Chapter 13

JERRY'S MAGGOT

For those of us who dwell in large cities, direct interactions with other species may be limited to encounters with dogs and cats (and even then we tend to treat them as conspecifics) and occasional battles with cockroaches. Modern urban life has pushed us to a distant final link in a disrupted ecosystem. We live our lives far removed from the food chains that support us, sitting atop a trophic pyramid we never really become a part of.

Our limited interactions with other species force on us a form of ecological myopia. The message of interconnectedness has never penetrated deeply into our society, and even those of us who accept it intellectually may fail to appreciate how complicated some of these relationships are. College biology texts often gloss over interspecific interactions, offering simplified discussions of predation, competition, mutualism, and little else. But there are still places and occasions when an urban North American can step back into a food chain and experience firsthand the ecological relationships between himself and other species. Our friend Jerry Coyne had such an experience on his first visit to the tropical forests of Central America.

Jerry is a biologist. At the time, he was a graduate student at Harvard's Museum of Comparative Zoology. Well versed in evolutionary logic, genetical theory, Ivy League ecology, and the use of biometrical tools, he was also aware that his actual experience with living creatures was "limited to unexciting fruit flies crawling feebly around food-filled glass tubes." Working in the Museum of Comparative Zoology had done little to change that. The Museum was no longer what it had been in the days of its founder, the celebrated Swiss naturalist Louis Agassiz, whose constant exhortation to "study Nature, not books" was practiced by all. Jerry's biological interactions continued to be with fruit flies in a crowded, sterile lab, and the only animals he saw, aside from his fellow graduate students and the ubiquitous dogs of Cambridge, were the stuffed mammals that resided in the display cases between his office and the Pepsi machine. Finally, after a winter and spring of listening to some of us urge him to get out of the lab, he enrolled in a field course in tropical ecology. Soon he was jetting to Costa Rica, determined to experience for himself the riches of tropical nature.

Jerry's introduction to the tropics was a revelation. It not only confirmed his misgivings about his previous training but changed his entire approach to his science. No longer would he trust "the naive and simple generalizations about nature produced by so-called theoretical ecologists," as he put it, and no longer would he search for slick hypotheses while glossing over the rich natural historical details of life. But he came away with more than these intellectual revelations.

A few weeks before Jerry was due to return to the Museum, his head began to itch. This was hardly remarkable. Skin fungus, chigger and mosquito bites, and a wealth of other pruriginous rot are the lot of field biologists in the lowland tropics, as he and his fellow students were by then well aware. Their field station was next to a large marsh, and hordes of mosquitoes descended on them as they listened to lectures after dinner. At first, Jerry assumed that the itch on his scalp was a mosquito bite, as indeed it was. But unlike the usual mosquito bite, this one did not subside. It grew larger, forming a small mound, and besides scratching Jerry began to worry. After several days of private fretting Jerry sought help. One of his fellow students, a medical entomologist, agreed to examine the wound. Her diagnosis sent a chill of fear through poor Jerry. Poking out of a tiny hole in his scalp was a wiggling insect spiracle. A hideous little botfly maggot was living inside the skin on his head and eating his flesh! This intimacy with nature was a little too much for Jerry, and he ran around in circles crying for the removal of the maggot.

Unfortunately, removal of a botfly maggot is no simple task. This botfly *(Dermatobia hominis)* has existed as an unwanted guest in the skins of mammals and birds for countless generations. Its larvae have evolved two anal hooks that hold them firmly in their meaty burrow. If you pull gently on the larva, these hooks dig in deeper and bind it tightly to your flesh. If you pull harder, the maggot will eventually burst, leaving part of its body inside the host, which can lead to an infection far more dangerous to the host than the original bot. Botfly larvae secrete an antibiotic into their burrow, a tactic that prevents competing bacteria and fungi from tainting their food. A single bot in a non-vital organ thus poses little danger to an adult human, aside from mild physical discomfort and possible psychological trauma.

