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New Types of Inventories at the Natural History Museum of Los Angeles County

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Bioinventory (the enumeration and identification of species in an area) has long been a function of museum-based researchers, and in some ways there's nothing new about sampling an area to determine what kinds of insects live there. At the Natural History Museum of Los Angeles County (LACM), however, we are trying to push the boundaries of inventory in unusual ways. Through our two programs discussed below, we hope not only to obtain interesting results, but also to set precedents that can be followed for other inventories.

Inventory of a Costa Rican Cloud Forest

Our first project is called the Zurqui All Diptera Biodiversity Inventory (ZADBI), and represents a refinement of the ATBI (All Taxa Biodiversity Inventory) concept proposed by Janzen (1997) for Guanacaste National Park in Costa Rica. The great original vision was a complete inventory, from the sea to the mountaintops, of all types of life in this park. Unfortunately, the ATBI project collapsed, partly because it was too big, too expensive, and lacked sufficient taxonomic expertise in many groups. Other inventory projects with narrower goals, often with a small subset of taxa from any one group (inventories including a few beetle families, some Hymenoptera, and perhaps a few flies), have been focused on larger areas, or try to approach the ATBI ideal over an even larger area (such as the Great Smoky Mountains National Park ATBI).

Fig. 1. Forest at the ZADBI site. (Photo by Brian V. Brown)

The sampling by these projects, although often impressive, does not solve the problems faced by systematists participating in such inventories. In particular, collaborators often receive large numbers of insects in alcohol that they must then prepare (dry, mount, and label) on their own time and using their own resources. During hectic times (i.e., throughout most careers), bags of alcohol-filled vials are often pushed aside to address more pressing issues, and are gradually forgotten about. In the worst cases, the vials dry in three or four years, the specimens are ruined, and nothing is ever published.

To address these problems, the ZADBI project was conceived with the following ideas: unlike typical inventory projects, our collecting is strictly controlled so that the majority of the material is from just two Malaise traps. Furthermore, our study site is small, only 150 x 266 m (roughly 40,000 m^2). Finally, all of the material goes out to collaborators fully prepared, labeled, and databased, so that they don't have to perform the technical tasks for which they do not often have time or money (except for a few taxonomists who requested material in alcohol).

Most importantly, our project aspires to study *all* Diptera at the site. This means that large, "impossible" groups like cecids, sciarids, ceratopogonids, tachinids, and phorids are included. Over 50 specialists worldwide have agreed to identify the material they are sent for this inventory. So far, we have 72 fly families from our site, representing a still unknown number of species but likely topping 3,000.

Restricted sampling area is a key component of our project. We have steadfastly resisted expansion of our site to neighboring properties or even the adjacent Braulio Carrillo National Park (BCNP). Instead, we collected for one year in our small 40,000 m^2 area. This site, behind the "Restaurant La Fonda" and on private property, is only 20 minutes north of San José, is continuous with the greater BCNP, and located at 1,600 m in elevation (Fig. 1).

Of course, the exclusive use of Malaise traps would miss many species of flies. For this reason, we also did extensive collecting using light traps, baited traps, and searching. Additionally, we hosted a "Diptera blitz," a week in which some 20 of our experts came to the site to collect using their specialized techniques and knowledge. This included capturing bats and birds to collect the host-specific bat flies (Streblidae) and bird louse flies (Hippoboscidae) with which they associate.

Our project would not be possible without the skills and energy of five parataxonomists who are hosted at Instituto Nacional de Biodiversidad (INBio) in Costa Rica (Fig. 2). Our dedicated local team not only collected most of the material, but prepared each family to the curatorial standards needed by each of our collaborators (e.g. pinned, slide-mounted, or in alcohol). This ensures that each collaborator can dedicate his/her time entirely to identifying the specimens at hand.

Eventually, we will have the most complete inventory of flies ever assembled for a tropical mainland site. At a time when molecular techniques and approaches dominate our field, inventories like this one are the only source of whole-organism evidence against which estimates based on "barcodes" and other DNA-based sources of evidence can be evaluated. Doubtless, our approach will not detect all species present at the site, but the predilection of dipterists to study fine details of male genitalia in their specimens makes it more likely that they will not overlook as many cryptic species as do those working on more generalized external characters. Additionally, our specialized collaborators have a broad knowledge regarding their groups and can often tie the morphological variation in their groups to ecological and behavioral features that inform us about the nature of the community we are investigating.

Inventory in the Urban Frontier

Cities are rapidly growing throughout the world, and more than half of all humans now live in an urban landscape. Thus, for an increasing portion of our population, urban wildlife is "nature." For entomologists, this provides an opportunity to better understand urban biodiversity by including insects among the taxa surveyed in urban studies (which are overwhelmingly based on vertebrates, especially birds).

