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AFFIRMATIVE ACTION FOR INSECTS IN TROPICAL NATIONAL PARKS

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The conservation of a tropical wildland into perpetuity demands that it offer a product to its neighbors and other users. This product must be offered with a minimal loss of biodiversity in the conserved wildland. All uses involve some interference and impact on individual organisms and ecosystems under examination, study, manipulation etc; this is the tax that conserved wildlands must pay for their existence, just as the rugs in a library wear out and some borrowed books never return. In general: a) the larger the population of the focal organism, b) the faster its replacement rate, c) the wilder its swings in density in the natural circumstance, and d) the less bothered it is by the presence of a large mammal, the more likely is the human population to be able to make use of it without interfering with its conservation, either in isolation or in its interactions with other organisms. Insects (and other invertebrates) rank much higher on this scale of potential use than do vertebrates. That is to say, the conservation problems generated by human-insect interactions in a user-friendly national park are potentially much less than are those generated by interactions between humans and other vertebrates.

Tropical national parks have had their historical roots primarily in their forests, big woolly mammals, and birds. Insects have long received short shrift; it's time that they get their dues. Tropical conservationists have always had insects in the backs of their minds; insects are those little creatures that get conserved along with the Brazil nuts and the tigers. But explicit conservation efforts for insects are almost non-existent except when some gaudy butterfly gets on an endangered species list. Yes, I know that insects often get honorary mention in the plans, but when it gets down to the nuts and bolts of tropical conservation, who ever gave a half a million dollars to save the Alexander beetle?

What is an entomological emphasis in a national park? It is affirmative action for the conservation and non-destructive use of invertebrates, along with the other organisms and habitats. This action takes the form, in a large part, of fine-tuning to the biological needs of insects and to the peculiarities of getting to know and use insects. These needs and peculiarities have generally

escaped the traditional tropical national park. Taking insects into account implies a broadening and even modification of the way the park is viewed.

Size of the Park (and Related Considerations)

Humans have better instincts and data for the amount of area needed to support vertebrate populations than they do for invertebrate populations. Since almost all individual insects are thought of as needing much less resource than even the smallest vertebrate, it is implicit in contemporary park design that an area big enough to maintain the vertebrates will automatically pick up the invertebrates. Equally, it is implicit that an insect population contains so many individuals that it is always much further from extinction than is a vertebrate population. While there is much truth to these two generalizations, there are many important exceptions:

1. Entire populations of invertebrates often move seasonally from one area to another - wasps, bees, dragonflies butterflies, moths, beetles, flies, etc.. This makes them appear analogous to birds in needing either a very large area or at least two areas, but insect migration distances, routes and targets are often not the same as are those of the birds from the same source area, and therefore are not automatically covered by considerations of bird, bat or megafaunal migration. Worse, one group of insect species may migrate 2 km north of a park to a seasonal refugium, another group may migrate 10 km downward to leave an inimical season behind, and a third group may move 100 km east - and even do it to escape a different season. That is to say, among the tens of thousands of species of insects in a tropical national park, there are many more kinds of movement patterns and seasons than among the vertebrates. Park planning that takes these movements into account is a severe challenge, and park size may have to be large not so much to allow the persistence of a large population as to include the several habitats that large population uses in the course of a year. It is like planning for migratory waterfowl with one single chain of parks from Canada to Mexico, but simultaneously doing it for other life forms migrating in other directions.

2. Easily 50% of the species of insects in a tropical habitat can be herbivores. Owing to the extreme dependency of many herbivorous insects on particular species of plants, what may well matter is not whether the area is large but whether it contains appropriate individuals of particular species of plants. Very large areas of undisturbed habitat may be nothing more than

wastelands to a monophagous moth species - even if the adult moth can be captured throughout the habitat.

3. The more generalist insects are often thought of as being able to, like deer and coyotes, range over a variety of habitats for their resources. However, many insects have complex life cycles, demanding one very special habitat for one portion of the cycle (e.g. a particular nesting site for a bee or wasp) even if another portion of the life cycle can range far and wide in a very generalist manner.

4. Tropical insects often fluctuate wildly in density between and among years. They are noticed when common ('ah, see, they are so common that we need not worry about them being in danger of extinction'), but simply forgotten about in a bad year ('ah, insects always fluctuate in abundance'). However, the question is whether the park is large or complex enough to sustain the population in its "bad years." A three year run of dry years may easily eliminate the springs that are needed to keep an aquatic insect population alive in the park during the dry season. A smaller park designed such that it includes some ever-running springs may be much better than a much larger park with many springs that are, however, susceptible to regional drought. For vertebrates, a spring, a river or a stock watering tank may be nothing more than a drink of water, while to an aquatic insect they are three vastly different habitats.

