What's Causing the Sharp Decline in Insects, and Why It Matters

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Illustration by Luisa Rivera for Yale E360

On three occasions from 1989 to 2014, entomologists set up tents in the meadows and woodlands of the Orbroicher Bruch nature reserve and 87 other areas in the western German state of North Rhine-Westphalia. The tents act as insect traps and enable the scientists to calculate how many bugs live in an area over a full summer period. Recently, researchers presented the results of their work to parliamentarians from the German Bundestag, and the findings were alarming: The average biomass of insects caught between May and October has steadily decreased from 1.6 kilograms (3.5 pounds) per trap in 1989 to just 300 grams (10.6 ounces) in 2014.

"The decline is dramatic and depressing and it affects all kinds of insects, including butterflies, wild bees, and hoverflies," says Martin Sorg, an entomologist from the Krefeld Entomological Association involved in running the monitoring project.

Another recent study has added to this concern. Scientists from the Technical University of Munich and the Senckenberg Natural History Museum in Frankfurt have determined that in a nature reserve near the Bavarian city of Regensburg, the number of recorded butterfly and Burnet moth species has declined from 117 in 1840 to 71 in 2013. "Our study reveals, through one detailed example, that even official protection status can't really prevent dramatic species loss," says Thomas Schmitt, director of the Senckenberg Entomological Institute.

Declines in insect populations are hardly limited to Germany. A 2014 study in *Science* documented a steep drop in insect and invertebrate populations worldwide. By combining data from the few comprehensive studies that exist, lead author Rodolfo Dirzo, an ecologist at Stanford University, developed a global index for invertebrate abundance that showed a 45 percent decline over the last four decades. Dirzo points out that out of 3,623 terrestrial invertebrate species on the International Union for Conservation of Nature [IUCN] Red List, 42 percent are classified as threatened with extinction.

“Although invertebrates are the least well-evaluated faunal groups within the IUCN database, the available information suggests a dire situation in many parts of the world,” says Dirzo.

> Scientists have described 1 million species of insects so far, and estimate at least 4 million are still unrecorded.

A major survey of threats to insect life by the Zoological Society of London, published in 2012, concluded that many insect populations worldwide are in severe decline, limiting food supplies for larger animals and affecting ecosystem services like pollination. In Europe and the United States, researchers have documented declines in wild and managed bee populations of 30 to 40 percent and more due to so-called colony collapse disorder. Other insect species, such as the monarch butterfly, also have experienced sharp declines.

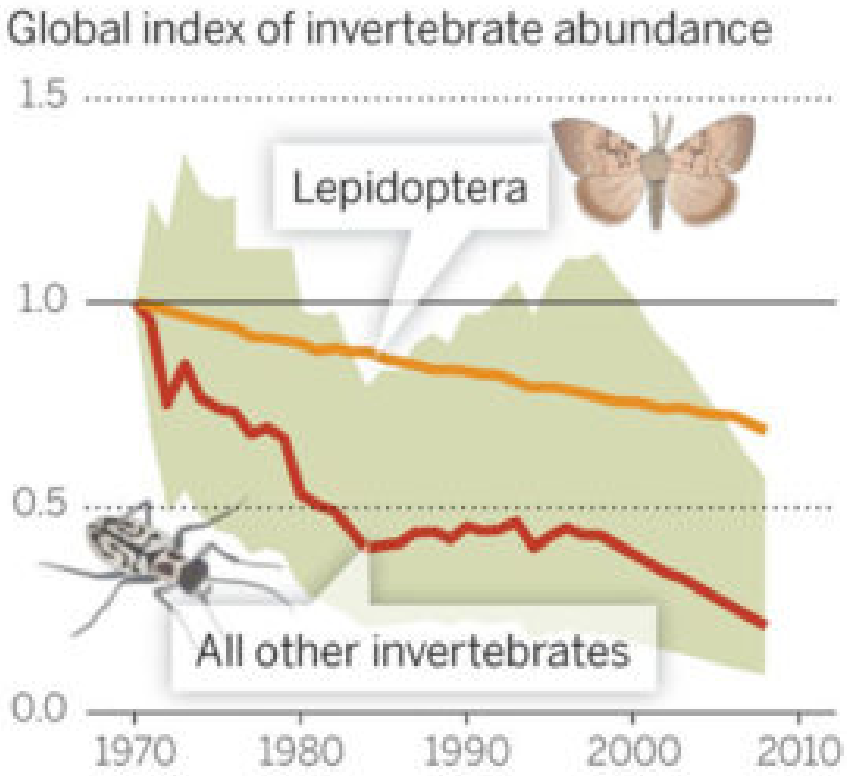
Jürgen Deckert, insect custodian at the Berlin Natural History Museum, says he is worried that “the decline in insect populations is gradual and that there’s a risk we will only really take notice once it is too late.”

Scientists cite many factors in the fall-off of the world’s insect populations, but chief among them are the ubiquitous use of pesticides, the spread of monoculture crops such as corn and soybeans, urbanization, and habitat destruction.

A significant drop in insect populations could have far-reaching consequences for the natural world and for humans, who depend on bees and other invertebrates to pollinate crops. A study by Canadian biologists, published in 2010, suggests that North American bird species that depend on aerial insects for feeding themselves and their offspring have suffered much more pronounced declines in recent years than other perching birds that largely feed on seeds. The analysis is based on data from the North American Breeding Bird Survey. The decline in birds that feed on flying insects appears to be significantly stronger than in perching birds in general, according to co-author Silke Nebel, now with the Upper Thames River Conservation Authority in Ontario.