As discussed above, Malaise traps are frequently used

Fig. 2. Parataxonomist Marco Moraga preparing specimens. (Photo by Anna Holden)

inventory devices in wildland insect surveys. They are biased, as are all sampling methods, towards specific groups, especially small Diptera and Hymenoptera (Brown 2005). Small flies in particular have advantages over larger insects as survey taxa, in that they presumably do not travel as far as stronger-flying Lepidoptera and Odonata (frequently surveyed in biodiversity studies); they are extremely diverse biologically (far more than the mostly herbivorous Lepidoptera and aquatic and predaceous Odonata); and they are represented by hundreds of species. They are appropriate for a finer-grained analysis of insect biodiversity (perhaps at the neighborhood scale) than larger, more mobile taxa. The limiting factor, however, is the presence of taxonomists willing to identify such challengingly small creatures. And if researchers actually are willing to identify such creatures, will there be anything of interest scientifically? Or will they be studying the equivalent of house flies, cockroaches, and rats?

This is a question for which we actually have some data. Challenged by a trustee to make good on the first author's frequent boast that he can find a new species of phorid fly anywhere, we placed a Malaise trap in her backyard in Brentwood, on the west side of Los Angeles, California. Anxious to make sure that a new species would be discovered, trapping was begun three months before the planned event in which the new species would be unveiled. Thus the first sample was poured out in April, and phorids were extracted for mounting and identification.

The first phorid mounted was a large, yellowish species of *Megaselia* Rondani, one of the most species-rich genera of all insects, whose approximate 1,500 species account for nearly half of all phorids alone. Running this first specimen through the keys to North American and European *Megaselia*, it was quickly concluded (and later corroborated by our colleague Henry Disney in England) that it represented a species new to science!

This was a remarkable result, but what else was present in the sample? The second specimen prepared had leg structures that BVB recognized from a European key, and indeed it turned out to be *Megaselia scutellaris*, previously known only from Europe and Great Britain.

Finally, a male specimen of the genus *Chonocephalus* Wandolleck was noticed in the sample. Although this was not the third specimen identified, it was unusual enough that it was sent to Disney, who is actively revising the genus. He quickly wrote back, stating that the specimen was *Chonocephalus bentcasei*, known previously only from the Seychelles and Canary Islands (i.e., both coasts of Africa). So far, the sample has yielded a scientific paper describing the new distributions, with another one describing the *Megaselia* in the planning stages. What else was in the sample, you might ask? Who knows: the first author had enough material for a

Fig. 3. One of the BioSCAN site hosts, Eric Keller, with his backyard Malaise trap. (Photo by Phyllis Sun)

Fig. 4. Urban Los Angeles Malaise trap sites. (Google Maps)

speech at the trustee's house, so no further study was completed on this sample.

The answer to this "what else" question, however, is the inspiration for our second inventory, dubbed the BIOSCAN (Biodiversity science: city and nature) project. Using Malaise traps, we intend to inventory across a swath of Los Angeles from the "natural" settings of Griffith Park in the Santa Monica Mountains to the urban core, in which the Natural History Museum of Los Angeles County (LACM) is located. Although backyard Malaise trapping is frequently done by entomologists at their own homes, the BIOSCAN project involves an ambitious 30 sites distributed among the houses of Museum employees, members, and even trustees (Fig. 3 and Fig. 4). Each site includes, besides the Malaise trap, a weather station to record variables of humidity, light, temperature, and so on. Combined with variables associated with urbanization, such as density of housing, number of people living per unit area, and the amount of green space versus hardscape, our inventory of small flies will give us an unprecedented detailed tool to evaluate the Los Angeles area and its biodiversity.

Although this project does not fit the typical mold of "citizen science," it does involve 30 households in an intimate study of their backyard fauna. From our point of view, being aware of (and even proud of) your local biodiversity is a step in the right direction towards greater nature literacy and appreciation. Furthermore, the study is not a mere exercise, as Los Angeles fly biodiversity is almost as completely unexplored as that of the Amazon rainforest. Los Angeles is a major port in the warm temperate zone and is constantly being enriched by introductions from other parts of the world, most of which are undetected unless they have a medical, agricultural, or horticultural impact. Small flies, in general, are not on anyone's radar (with the notable exceptions of mosquitoes and fruit flies) in Los Angeles.

Our long-term time (3 years) and space sampling has not gone unnoticed by our peers. Molecular biologists at the nearby University of Southern California are eagerly awaiting access to our material to start examining the molecular basis of responses to urbanization variables such as light levels. A University of California–Davis *Wolbachia* expert is also making use of our unique sampling regime.

The final unique aspect of this project is that it is funded not by the National Science Foundation, but by the museum itself. This indicates to us that the project is hitting the elusive "sweet spot" where the goals of science and the interests of the local community are integrating and meshing well.

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