5. Even a very small area may well be large enough to maintain a healthy population of a given species of insect, provided that its host plants and other needs are present. Even peninsulas in park margins and very linear parks may be of value in this context, despite that they have lost many of their vertebrate populations. A monophagous insect may persist in a habitat despite very severe reduction in the species richness of other organisms, if its host plant is hanging on. These considerations are especially critical in restoration of ecosystems. hHabitat fragments may contain many of their original invertebrate populations; these population fragments that can later expand into more 'normal' populations if the habitat is given back.

6. It is commonplace to note that a small park carved out of a large habitat gradually "decays" through the loss of species and changes in relationships between species. However, such an insular fragment of habitat will eventually come into some kind of equilibrium, just as naturally small habitats have their equilibrium faunas. If the focus is just on the vertebrates and the large plants, such a shrinking jewel may seem far too damaged to be worth saving. However, from the invertebrate standpoint, it still may be very species-rich and quite worth bothering with. A

damaged 15th century cathedral is better than none at all; from the viewpoint of the vertebrate conservationist, the cathedral may be a pile of rubble, while from the entomological viewpoint, it may still be standing and even serving a community function. Equally, a park that is too small to maintain significant vertebrate populations may well be worth saving just for its invertebrate and small plant populations; this concept has long been in place in extra-tropical habitats, but is conspicuously lacking as a major rational for tropical national parks and preserves.

Biocultural Restoration

In today's tropics, humanity is very rapidly extinguishing its remnant rich knowledge of the natural world. A national park offers a major opportunity to re-enrich the cultural heritage of a tropical farming region. Such a view places a major emphasis on demonstration of intellectually and emotionally interesting aspects of the park. This means intellectual and physical contact with organisms. Plants sit quietly feeding and breathing during most of the year. Big woolly mammals are often hard to find and get close to (and once you have seen one lion and zebra, you have seen them all). Birds are often no more than feathered sounds that flee from any group of people greater than one. That leaves us with the lowly caterpillar, the hunting beetle and the soaring butterflies. And the moths at the lights at night, the bees on the flowers, and the columns of army ants. And the dung beetles with their dungy cakes. The list of coming attractions is almost endless.

Insects are not just decorations on the great green natural cake. Sex aggression, competition, mutualism, hunting, fleeing, allurement, deception, parasitism and all those other very human traits can be very easily examined with insects. A pair of copulating beetles is a very convenient device to begin a discussion with park visitors of why there is sex in the first place, and those beetles often stay put for all to see. There are a multitude of very human traits, traits that badly need understanding by their human practioners, that can be most instructively examined by seeing them first in other organisms. And insects certainly can be cooperative about performing right in front of the visitor's nose. On the other hand, because they are insects, the visitor may need more guidance than with mammals or other vertebrates so as to be able to begin to interpret what is being seen. Is a hovering bee waiting for females, searching for a nest site, waiting for you to remove your foot from its nest entrance, or deciding to attack? It may take a gentle prod to get past 8 or 30 years of fear of caterpillars.

What does a tropical national park offer its neighbors? It offers, among other things, a chance to regain an understanding of the world that comes from a much more diverse teacher than are a school and set of neighbors/parents. And when the visitor walks into the green library of a tropical forest, it is the insects that are the books most easily opened. Why are leaves shaped like they are? Tough question. Why are butterfly wings shaped like they are? Much easier. Why do the big cats hunt where they hunt? Just try following one some time. Why do army ants hunt where they hunt? Much easier.

The diversity of the easily observable insect world is vastly greater than is that of other groups. All that is required is that we take some affirmative action towards its display, and devote the same kinds of time to learning its natural history that has long been bestowed on vertebrates and plants. A few things come immediately to mind:

a. Big crawlly caterpillars are almost begging to be passed around among small school children. A large net over a host treelet, with a gravid female saturniid moth tossed in on occasion, can guarantee a nearly year-round supply of large caterpillars for public discussion, photographs and destruction of aversion to insects.

b. The visitor to a national park often is frustrated by seeing hardly more than a brilliant blue or yellow dot sailing far overhead, or flitting off through the shady understory. This is the place to recognize the museum-display component of a national park. A visitor center with a large collection, for example, of the butterflies likely to be seen on nature trails is highly appropriate. But not just a display - a micro-discourse on their biology as well is appropriate. Mimicry, flash colors, crypsis, etc., are all well and good to be seen in the field, but there is nothing like an accompanying static (and colorful) display to orient the visitor.

c. We need affirmative action to think small. Many visitors bumble along looking for the monkey or parrot in distant tree crowns, but are not offered the suggestion that if you look through your binoculars backwards, they make excellent magnifying glasses. Searching the foliage for trailside insects may result in moving only 100 m in a morning, but what was the hurry anyway?

d. Field guides to the birds and mammals have long been in hand, but somehow field guides to the conspicuous insects have been very slow to appear in Neotropics. While taxonomic incompleteness may be a legitimate excuse for the lack of field guides to many groups of tropical insects, for others such as

butterflies and moths, there is no scientific excuse for their absence.

