Conservation Matters: Contributions from the Conservation Committee

Persistent decline in the abundance and diversity of Lepidoptera

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We have studied the ecology and conservation of some of the rarest North American butterflies, including *Neonympha mitchellii francisci* (Fig. 1), *Cyclargus thomasi bethunbakeri* (Fig. 2), *Strymon acis bartrami*, and eastern segregate of the *Speyeria idalia*. Populations of these butterflies are estimated to be in the low thousands. For three of these, their current global ranges encompass the low tens of hectares. The abundance of each species and the number of extant populations has declined precipitously from their known historical ranges and estimated abundances in the USA. Are these species exceptional outliers? Or are they indicative of many other butterflies, moths, and terrestrial insects in general?

Figure 1. *Neonympha mitchellii francisci* populations have declined to small numbers and are contained within one army installation. A key aspect of habitat loss has been loss of natural disturbance by fire and by beaver creation of wetlands. (photo credit Jenny McCarty)

Figure 2. *Cyclargus thomasi bethunbakeri* was once common throughout South Florida. It has been eliminated from the mainland and from the Florida Keys with road access by urbanization. It is now found in small populations on remote islands. (photo credit Helen Haddad)

We draw member’s attention to the findings of a large meta-analysis of animal abundances that was carried out by Dirzo and five other researchers from around the world (2014, *Science* 345:401-406) (http://science.sciencemag.org/content/345/6195/401). Their review, titled *Defaunation in the Anthropocene*, examines faunal changes of vertebrates and invertebrates globally, but emphasizes vertebrates and the upward and downward ecological cascades that follow when a keystone taxon is lost from a community or ecosystem.

We relate only their unsettling findings for invertebrates, which were based on comprehensive, decade-plus datasets on insect populations. The mean study duration was nearly 40 years. They analyzed 452 species, the largest number of which were Lepidoptera, principally from Europe and North America, but also Australia, Japan, Panama, and elsewhere.

What first drew our eye to this paper was their claim that 67% of the monitored insect population had a mean population decline of 45% over the four decades that were analyzed. Since 1970, lepidopteran populations had declined by an average of 30% (Figs. 3, 4). The overall trend was nearly linear—it is disturbing that the decline did not level off either for Lepidoptera alone or when all insects was taken together. It does not bode well for insects confronted with accelerating global change. Even more alarming, among non-Lepidoptera invertebrates, Dirzo et al. reported that the rate of loss was significantly higher: about 25% per decade, although there were many fewer species analyzed and the variance in their estimates were greater. This result is supported by new findings reported in the May issue of *Science* (356: 576-579) for one of Europe’s most intensively sampled insect faunas: the Orброich Bruch Nature Reserve in northwestern Germany. Over the past quarter century of monitoring, the Krefield Entomological Society has documented a 78% decline in insect biomass in the preserves’s flight interception (malaise) traps—run season-long in the same sites, and with the same trap design. Declines almost as large are being reported for long-term insect monitoring sites in Great England and Scotland, over the same decades, but interestingly the downturns come in different years in different regions.

An obvious source of decline in abundance and diversity is landscape transformation. To assess these effects, Dirzo et
al. conducted a separate literature review where responses of Lepidoptera were measured in human-disturbed landscapes, i.e., areas affected by logging and silviculture, agriculture, and urbanization. They found that insect species diversity in disturbed areas trended downward in nearly all studies, reducing (species) diversity by 40% on average. There was greater variation in whether human disturbance increased or decreased Lepidopteran abundances, but on average there were even greater effects with lower insect abundances in 90% of the long-term studies that Dirzo et al. examined.

In an analysis of species for which International Union for the Conservation of Nature (IUCN) had assessed population trends, Lepidoptera were among the orders with the fewest species (about 25%) declining in abundance, faring better than Hymenoptera, Coleoptera, and especially Orthoptera (which had 50% of species declining). In analysis of UK insects alone, arguably the world’s best-studied insect fauna, 25 species have seen declines of 30% or more, a rate that is similar to that of the elevated rates found in other insect orders.