Occasionally a bot sets up residence in a particularly tender or private patch of flesh that cries out for immediate removal. In Costa Rica the locals used to use a plant called *matatorsalo* (bot-killer) to kill the embedded larva. The acrid white sap of this milkweed kills the larva, but the task of removing the corpse remains. The most appropriate course of action then is a deft slice of a sterile scalpel. But surgeons are few and scattered in most tropical forests, and under these conditions many unwilling botfly hosts choose the meat cure.

This treatment, which is far from perfect, takes advantage of the biology of the botfly larva. The maggots are air-breathers and must maintain contact with the air through their respiratory spiracle, a snorkel-like tube that they poke through the host’s skin. If you sandwich a piece of soft, raw meat over this air-hole tightly enough the larva must eventually leave its hole and burrow up through the meat in search of fresh air. When this happens, both meat and botfly are discarded. One of the students in Jerry’s course afflicted with a bot in the buttock did this successfully. But the dense mat of hair that was Jerry’s pride and joy would have to be shaved off in order for this to work, and toiling in the sweaty tropical heat with a patch of raw meat strapped atop his head was not something he relished. Faced with such a choice, Jerry decided to live and let live for the time being, and to seek professional help when he returned to Harvard.

After his initial bout of hysterical revulsion, Jerry learned to accept his guest. It was relatively painless most of the time. Only when the larva twisted would it cause sharp twinges of pain. Swimming made the larva squirm; presumably a reaction to having its air supply cut off temporarily, and Jerry felt this as a grating against his skull. These inconveniences were not enough to blind him to the wonder of it all. The bot was taking Jerry's "own body substance" and rendering it into more botfly flesh. This transmogrification of one creature into another is a miracle easily observed, but difficult to experience. Sudden death at the jaws of a large carnivore or the brief bite of a flea do not provide one the opportunity to reflect on the transmutative nature of predation and parasitism. But for the minor expense of a few milligrams of flesh Jerry could both contemplate and feel the process at his leisure. He was inside a food chain, rather than at its end. Jerry grew fond of his bot and the bot grew fat on Jerry.

When Jerry returned to New England, his bot had produced a goose egg—sized swelling on his head. It hurt more and he immediately sought medical advice at the Harvard Health Services *clinic.* Although he was quickly surrounded by a crowd of physicians and nurses, none of them had seen a botfly before and they regarded Jerry more as a medical curiosity than a suffering patient. Chagrined, he abandoned thoughts of a medical solution and decided to let nature take its course. Despite the discomfort, the bot continued to provide some pleasure. Jerry took great delight in the looks of horror he could produce by telling acquaintances of his guest as he dramatically brushed aside his hair.

While sitting in the bleachers at Fenway Park one evening watching the Red Sox fall prey to the Yankees, Jerry felt the beginning of the end. Protruding from the goose egg atop his scalp was a quarter inch of botfly larva. Over the course of the evening this protrusion grew, and eventually the bristly, inch-long larva fell free. Jerry prepared a glass jar with sterilized sand to act as a nursery for his pupating bot, but despite his tender ministrations the larva dried out and died before it could encase itself in a pupal sheath.

The saga of Jerry's maggot began long before Jerry came along. It started with an egg, or more precisely, with a means of getting an egg onto a suitable host. Botflies should be stealthy in order to parasitize dexterous, perceptive animals like birds, monkeys, and humans. But adult botflies are large, day-flying creatures that are easy to see and hear and easy to avoid. Botfly species that parasitize rodents glue their eggs to the root hairs of plants that stick out along the sides of rodent burrows. When a rodent walks by, its body heat causes the eggs to hatch; the larvae wriggle onto the animal's fur, and thence into its flesh.

Dermatobia solves the problem of egg placement with a remarkable adaptation. An egg-laden female captures a female mosquito, glues her fertile eggs onto the mosquito and then releases her. The smaller, sneakier, night-flying mosquito is well suited for feeding on a dexterous and perceptive animal like a human. When the mosquito begins her meal, the body heat of the host triggers the hatching of the botfly egg, and the tiny larva falls off its carrier and burrows into the human or animal host. It is hard to imagine a more surreptitious strategy than this oviposition by proxy—an adaptation that evolutionary biologists could never anticipate.