A New Role for Taxonomists

Taxonomic knowledge of tropical plants and vertebrates is now to the point where the taxonomist can say, for many parks, well, if tropical parks want their field guides, all they have to do is take their photographs and tie them up with taxonomic literature. That is a job for writers, for teachers. Things have not progressed to this stage with insects, and are not likely to in the near future. There are not more than 5 new species of birds to be described from Costa Rica; there are at least 50,000 undescribed species of insects in Costa Rica.

The world of insect taxonomy has evolved from general collecting and species descriptions to today's strong emphasis on generic and familial revisions coupled with development of theory that is of use to such revisions. While it is evident that generic and high-level revisions are necessary and will eventually appear for all groups, they are expensive in time and resources. We do not have a century to revise the 610 species of a genus of parasitic wasp ranging from Canada to Paraguay before offering a reliable taxonomic literature for the 52 species of this genus that occur in a single Panamanian national park. The work-management, education, basic biology - done with these 52 species will be a solid brick in the park edifice, the edifice that will have to withstand the continuous social pressure to turn the park into the production of more directly edible materials. That is to say, an insect taxonomist's focused contribution to the field guide library of the park now will be a significant component of whether those 52 species exist as anything other than museum specimens when the revision is finished a century later.

This affirmative action for an entomological national park requires far more than a simple personal decision by a taxonomist to take a half a year out of the revisionary work flow to produce a field guide for a select park. It requires that the social and administrative structure that supports that taxonomist accept such an action as a legitimate and rewardable activity. The ledger should be clear. If it takes ten years to do a serious revision of the 1100 members of a Neotropical moth subfamily, an additional year spent along the way to produce a field guide to the 30-70 species of moths of that subfamily in each of five geographically distinct entomological national parks is clearly a good conservation investment. There is even a conservation spinoff. The insect fauna of a given neotropical national park has much in common with faunas of other neotropical national parks. That is to

say, a field guide for one national park's 28 species of dung beetles, for example, will apply to perhaps 20 species of dung beetles even tens of degrees of latitude away. Furthermore, experience with regional field guides to birds suggests that the presence of an incomplete field guide (because it was done for a different area) is a strong incentive for the production of a complete guide written specifically for the park in question.

It should be clear that we have now entered, once again, into an area where the entomologist cannot do the task alone. Maximally efficient use of the taxonomist's expertise is attained by a writer or other park-oriented person teaming up with the taxonomist and providing the perspective, the budget, the illustrations and the leg-work to generate park-specific field guides and reference collections.

Insects Are Glue

As people set up to preserve the vertebrates and the plants, there is a strong tendency to simply forget the trophic and social roles played by the insects, or to feel that insects occur in such large numbers that we need not worry about them. After all, there always seem to be enough *Trigona* bees to eat your lunch, so what's the problem, anyway?

When a biologist notes that there are many species of migrant moths that fly in and out of a tropical national park, if there is any reaction at all, it is to ask if their loss would mean a serious reduction in available pollinators. The answer is certainly yes, but that is a very incomplete answer. The migrant moths are often very abundant during their 1-2 generations in the park; many of their larvae are a major part of the food for vertebrate and invertebrate predators. This is not the place to treat this in detail, but many of these insect species are not interchangeable; because of their species-level traits, or because of the portion of the habitat in which they live, a kilo of sphingid moth caterpillars does not equal a kilo of noctuid moth caterpillars. The same applies to bees. Yes, bees visit flowers, but certainly not all flowers. Social bees, largely pollen and nectar robbers, are no substitute for solitary bees. The loss of a few hectares of nesting habitat for a group of solitary bees may result in no pollinations for many square kilometers of plants.

Planning in relation to aquatic systems in tropical national parks always ignores the insects. Insectivorous game fish are introduced without a thought. Rivers are often chosen as park boundaries, thereby almost guaranteeing that no aquatic fauna will be preserved as the agrochemical application by the park's neighbors moves into full swing. Parks established to protect

rivers and drainage basins often forget that even the smallest feeder streams must be included. While sprayplane over flights of national parks are greeted with cries of outrage, little or no thought is given to surface runoff into the feeder streams that later deliver to the park.

