México ante los retos de la biodiversidad

Mexico Confronts the Challenges of Biodiversity

José Sarukhán y *Rodolfo Dirzo*,
compiladores

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A CURRENT VISION OF INSECT DIVERSITY

Terry L. Erwin
The Smithsonian Institution

The landscape of this planet is composed of water and soils (and the rocks from which the soils are formed) plus the plants which occupy them. This landscape is overwhelmingly dominated by two groups of organisms: arthropods (mainly the insects) and mankind. From mankind's perspective there is a love/hate relationship with the insects and with good cause. Pollinating insects not only provide us with a great variety of interesting and tasty fruits and vegetable to eat; they also pollinate plants from which we extract fiber, hardwood timber, some oils and other liquids, and nearly half our pharmaceuticals. Insects create useable products such as silk, wax, dyes, and honey; they are the source of biocontrol agents and undoubtedly will serve as future sources of gene strands for biotechnology. They are also a primary driving force of evolution creating new kinds of plants.

On the other hand, a few insects and their close allies, the arachnomorphs, bring death and misery to millions of people around the globe every year. According to the Center for Disease Control in Atlanta, approximately 2 million people die from malaria each year. There are now 20 million cases of onchocercosis, which often results in blindness and is sometimes fatal, 250 million cases o debilitating filariases, and thousands of casualties from equine encephalitis, sleeping sickness, plague, yellow fever, and typhus —all the well-known historical insect-borne diseases—and now a new one, lyme disease, is taking its toll. Death, especially for close family and friends, is tragic, but morbidity goes beyond that into the economic fabric of the country, resulting in loss of production and, in many developing countries, severe impact on the economy. Insects also affect the economy in the agriculture and the timber industry sectors; the United States Department of Agriculture estimates this loss to be 19 to 25 billion dollars per year globally, 5.5 billion in the U.S. alone. Of course, there will be greater expenditures in the next 10 to 15 years, perhaps equal or more than that of the combined total of the last hundred years, solely on cleaning up environmental contaminants from the production and use of dangerous insecticides. Insects have had, are having, and will have a greater impact on human evolution than any other factor we face, except perhaps a nuclear winter (which thankfully is becoming more remote with time).

These are the reasons why humanity needs to be concerned with insect biodiversity. Those few of us in the basic biological sciences perhaps have additional interests and a growing contingent of conservation scientists and practioners have recently become interested for still other reasons. However, the common thread of concern and interest among all of us is the incrediblely high biodiversity exhibited by insects and their relatives.

Insect biodiversity is not only a list of species, it is also all interactions between species, between insects themselves, and among insects and those species of plants, animals, and microorganisms with which they come in contact. The sheer magnitude of insect biodiversity is what all of us in society must face. We must deal with 3 500 pest species worldwide, 600 in the U.S. and Mexico alone. Taxonomists must deal with genera that contain as many as 2 000 species and with insect families with hundreds, or even thousands, of genera; and conservationists (and society's collective

conscience) must deal with the threatened loss of perhaps millions of species, particularly in the tropics.

Just how many species has been a standing, and often heated debate for the last few years. There are surely, at a minimum, more than 1 million insect species; these have names and descriptions in the scientific literature. Although, some species have been described twice, there are easily sufficient new species already represented in museums and under study today to make up for any newly discovered synonymy. Obviously, many others await discovery in nature. Unless all of them are collected and described, we cannot know how many species make up the insect biodiversity list, something that is technically feasible although pragmatically impossible. On the other hand, I think it is clear we will never know all the species interactions, which is a far more important feature of biodiversity to human welfare.

Several scientists are now trying to develop methods of estimating species numbers based on taxonomic criteria, taxonomists' opinions, or site sampling of various sorts. Thoughts have been given to methods of scaling up such estimates globally so that we might have some perception of the world's fauna. Such endeavors are for the most part academic; they are part of the human spirit that seeks to know for knowledge sake. However, these interesting scientific exercises do not help the agriculturists who need to control boll weevils, the health care worker who combats malaria vectors, or even the conservationists who want to preserve 5 000 hectares of cloud forest in Jalisco, Costa Rica, or Peru.

