthy and Nussbaum 2001; Andreone *et al.* 2006b; Mattioli *et al.* 2006). There is still a paucity of reliable data on the impact of trade on wild populations, although in some cases it is evident that collecting represents a confounding threat when the habitat is already compromised and the populations are small. This is the case, for example, for the rare harlequin mantella, *Mantella cowani,* which was collected in high numbers and survived in a very degraded environment on the high plateau of Madagascar (Andreone and Randrianarina 2003; Chiari *et al.* 2005). Fortunately, the collecting and exportation of this species, classified as Critically Endangered, are now banned, a measure that should reinforce its protection (Andreone *et al.* 2006b). Due to concerns about overharvesting for commercial trade, all frogs in the genus *Mantella* as well as the species *Scaphiophryne gottlebei* are now included on CITES Appendix II. Other species are also of conservation concern, such as the Tomato Frog, *Dyscophus antongili,* the only native species included on CITES Appendix I. Although its distribution area is wider than formerly believed (Andreone *et al.* 2006b), the habitat degradation around the town of Maroantsetra, where most known populations occur, is high. There is also evidence that the populations have apparently declined in numbers, and the species appears to have vanished from sites at which it was formerly known to occur (Chiari *et al.* 2006).

Fortunately, field surveys conducted during the last 15 years have revealed no known extinctions of Malagasy amphibians resulting from habitat loss, disease or other agents (Andreone *et al.* 2005b), as has been reported elsewhere. On the other hand, 12 highly threatened species now have their last remaining populations confined to a single site (Ricketts *et al.* 2005), and several of these sites, such as the Ankaratra Massif and Fierenana, remain unprotected. In general, the two areas with the majority of threatened species are the northern Tsaratanana-Marojejy-Masoala highlands and the southeastern Anosy Mountains (Andreone *et al.* 2005b).

Following the remarkable declaration by Malagasy president Marc Ravalomanana to triple the existing coverage of the island's protected areas network (see Figure 2), amphibians are now beginning to be considered in the identification of globally important sites for conservation (see Essay 11.3). This is all the more important since, as already noted, several highly threatened species experience no protection whatsoever. For example, of the nine Critically Endangered amphibians, six are not recorded from any protected area (Andreone *et al.* 2005b, 2006b). Amphibians also represent an excellent candidate to become a symbol for the conservation strategies in Madagascar. Indeed, it is clear that, as with lemurs, the frogs of Madagascar have the potential to become an important tool for the conservation of wildlife in Madagascar. This aspect, as well as long-term conservation planning, was the focus of a workshop (*A Conservation Strategy for the Amphibians of Madagascar*) held in Antananarivo in September 2006 specifically dedicated to the amphibians of Madagascar, and attended by more than 80 scientists and conservation practitioners.

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1 Although only some 226 species are currently classified through the Global Amphibian Assessment, several new species were recently described, including *Paradoxaphyla tiarano* from Masoalo Forest in north-eastern Madagascar (Andreone *et al.* 2006a).

2 The Ranidae were disaggregated into several families by Frost *et al.* (2006). In Madagascar, *Pthychadena* is ascribed to Ptychadenidae and *Hoplobatrachus* to Dicroglossidae. Thus, the number of families becomes five.

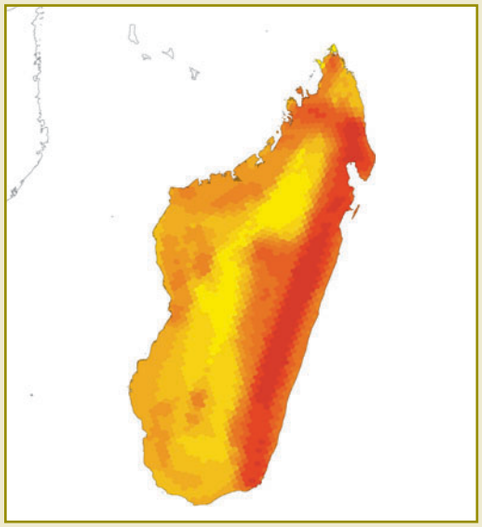

Figure 1. *Richness map of amphibian species in Madagascar, with dark red colours corresponding to areas of higher richness. Colour scale based on 10 quantile classes. Maximum richness equals 91 species.*

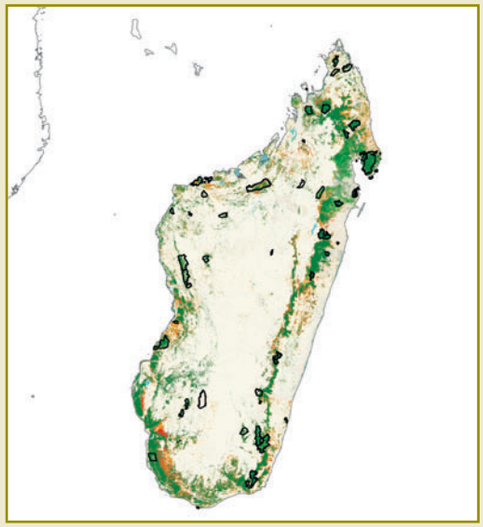

Figure 2. *Forest cover map for Madagascar, and existing protected areas in black. Red corresponds to forest clearance between 1990 and 2000, brown to clearance between 1975 and 1990, and green to forest cover in 2000.*

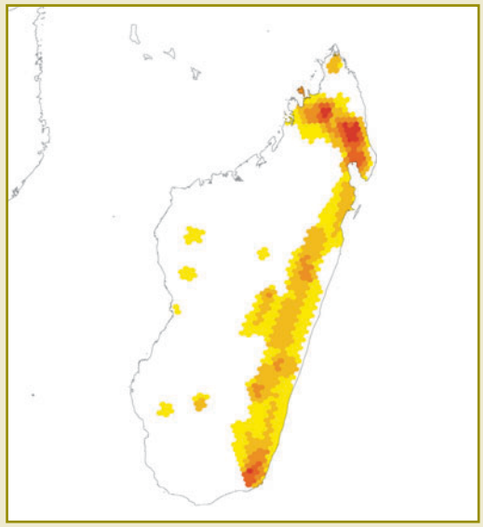

Figure 3. *Richness map of threatened amphibian species in Madagascar, with dark red colours corresponding to areas of higher richness. Colour scale based on five quantile classes. Maximum richness equals nine species.*