18

The Future

A puff adder, *Bitis arietans*, crossing a road in South Africa. My fellow travelers could not understand why I didn't want to kill it.
Photo by Bill Magnusson.

What does the future hold for snakes and other lizards? We are modifying the landscape, polluting the waters, and even changing the climate. What will this mean for the Squamata, which is the collective name that scientists give to lizards and snakes? The effects of some changes are obvious. Virtually no vertebrates live in a field of soy beans. Species that eat fish will starve in the streams that now carry only herbicides and pesticides. This human blitzkrieg will probably leave only the bacteria and fungi that are small enough and breed fast enough to stay ahead of the chemical weapons. However, many of the less productive areas for agriculture hopefully will continue to supply the ecosystem services that support large organisms, such as insects, woody plants and us.

The Squamata stands out from other vertebrate groups in the ability of many of its species to use solar energy or to operate in shaded areas where productivity is too low to support profligate energy users, such as mammals and the dinosaurs we call birds. Will this give them an edge in landscapes dominated by humans? They have some things going for them, but other aspects of their biology may make them vulnerable.

Efficient energy use means that individuals and populations do not need large areas to meet their needs. Species that are small enough to avoid predation by domestic dogs and cats can live in urban areas. In fact, the high densities of larger carnivores that people keep as pets may reduce the number of lizard predators, such as small mammals and birds. We know very little about this process. Go to a party, ask who is a bird twitcher, and you will probably get two or three affirmative replies. Ask what species of birds or medium-sized mammals live around your neighbors' houses and you will be given long and largely accurate lists. However, if you ask what lizards and snakes live in the area you will be told only about a few venomous species, many of which the person has never seen. Every school should have a poster with local lizards and

snakes so that each generation will know about the wonderful creatures in their midst, and perhaps also what they are losing.

Photo 18.1 *A* Coeranoscincus frontalis *in the Licuala State Forest, in Queenlsand, Australia. Fossorial species, such as this spectacular skink, could go extinct without anybody noticing. Photo by Bill Magnusson.*

Being cryptic is a double-edged sword. When your main enemy seeks you out and kills you individually, it pays to know how to hide. Snakes are masters at this. I remember leaping out of a car in South Africa because I saw a puff adder[198] crossing the road, and some of the other passengers thought it strange that I wanted to photograph it rather than kill it. This is understandable in a country where vipers are one of the major causes of accidental death. It is hard to be attracted to a species that has killed one of your loved ones. The Gaboon viper is much more spectacular, but it is the cryptic puff adder[199] that kills the most people in Africa. The fact that it hides so well explains both why it is so feared and why it remains common despite unrelenting persecution.

People often clear all leaf litter and vegetation from around their homes to avoid snake bite and, in many areas, that is a sensible strategy. This probably has little effect on the total number of snakes, but may not be so good for other animals. Despite almost universal, and often illogical, hatred, snakes are rarely endangered by direct persecution. Most species can hide well from humans, and it is the species whose habitats are being destroyed that are the most vulnerable. However, as they are so difficult to see and count, we don't realize that they are disappearing until it is too late. Lizards are generally better tolerated, but most people just take them for granted and would not realize if several types of lizard disappeared from their backyards.

In 2014, I photographed a spectacular legless skink in the Licuala State Forest in Australia. I couldn't identify it and Ceinwen Edwards sent the photo to Keith McDonald, who identified it as a *Coeranoscincus frontalis* and said that it had never been recorded there before. If it could persist in a heavily-used, almost urban, park for so long without anybody noticing, would anybody know if it went extinct? The many species that live under ground or in leaf litter could be gone for years before anyone realizes it. It is for this reason that I said that being cryptic is a double-edged sword. Conservation is directed at the obvious charismatic species, which are usually mammals or birds. We only value what we can see, and most people have to be trained to see lizards and snakes. You can't teach old dogs new tricks. If we don't start in the schools, nobody in the next generation will be interested in the Squamates.

