In Praise of Looking

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I LEARNED THE EXTRAORDINARY VALUE OF PERSONALLY OBSERVING INSECTS, OF CONTINUOUS WATCHING, AND EVEN OF IMAGINING MYSELF AS THE CREATURE OF INTEREST.

Early in my career, I was encouraged to read papers on ways to obtain information about insect behavior "objectively." There were any number of gadgets to record movement and feeding of different insects, as well as experimental designs that provided information *after* the event, from which data were analyzed and graphs were produced about groups or individuals. The development was part of a broader commitment in biology to rigorously avoid bias and anthropomorphism, and we all can agree that this is important. However, in my life's work as an entomologist, I learned the extraordinary value of personally observing insects, of continuous watching, and even of imagining myself as the creature of interest.

Apart from the information I gleaned from watching, which was infinitely more useful than "come back and see" data, I have found pleasure in the process of seeing the array of behaviors in an animal and recording them. If there is a pause in behavior, it is a time to think about what I see, and indeed, contemplate the scene and develop ideas and hypotheses about what the behaviors mean in both the immediate situation and in an ecological or evolutionary context. At such deliberative times, I have had most of my creative ideas in research. On the other hand, if there is a lot of behavioral activity to record, the time goes by quickly; attentiveness is stretched to the limit, and data are logged on a computer or notebook. At such times, the results may not be understood until later, when analyses may lead to great excitement.

I think of watching predation of different caterpillar species while in the field in California. Long days and weeks of continuous observation were the only way to discover the many tricks prey species use to avoid death, as well as all of the intricate behaviors that affected the chance of death. Most importantly, feeding activity caused predation to increase by up to 100 times, relative to resting. How strong, then, must be the selective pressure to feed quickly! There must be selection on mouthpart structures to speed ingestion and enhancement of sensory input from foods to minimize distractions.

Over many years of watching foraging behavior of whiteflies, aphids, grasshoppers, and caterpillars, a pattern emerged: the species or genotypes with narrow host ranges made fast decisions and fed with few pauses, whereas generalists were much more tentative and spent more time at dinner being less vigilant. In addition, generalists within any particular insect group are relatively more vulnerable to predation than the specialist. Is that why host range tends to be narrow in plant-feeding insects? It became a hypothesis for which subsequent experiments provided support.

Working on the spotted stalk borer, *Chilo partellus* (Swinhoe), in India, I spent many dawn hours lying out in the fields watching caterpillars climbing the stems of sorghum plants before scuttling down into the whorl, where, out of sight, they killed the plant by eating its growing point. I spent those hours watching, observing, thinking: what would I do if I were that tiny insect? It was the only way I could have discovered that on susceptible cultivars, as the tiny creature climbed, it automatically crawled up the undersurface of a sorghum leaf. Eventually, it would reach a leaf edge and then turn back toward the stem to continue its climb to the top of the plant, which it needed to reach. By watching the caterpillars on different plants and subsequently on precisely made artificial model plants (complete with leaf waxes), I found that the wax chemistry on particular leaf shapes determined the necessary turn. On nonhosts or resistant varieties, the wax chemistry gave the caterpillars the wrong message, and instead of the all-important turn, they ambled along to the leaf tip and "floated away" to their certain demise. The chemistry of the leaf waxes could be altered in the development of sorghum resistant to *C. partellus*; with the developing knowledge of genes involved in wax synthesis, changes can now be made. We would never have known what to do without a lot of careful looking.

There were endless new findings from

continuous observation of *Zonocerus variegatus* (L.) (Orthoptera: Pyrgomorphidae) grasshoppers in Nigeria, where we worked on them in relation to their pest status on cassava crops. For one thing, individuals jumped off a cassava plant if they bit into turgid leaves, but they fed with abandon if the leaves were wilted. This led to a study of what changed in the leaves, and it turned out that repellent HCN was released when turgid leaves were chewed, but not when wilted leaves were chewed. This finding led to the study of the grasshoppers' gregarious nature: a dozen grasshoppers taking exploratory bites on a couple of leaves could cause wilting, thus enabling them all to feed. This work involved all-day observations, and it turned out that around midday, when most researchers were inside to avoid the tropical heat, female grasshoppers came together in hundreds to lay eggs, assisted by the secretion of an aggregation pheromone. This led to very large groups of females all laying eggs in a small area. We found just one such group per hectare. There were two consequences. First, in the following season, tens of thousands of baby grasshoppers hatched at the same time and place, ensuring that there was group feeding. Second, the discovery was the means of controlling population size, because farmers had only to discover the huge groups of females once; then, at leisure during the off season, they could dig up the buried egg masses, exposing them to desiccation and death.

Observations in controlled lab conditions are needed to test hypotheses, but watching individuals in the field has a special appeal—how many wonderful days I have spent in beautiful places where real lives are lived, birds or cicadas sing, butterflies flutter and soar, sun shines, and breezes caress. I feel so lucky to have had a life for which I was paid to do so much in interesting or enchanting places. Such pleasures may even enhance the ideas circulating in my brain, given that it is now established that such pleasurable experiences profoundly influence our well-being.

I began looking at insects early in my childhood, watching butterflies and beetles in my parents' tropical Queensland garden and becoming ever more fascinated by their activities. Although I had a few youthful bohemian years, I have spent a large part of my life watching insects and nature generally. My new book, *Six Legs Walking: Notes from an Entomological Life* (Raised Voice Press), tells stories of my life with insects, including my life of watching them.

Over the years, many students and postdocs worked in my lab, and most of them became captivated by the vast amount of information that observation gave them—information that enhanced understanding of host plant selection by insects, of specific pest behaviors and their natural enemies, of foraging patterns by generalist herbivores, and of evolutionary processes in plant–herbivore interactions. For many of their projects, continuous observation led to new ideas that required acquiring other skills, such as chemistry, neurobiology, genetics, and molecular biology. For my students and postdocs who went into other fields or left science altogether, they have taken with them an intimate appreciation for insects that comes with time spent looking.

In spite of my passion for observation, and all that I have learned with a contemplative approach to entomology, I realize it is not for everyone. It is not so appealing for fast thinkers; e.g., brains that race ahead or have ADHD. Rather, a contemplative approach is suited to slower thinkers who mull things over and reflect on things: Darwin and Einstein come to mind, both of whom described themselves as slow thinkers. In any case, because the behavior of animals defines so much about them, those of us who love to watch will always be rewarded.

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