Economic Value

The mass of insects in a national park are, quite simply, the biotic gene and species bank that supports those few species that will eventually turn out to be critical to the sophisticated agriculture that will be coming down the road. The insects support the invertebrate carnivores - parasitoids, viruses, bacteria, predators - that will be major tools in the game of biotic pest controls. The wildland insect population may also even be the agroecosystem designer's only chance to locate genomes not yet resistant to pesticides, carnivores and climate modification.

Today the tropics often seems nothing more than a 1940's throwback, complete with DDT, pesticide blooms on the produce, and sprayplane pilots with their bare arms glistening with spray. But it is fast changing - economics and better health education are demanding it. And with genetic engineering of better crop plants bustling down the road, the parks will be evermore small islands of the natural world dotted over a very artificial landscape. This already is a landscape of intense agriculture and intensive investment. As the yield goes up and the investment goes up, so also rises the impact of an insect outbreak. It's all well and good to get the tropical act together to produce multi-million dollar rice crops in Costa Rica, but it's a multi-million dollar loss when a new strain of rice borer goes to work on it.

The parks are going to be the libraries to which that high-tech, fine-tuned agricultural system turns when it is searching for the next wave of genetic engineering materials. And the insects will be among the most used books. A moth fauna of 3000 species is 3000 little packages of multi-specific genomes capable of detoxifying about as many kinds of plant defenses; that's what caterpillars are.

Administration

Affirmative action for the insect conservation in a tropical national park does introduce some administrative peculiarities. Perhaps the most outstanding is generated by the fact that insect taxonomy is far, far behind that of vertebrates and plants. This means that we are still in the days where simple collecting is mandatory. Worse, many insects are small enough that they must be collected in large numbers, and studied as such, before they can

be taxonomically well enough understood to explain and identify for the park user.

A national park can often be made legitimately off limits to the collector of vertebrates. It may be able to develop with minimal plant collecting. However, the administrative attitude towards the world of insect taxonomy must be "come and use us." Get series of our specimens into every major collection, so that we get considered in each and every regional and higher order taxonomic revision. And then bring some of specimens back to us or to national collections as identified reference material, and help to produce the first field guides. A park administration can largely ignore the services and administrative complications of close ties with a major vertebrate museum or herbarium; most of the needed taxonomic work can be done with the use of already extant field guides and some plant collecting by park personnel. However, a national park is helpless to deal with the tens of thousands of insect and other invertebrate species that it contains. A mutualism between the administration and the community of taxonomists, with all its implications, is mandatory.

Manipulative research, like taxonomic collections, is much more possible in the context of conservation biodiversity if done with insects than with vertebrates (due to our primitive understanding of the conservation needs of invertebrates, it is also much more needed). To remove the 11 resident tapirs from a valley bottom is likely to have dramatic and long-reaching impact on the very biodiversity that the park conserves; to remove (or double) all the caterpillars on ten individuals of a single individual host plant may both illuminate the relationship between the caterpillar and the host, and do no more than mimic something that occurs annually throughout the habitat. A hundred individuals of common butterfly may be removed for a starvation experiment, with no measurable or real effect on the habitat overall, whereas the removal of 100 squirrels for the same experiment may well alter the site for decades.

A consideration of the entomological nature of a national park also increases the justification for resource expenditure on other seemingly disparate activities. Rain gauges, floras, and flowering phenology may all be justified solely in their facilitation of insect studies, as well as be scientific activities in their own right. A mouse live-trapping study gives the opportunity for the study of ectoparasite population dynamics. A road or trail through unexceptional vertebrate habitat may offer exceptional opportunities in insect-watching. An anthropogenic fire, of no threat to highly mobile or subterranean vertebrates (and even producing food for them in the form of sucker shoots), may be

worth extinguishing because it consumes enormous numbers of dormant and active insects, as well as much of the food for the litter community (which may in turn have been a major food item for the armadillos on the site).

In Closing

This essay was written in the midst of the social and conservation turmoil of Costa Rica's strenuous efforts to bring its economic and conservation development into harmony. When Herbert Baker and I arrived in Costa Rica in early 1965, the abundant forest was a biological inspiration, a meat market and lumber mill to all of us. A little more than two decades later it is almost all gone except for the 20% with explicit reserve status. The challenge today is not how to set aside more parks, but how to make the parks so user-friendly that they are still here, with their biodiversity as intact as biologically possible, a century from now. Insects play a dormant but potentially great role in the answer to this challenge.

Twenty-five years ago, Herbert and Irene Baker aggressively sought out the entomology department at the University of California at Berkeley, as a source of different thinking about plants. We all profited from that. We all played in Herbert and Irene's garden, and we still do. Their botany was user-friendly. There is a lesson there.