The problems I have related in the previous paragraphs probably apply to many biological groups. However, in 2010, Barry Sinervo and 25 coauthors

published a paper in Science that suggested that lizards are especially sensitive to climate changes due to their need to thermoregulate behaviorally[200]. That paper, and several others, suggested that tropical lizards were probably more sensitive to climate change than species further from the equator. I was initially skeptical, because the trends reported in the 2010 paper indicated that many of the lizards in Reserva Ducke, especially the shade-loving species, should already have gone extinct, or at least had their densities drastically reduced, something that I was sure hadn't happened. I thought that the models had to include other factors and, although I did not know it at the time, so did Barry Sinervo.

Photo 18.2 *Guarino Colli and Santos Balbino look on as Barry Sinervo has a difference of opinion about the best postion with a Brazilian member of the team. Photo by Cec ília Rodrigues Vieira.*

In 2014, Emerson Pontes asked me to co-supervise his Masters thesis with Fernanda Werneck. He was from Manaus and would work in a large project run

by Barry Sinervo to investigate the susceptibility of Amazonian lizards to climate change. Emerson concentrated on my favorite species, the forest whiptail, which he studied at three sites deep in the Amazon and one site near the interface between the Amazon forest and the dry savanna areas to the south.

I was unsure of the effects that a simple raising of the temperature by a few degrees would have on the forest whiptails. Air temperature is important for species that live in the shade, and if the temperature rises above their tolerance levels, they have only limited means to cool down, because most places in the shade equilibrate with air temperature. However, forest whiptails are more limited by low temperatures than high temperatures, because direct sunlight rarely reaches the forest floor and mean air temperatures are unlikely to approach their maximum activity temperatures, which our studies had shown are up to 40 ℃.

Emerson carried out a series of experiments at each locality, measuring the effect of temperature on the lizards' ability to run, and their ability to function at high and low temperatures. He also measured the temperatures that the lizards selected in thermal gradients in the laboratory, which was the most common way to determine lizard preferred temperatures that had been reported in the literature.

The experiments revealed many interesting things about the lizards. The first was that their preferred temperature in the laboratory was lower than the temperatures they sought in the wild. With hindsight, that makes sense. Several researchers had said that there is no one preferred temperature for an individual. What the animal prefers depends on what it is doing. They may have different preferred temperatures for foraging, digesting food, sex, resting, when hiding from enemies and other activities. Emerson therefore used field-active temperatures rather than results of laboratory-gradient analyses in his models.

I met Barry Sinervo and Don Miles at a conference in Gramado in the South of Brazil in 2015. That was perhaps a good place to think about the effects of

temperature because it got cold at night and we discussed lizard thermoregulation over glasses of wine at one of the town's famous fondue restaurants. The models that Barry and Don were using had advanced considerably since 2010 and included the effects of climate change on the habitat that the lizards needed. Forest whiptails need forest, independent of their ability to thermoregulate, so the models that Emerson would use included information on the likely distribution of forest under the climate-change scenarios.

Photo 18.3 *Emerson Pontes conducted experiments to see whether Amazonian lizards will be sensitive to climate change. Photo by Emma van Baalen.*

Emerson's experiments had also revealed another aspect that still hasn't been included in the models: the ability of the species to evolve under the new selective pressures. Unsurprisingly, the behavioral and physiological characteristics of the lizards varied among localities, but what we hadn't expected was that the greatest variation among individuals occurred in the

places with the least-extreme temperature regimes. That is, there was plenty of intra-individual variation that natural selection could act upon, even in the places with apparently the most stable temperature regimes[201]. What will this mean in terms of survival of the species in different places in the face of climate change? We will probably have to wait and see.

The combined physiological and species-distribution models indicated that the distribution of forest whiptails is likely to be more restricted in the future than it is now, but that it is unlikely that the species will go extinct globally. What about other Amazonian lizards and snakes? Fortunately, most Amazonian lizards have very wide distributions, which we know from the maps produced by Teresa Cristina Avila-Pires[202].

Future genetic studies may reveal a few more species, but the overall pattern is unlikely to change. Rafael de Fraga, the famous Rato, has looked at genetic variation in snakes over more than 700 km between Manaus and Porto Velho. The effects of distance and geographical barriers are minimal, so most species are capable of dispersing over large distances. We will keep a wary eye on the Amazonian lizards and snakes, but at the moment it appears that they will be less susceptible to the effects of climate change than species in other regions, as long as forest clearing and the unrestricted use of fire do not combine to take away the landscapes on which they depend.