The intermediate evolutionary steps that led to such egg-laying behavior are baffling. Indeed, it is a good example of the type of "perfection" of sophisticated adaptations that troubled Darwin in the *Origin of Species*. If we assume that the ancestral condition of the botfly was to deposit its eggs directly on the host, or even on grass or leaves, the number of steps between this and the oviposition via mosquito is difficult to contemplate. It is not enough to grab any small fly, because this would be wasteful. The botfly must be able to discriminate between suitable vectors and unsuitable ones, and this discrimination must be sophisticated because *Dermatobia* usually uses mosquitoes of the genus *Psorophora* as egg carriers. The recognition cue may be simple; but even if this is the case, the transitional stages to evolve the mechanism would not be apparent.

You might wonder why this sort of oviposition by proxy is confined to the lowland tropics and has not evolved in or spread to the northern temperate zone. Boreal and alpine habitats are unrivaled for the voracity of their mosquitoes. Our most vivid memories of clouds of bloodthirsty mosquitoes and biting flies come not from the tropics (although we have spent many hellish evenings in clouds of mosquitoes in mangrove swamps), but from pastoral New England wood and idyllic rocky Mountain meadows. Perhaps the issue pivots around the dexterity of their mammalian prey. In boreal areas, dexterous animals like monkeys, kinkajous, and coatimundis do not exist. Except for humans and raccoons, most of the larger mammals in North America are rather clumsy, at least in the sense of manual dexterity. Moose, deer, bear, coyotes, and their ilk do not manipulate their food and they keep all four feet on the ground most of the time. Northern biting flies thus exhibit no subtlety in their approach because no hand or paw will rise to crush them.

Temperate zone mosquitoes whine a direct, noisy approach, and their landing and bite are easily detected. But consider a typical rain forest mosquito. She rarely lands on you if you are moving, and you hear her only in the quiet of night after conversation has ended and you are drifting off to sleep. Her landing is soft, even tentative, and if you move she flies of and bides her time. Her bite is gentle when it comes, a delicate touch that is rarely felt. She is careful; she is sneaky.

Of course, both temperate latitudes and the tropics support many mosquitoes, and some species don't fit these generalizations. But it seems to us that the general stealthiness of tropical mosquitoes owes something to having evolved in concert with dexterous mammalian hosts. And this stealthiness provides an plausible explanation why *Dermatobia hominis* is a tropical creature. In the northern temperate zone where most warm meals walk on all fours, a botfly doesn't have to rely on cumbersome reproductive adaptations. With little persistence, it can void swishing tails and eventually home in on its target to lay its eggs. There is no advantage in seeking out a mosquito to do this work, and botflies and warble flies in North American lay their eggs directly onto their hosts.

The interaction between *Dermatobia hominis* and its host is complicated in terms of the mechanics of oviposition, but the ecological relationship between Jerry and his bot was quite straightforward. The bot gained and Jerry lost. This was parasitism, and it fits easily into the classification scheme of interspecific interactions that can be found in most textbooks. The char below is typical of such classifications, where the effect of one species on another is given a sign indicating positive (+), negative (-), or neutral (0) associations:

Species A	Species B	
+	-	parasitism or predation
+	0	commensalism
+	+	mutualism

Parasitism and predation are both pretty clear; the predator or parasite gains and the prey or host obviously loses. Equally clear are those situations where both species gain, as in mutualistic interactions. A good example would be the trees and fungal mycorrhizae discussed in Chapter 2. Commensalistic interactions, in which one species gains without having any effect on the other, are perhaps less obvious, although algae growing on a tree trunk might be one example. But this simple scheme, like most such schemes in nature, has its shortcomings. Things are not always so simple, especially in the tropics, where the vast number of species can lead to complex interactions. There the lines distinguishing parasitism from mutualism and commensalism can twist and turn with byzantine complexity, and the nature of these relationships can become hazy indeed.

One of the best examples of the complexity of ecological interactions in the tropics and the hazy intergradations linking parasitism with mutualism also happens to involve botflies. Another type of parasite plays a major role in this particular web of interactions, although this other parasite does not actually enter the body of its host.