13

Wrong Again

It is easy to see which savanna plants are important for herbivorous lizards, such as this *Iguana iguana*, but much harder to determine which plants provide the energy for insectivorous species. Photo by Bill Magnusson.

When we examined the diet of the lizards, I was surprised to find many seeds in their stomachs, some of which even germinated when we sowed them on Petri dishes[158]. The lizards didn't eat the fruits incidentally. We would often watch rainbow lizards waiting under a murici[159] tree. When a fruit fell, the lizards rushed over to be the first to grab it. However, the rainbow lizards rarely swallowed the seed. They just nibbled off the soft pulp and left the seed nearby. In contrast, the giant ameivas swallowed the murici seeds whole and probably carried them long distances before they had passed through the digestive tract. The striped whiptails also dispersed the seeds of wild manioc[160], but we are unsure why. They did not appear to eat the pulp of the fruit, which is quite big in relation to the size of the lizard's head. Rather, they seemed to be picking up the dry seeds from the ground and the only explanation we could think of was that the seeds had patterns on them that made them look like beetles.

None of the lizards we studied ate green vegetation, though the large iguanas we occasionally saw in the area ate the leaves of many plants. We saw another species of rainbow lizard[161] eating leaves on an island in the Los Frailes Arquipelago in the Caribbean. It was the same size as the rainbow lizards at Alter do Chão, but was bright yellow with no blue on its head. The lizards left bite marks on the leaves of the seaside plants, which looked as though someone had taken to them with pinking shears. This raised many questions in our minds as to why the closely related species in the Amazon did not eat leaves. Is it because there are no competitors for leaves on the island, because the leaves there are more nutritious, because there are fewer insect prey on the island, because the lack of predators on the island allowed the lizards to subsist on a diet that made them less agile, or something else? We continue to ponder those questions, but have not come up with a convincing answer.

The paper on what the lizards ate led us into a series of studies that moved us from basic natural history into what would be called ecosystem ecology. Examining the stomach contents of the lizards I had collected led us to believe that the difference between the diets of adult and juvenile lizards was mainly due to the size of the prey, and not the type of insects they ate. There were some differences in the diets of the large and small lizards within the same species, but these were much less than the differences between lizards of the same size but different species[162].

Photo 13.1 *Savanna lizards at Alter do Chão, such as this* Kentropyx striatus, *sometimes eat fruits, but most of their dietary energy comes from insects. Photo by Bill Magnusson.*

We had not expected that, because our studies of frogs had shown greater differences in the type of prey taken between different size classes within the same species than there were between the same size frogs of different species[163]. We probably would have concluded that the lizards were very different from the frogs if we hadn't become interested in the relationship between the population dynamics of the lizards and fire.

Savannas everywhere in the World are subject to regular fires, and the area around Alter do Chão is no exception. Many studies had shown that the proportion of the area covered by grasses and sedges increases with the frequency of fire, and that the area will eventually be covered by bushes and trees if you exclude fires. At first, we just studied the direct effects of fire on the lizards, but burning the area appeared to have little effect on the density of lizards[164]. This is perhaps to be expected, because the savanna lizards are restricted to areas that burn frequently, and therefore must have evolved efficient methods to avoid negative effects of fire, whether from direct mortality or from loss of cover and food.

The importance of fire altering the proportions of grassland and shrubland was only brought home to me by chance meetings in the INPA corridors with Reynaldo Victoria and Luiz Martinelli, who everyone just calls Zebu. They worked with Albertina's ex-husband, Bruce Forsberg, in a big project investigating energy fluxes associated with the Amazon River. Bruce was interested in where the fish got their energy; whether it was from algae, floating grass mats on the river, or from flooded forest.

You couldn't see the fish feeding in the murky water and in any case you didn't know whether the animals they fed on got their energy from one sort of plant or another. However, Reinaldo and Zebu knew how to follow the carbon that was fixed by the plants through the food chain to the fish. They studied stable isotopes, which are forms of carbon and other elements that have

different molecular weights, but do not decay with time like the isotopes of Uranium that are used to generate atomic energy.

Photo 13.2 *Fires are frequent in the savannas of Alter do Chão and they alter the structure of the vegetation by favoring grasses over bushes and trees. Photo by Bill Magnusson.*

The proportion of the two forms of carbon is just about the same everywhere in the atmosphere at any given time, but different types of plants absorb different quantities when they undertake photosynthesis, which means that you can tell who originally fixed the carbon that is in the tissues of an animal by determining the proportions of the different isotopes. So-called C4 plants, which include most tropical grasses, have more of the heavy isotope and C3 plants, which includes bushes and trees, have less. Reinaldo and Zebu worked for the Center for Nuclear Energy in Agriculture (CENA) and had access to the sophisticated equipment necessary to do the analyses.

I realized that if they could distinguish the isotope signals from floating grasses and flooded forest they would be able to do the same with savanna grasses and savanna shrubs. We first confirmed that by analyzing the isotopic signatures of many species of plants in the savanna[165], and used the information to estimate how much energy the lizards got from the grasses and how much they got from the shrubs and trees[166].

That was when we realized just how wrong we had been about the similarity between the diets of juveniles and adults. It was true that they basically ate the same types of prey, mainly herbivorous insects, but the insects the juveniles ate had mainly been feeding on grass, and the insects that comprised most of the diet of adults fed mostly on bushes or trees. That is, the juveniles and adults were not even on the same food chains!

This made us realize just how different the ecology of lizards and most other ectotherms was from the ecology of birds and mammals. Many people had studied the relationships among species of mammals and birds and concluded that they avoided interspecific competition by eating different foods. Similar stories had been told about lizards, but we now realized how unrealistic they were. You don't have to worry much about the size or age of a bird or mammal if you are studying food chains. The babies eat different food than the adults, but that is provided by their parents until they are large enough to eat the same things that all the other members of the same species are eating. Baby lizards and snakes look after themselves and are free to eat things that their parents can't catch.

Photo 13.3 *Trees and shrubs grow amongst grasses in the savanna, but they fix carbon differently. Small lizards tend to eat insects that feed on grasses, while larger lizards catch insects that feed mainly on trees and shrubs. Photo by Bill Magnusson.*

Most frogs hatch as tadpoles, which are mainly vegetarian and dependent on food chains originating from algae in ponds. The adults eat insects and other small animals that get their energy from food chains starting with terrestrial plants. That they are on different food chains is obvious. Small frogs still eat different types of prey than their parents after they metamorphose, but we always assumed that those prey came from the same food chains as the prey of adults. Now we were no longer so sure. The small lizards ate similar types of prey to those of the adults, but were not dependent on the same primary producers. That is, they were not only different ecological species from the adults, they were from different ecosystems. This reduces the potential for competition and simplifies things for the lizards. However, the complex relationships, which change continually as the animal grows, make it much harder for lizard ecologists to tell simple just-so stories about competition like those told about birds and mammals.