The majority of the article is not about insects. Dirzo’s team describes one Kenyan study of system-wide effects that followed reductions in numbers of large mammals. A small fraction of the reported consequences involved arthropods, for example increased (e.g. Coleoptera) or decreased (e.g. ticks) abundances. Changes in abundances also affected species interactions (e.g. defense of acacia by ants) as well as ecosystem functions. In sum, defaunation, especially of vertebrates, often triggers species losses and the degradation of ecosystem functions that cut across taxonomic boundaries.

Although broader effects of defaunation and species loss were not examined for Lepidoptera, similar pathways can be imagined for them. Lepidoptera, and especially the larvae of geometrids and many lineages of tree-feeding noctuoids are essential elements in the diets of warblers and other songbirds. Even in birds that we regard as granivores—regulars at our bird feeders for the winter months—switch to insectivory when nesting. To build baby birds you need caterpillars, upwards of 3000 just for a clutch of chickadees. The pollination services of Lepidoptera are modest in temperate zones, but they become increasingly important in lower latitudes and can be important in tropical forests. Collectively, the planet’s 250,000 species of Lepidoptera are enormously important in nutrient cycling, regulating host plant abundances, and are an essential fabric in many of the world’s terrestrial food webs.

Dirzo’s et al.’s global meta-analysis puts other declines of individual species into context. Monarchs are declining at an even faster rate than the Dirzo global average, by more than 80% in the past two decades (note: this estimate is dependent on what starting year is chosen). Measures to stem this collapse can’t come too soon. And perhaps even more importantly, Dirzo et al.’s findings underscore that the monarch, while being an exceptional case, has an alarming amount of company, and that insect decline is happening across the globe, across a sweeping array of taxa.

Butterfly and moth conservation often focuses on those species and subspecies that are nearing extinction or on widely known known species, e.g., monarchs. But this emphasis could be blinding us from seeing an even greater problem, i.e., widespread downturns in insect abundance. These are undoubtedly of greater importance to community

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One wonders if we have put too little emphasis on common species and their interaction diversity, a measure of the number of direct ecological linkages that a species shares with other taxa. Abundant species have far higher measures of interaction diversity, and serve as important ecological (energy flow) hubs in communities. Quantifying these and monitoring their changes might serve as an early warning sign that a community or region is in decline. Are the declines of some bats, songbirds, and other insectivores linked to downturns in available insect biomass? Are butterflies and moths really much less common than they were a half century ago as lamented (and warned) by so many? And if so, how much so and what must be done to reverse these trends?

A core message from Dirzo et al.’s research is that more long-term datasets are needed, and especially those that record abundances. Members of the Lepidopterists’ Society have pioneered such efforts around the country and around the world. Accumulating long-term datasets of butterfly and moth numbers will enable more refined analysis of their ecology, their response to global change, the causal factors in declines, and provide the information needed to direct successful conservation. The UK Butterfly Monitoring Scheme has long served as the gold-standard for large-scale, long-term butterfly datasets, with 4000 sites sampled across 40 years. Indeed, this dataset comprises a good part of Dirzo et al.’s meta-analysis. A greater geographic expanse of long-term datasets are needed, especially in tropical areas where human population growth is high and deforestation is proceeding at alarming rates.

The threats to invertebrate diversity are many and gaining momentum. Presently, development and human-driven habitat degradation (including logging and agricultural practices, changed fire ecology, hydrological perturbations, damming and channelization, etc.) comprise the great global threat to biodiversity. Invasive species, especially on islands and in density populated areas, are becoming increasingly problematic. The planet’s biota will face increasing challenges from climate change. We are poised to plunge into E. O. Wilson’s BioDiversity Crisis. Species, entire lineages, will be lost. The charge will be to do one’s best to stem the losses by preserving habitat, working to change policies, embracing green technologies, and gathering the data needed to guide conservation efforts. We must act for those creatures without a voice.

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From the Editor’s Desk

James K. Adams

To the left is the aforementioned Catocala myristica (News 58:3, pg. 136) collected near Rome, GA near the end of August of 2016. Again in this coming August I will be checking on the status of the isolated population of the moth at the location where the host Nutmeg Hickories occur.

The specimen at the lower left is a nice morph of Catocala micronympha from Sapelo Island, GA, from May of this year. I collected two specimens like this.