Entirely feasible methods of estimating local biodiversity and its character, even for insects and their allies, could be especially useful to conservationist and park planners however. Local inventories can also be exceedingly useful to agriculturists in discovering new biocontrol agents or potential new pest species and to health care workers in knowing the local array of vectors with which they must deal.

My hypothesis that there are 30 000 000 arthropod species is still the only non-biased science-based estimate using samples from a field situation. Although, as has been pointed out, some underlying assumptions were weak, the approach was sound and, I believe, with further study, we will find this number closer to the global magnitude than what is currently described in the literature. In seeking to clarify and firm up those weak underlying assumptions in my earlier work, I have been studying the natural history of the Peruvian Amazon for the past 10 years. During this time, what I consider to be an exceendingly important feature of insect life was substantiated by my studies, namely, that insect biodiversity is directly proportional to altitude, latitude, and particularly, as suggested by MacArthur for birds and Southwood for insects, architectural complexity of the habitat. Insects and their allies occur within tropical vegetative habitats in nearly discreet faunules in well-defined microhabitats. The smaller species, which constitute the greater part of the fauna, have localized geographic amplitude. Equatorial lowland sites with diverse floras are the richest in arthropod species—the Neotropical Realm the richest of all. At higher latitudes and altitudes, more crossing-over among microhabitats occurs, thus there are fewer numbers of species in any given habitat and species have greater geographic amplitude. What do these factors mean in terms of conservation strategies and practices? They mean simply that given hard choices of selecting competing sites for preservation, biodiversity formulas based on the vast majority of biodiversity (that is insects and their allies) can be applied to assist in choosing the most diverse sites for our attention. They also mean that we are no longer dependent on using umbrella species, usually vertebrates, that we can only hope indicate maximum diversity. Now we have the methods to actually know and with comparatively little investment of resources.

Because insect biodiversity is a function of the number of microhabitats present and the relative location of the site, quick environ-

mental assessments could be made through inventories of microhabitats, or habitat architecture, rather than insect species inventories *per se*. However, this will only be possible after a baseline of data is obtained across a geographic grid at a continental scale. Such a baseline would establish the pattern of biodiversity geographically showing how and where numbers drop-off both latitudinally and altitudinally and would register habitat complexity across geographical space and season. About 100 carefully selected sites should be sufficient to understand the general pattern for the Neotropical Realm, from southernmost Texas to northernmost Argentina. Each Realm throughout the world would need careful analysis to determine appropriate baseline parameters. Using the methods now established in my laboratory, I estimate it would require about five dedicated years for several teams of three people each to collect, analyze, and synthesize the data from these 100 Neotropical sites. Such sites would then serve as reference points for future quick analysis of other potentially protectable sites within the continental grid and also serve as a weathervane for natural landscape health in general using the insects and arachnomorphs, the most sensitive members of the environment, as indicators. In the not too distant future, we will be forced to make choices between parcels of landscape that do not have their original large vertebrate faunas intact. Insects offer a criterion that will be present until the very end.

Historically, we have shied away from using insects and their relatives to any extent in environmental assessments because of the perceived need to name them using the cumbersome Zoological Code and because the number of species is high. We have also listened to very conservative entomologists and have not been encouraged to think that data on these species can be acquired and managed. These factors no longer limit or control us. An inventory data management system is already in place that takes advantage of powerful desktop computers, and since we now realize that

99% of tropical biodiversity has no great literature to track with fixed Latin names, a rapid retrieval interim taxonomy has been established for needed contemporary information. And, thanks to the Costa Ricans and Dr. Janzen, a model natural history inventory concept exists that can be adopted in developing tropical nations for vouchering biodiversity heritage.

Knowledge of biodiversity can be used to help us formulate earth-saving strategy and policy in making the hard choices we will have to make soon. I believe that, with earnest effort but relatively small expense, such factors as the INBio experience in Costa Rica and my recently developed tropical forest canopy research and laboratory techniques can offer an effective application at a meaningful scale to our environmental problems.

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