Scientists have described 1 million species of insects so far, and estimate that at least 4 million species worldwide are still unrecorded. For people living in areas with ample wilderness and a plethora of biting mosquitoes that carry malaria and other diseases, a

decline in insect populations might seem like an outlandish concern. But in areas with intensive industrialized agriculture, the drop in insect populations is worrying.



According to global monitoring data for 452 species, there has been a 45 percent decline in invertebrate populations over the past 40 years. Dirzo, *Science* (2014)

So far, only the decline of honeybee populations has received widespread public attention, in large measure because of their vital role in pollinating food crops. The rest of the insect world has been widely ignored. Often insects are perceived as a nuisance or merely as potential pests. But while certain insect species, such as the European corn borer, undoubtedly cause enormous damage in agriculture, scientists emphasize the ecological importance of diverse and abundant insect populations.

In Britain, an alliance of 22 publicly funded environmental research institutions has compiled a list of ecosystem services delivered by insects: “Over three-quarters of wild flowering plant species in temperate regions need pollination by animals like insects to develop their fruits and seeds fully,” the group says. The researchers emphasize that pollinating insects improve or stabilize the yield of three-quarters of all crop types globally — one-third of global crop production by volume.

Germany’s Federal Agency for Nature Conservation stresses that insects are a major food source not only for birds, but also for bats and amphibians. Another important role is played by specialized insects such as long-legged flies, dance flies, dagger flies, and balloon flies,

which prey upon pest species.

Deckert of the Berlin Natural History Museum has compiled a long list of factors that contribute to insect loss. One factor — the widespread overuse of nitrogen fertilizer — enables a few plant species such as corn to thrive, while the majority of plant species that live in symbiotic relationships with highly specialized insects dwindle.

In large parts of Europe, the U.S., and South America, monocultures cover vast areas of the landscape, creating “biological deserts” devoid of hedges or ponds where insects could reproduce. Attempts to make the European Union’s agricultural system more environmentally friendly have largely failed in recent years.

Of particular concern is the widespread use of pesticides and their impact on non-target species. Many conservationists view a special class of pesticides called neonicotinoids — used over many years in Europe until a partial ban in 2013 — as the prime suspect for insect losses. The European Food Safety Authority is currently reviewing the ban. Other pesticides are widely used worldwide.

“There are many indications that what we see is the result of a widespread poisoning of our landscape,” says Leif Miller, director general of the German chapter of BirdLife International.

> A recent increase in insect monitoring efforts stems from the rise of ‘citizen science’ projects.

Yet even environmental campaigners like Miller admit that the root causes and the full dimension of the problem aren’t yet fully understood. “I suspect it is a multiplicity of factors, most likely with habitat destruction, deforestation, fragmentation, urbanization, and agricultural conversion being the leading factors,” says Stanford ecologist Dirzo.

To understand the problem better, scientists are now urging increased monitoring efforts. Given the importance of insects for agriculture and biodiversity, one might assume that in rich countries like Germany, insect populations are being closely studied. But this is not the case. “For the 30,000 insect species in Central Europe, only a few specialists exist, and they often carry out monitoring as a side job,” says Deckert.

In-depth monitoring only exists in select regions or for specific species. In Germany, only 37 insect species are closely tracked, according to the Federal Agency for Nature Conservation — a mere 0.12 percent of all species.

A recent increase of monitoring efforts stems from the rise of “citizen science” projects, where lay people with an interest in the outdoors are trained to collect data. One such project is a butterfly monitoring program run in association with Butterfly Conservation Europe. Each year, thousands of volunteers comb through the landscape to compile lists of butterflies they encounter.

Globally, however, comprehensive data for long-term comparisons does not exist. “Unfortunately, information on invertebrates in general, including insects, is very limited, restricted to a few groups and a few localities,” says Dirzo.

That’s why Wolfgang Wägele, director of the Zoological Research Museum in Bonn, is now calling for a large-scale monitoring effort. Wägele and his team have developed a plan for an automated biodiversity surveillance system, which would photograph, videotape, capture, or audio-record animal and insect species and perform automatic analysis of species richness and abundance. “We have weather stations all over the country, so let’s add a dense network of biodiversity stations so we can measure automatically how much life there is in our landscapes,” says Wägele.

As they investigate the factors behind the decline of bee populations, scientists are now eyeing a new culprit — soaring levels of carbon dioxide, which alter plant physiology and significantly reduce protein in important sources of pollen. Read more.

He plans to use automated identification techniques, either through artificial intelligence image analysis or genetic fingerprinting, or by matching acoustic recordings with data collections. For example, if grasshoppers make their characteristic sounds near the station, the species will be identified and the number of insects recorded. If an aerial insect lands in a trap, its genome will be compared to a database. For larger insects like butterflies, scientists can use photographic image analysis to come up with a precise identification.

“Such a system could collect, identify, and record species data 24/7 and gather data we desperately need to assess the decline of insects,” says Wägele.

Recently, a pilot installation for the system already discovered a new mosquito species, now called *Ctenosciara alexanderkoenigi*, in the museum’s park. The nationwide monitoring scheme is currently under funding review by Germany’s Federal Research Ministry.

Many biologists support more intensive monitoring efforts, but point out that in Europe there’s already enough knowledge about insect decline to start addressing root causes — mainly in agricultural policy. According to conservation organizations like BirdLife International, new attempts are necessary to “green” EU agricultural policy in a substantial way by creating incentives for enriching landscapes with hedgerows, reducing fertilizer and pesticide use, and better rewarding organic agriculture. Previous efforts to do so have largely failed.

“The key question is whether governments view biodiversity as an add-on or as something that is of existential importance for our future,” says Deckert.