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The Insect Apocalypse: a cause for concern or simply an exaggeration?

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Insects, being the largest and most diverse group of organisms, play a vital role in ecosystem functioning. They are key components in pollination, decomposition of organic matter, nutrient cycling as well as suppression of pests and diseases, making them of high economic value (Noriega et al., 2018). This illustrates just how critical insects are for human welfare and a decrease in insect populations is expected to have great consequences. A significant loss of insect abundance and diversity would also have cascading effects across trophic levels and influence surrounding ecosystems (Forister et al., 2019). However, understanding exactly in which ways insect populations have changed recently may be more complicated than previously assumed.

Hallmann et al. (2017) found a steep decline of flying insect biomass in Germany. They suggested an estimated 75% decline over a 27-year period. The study pointed to climate change, habitat loss and fragmentation as well as the use of agricultural insecticides as potential drivers (Hallmann et al., 2017). This has since become a high-profile case study and is often used as a reference in news articles concerning changes in insect populations. Studies focused on individual species have also shown similar trends, with one reporting a sharp decline of the monarch butterfly (Danaus plexippus) in North America (Thogmartin et al., 2017). In the UK, 52% of butterfly species have declined in abundance since 1976 and in western US, the predicted mean occupancy of one bumble bee species (Bombus occidentalis) declined by 93% over 21 years (Fox et al., 2015; Graves et al., 2020).

These trends are alarming, and the media started sharing the news of an "insect apocalypse". In one of their articles, The Guardian announced that "Insects could vanish within a century at current rates of decline" and more recently stated "Our world will grind to a halt without them" (Carrington, 2019; Goulson, 2021). The New York Times Magazine also reported that "The Insects Apocalypse Is Here", further strengthening their message with an illustration of an exploding wasp (New York Times, 2018). ABC news used a slightly different term, calling it "Insect Armageddon" and declared that "If they go, we go" (Campbell, 2019). However, the notion of an insect apocalypse has met some resistance.

Populations appear stable in the US

Most of the evidence for a steep decline in insect abundance come from Europe, where humans have managed landscapes for centuries and human population densities are high. This type of research has been scarce in the US, which is why Crossley et al. (2020) researched how insect populations had changed for sites with varying degrees of human disturbance in the US. They conducted a meta-analysis consisting of 82,777 arthropod observations from 68 datasets spanning up to 36 years (Crossley et al. 2020). Here, they utilized these long-term datasets to search for evidence of insect declines. The data was collected using a variety of methods, but these methods were consistent over time based on taxa within each dataset. Types of data include grasshopper per sweep in Kansas, ground arthropods per pitfall trap in New Mexico and aphids per suction trap in Midwestern US (Crossley et al. (2020)). The research areas used in the study was Long-Term Ecological Research sites (LTERs), initiated by the US National Science Foundation. Of the 25 existing LTERs, 12 were used in their analysis (Fig. 1). The study sites were chosen to cover different habitats and with a wide range of human influence from urban or farmed regions to relatively undisturbed areas (Crossley et al. 2020).

A rather surprising trend of stable insect population size was found, challenging the current view of an ongoing insect apocalypse. Crossley et al. (2020) found that some arthropod taxa at some sites had a decline in abundance, while in other sites most taxa were stable or increased in

abundance. In most of the datasets, the median abundance change was modest, lying within 1.6 standard deviation of zero net difference (Crossley et al., 2020). No specific cause could be linked to any of the declines or increases detected. The results were similar when separating taxa into aquatic vs. terrestrial or when grouped based on feeding guilds. No trend was found even when comparing sites heavily altered by humans with more natural sites (Crossley et al. 2020). The seemingly robustness of insects and other arthropods in the US is comforting. Still, it begs the question of how previous research can differ so much from these findings.

One possible explanation for this could be location. Most of the research showing declines comes from Europe, here, human populations are dense. As a result, much of the natural landscape has been altered. Habitat loss and fragmentation is known to be a major threat to biodiversity and insect populations would be expected to suffer accordingly (Forister et al., 2019; Hanski, 2011). Second, the popular study from Germany used only one capturing method – malaise traps, thereby limiting their samples to flying insects. Several methods should be used to conclude any trends in insect abundance and diversi-

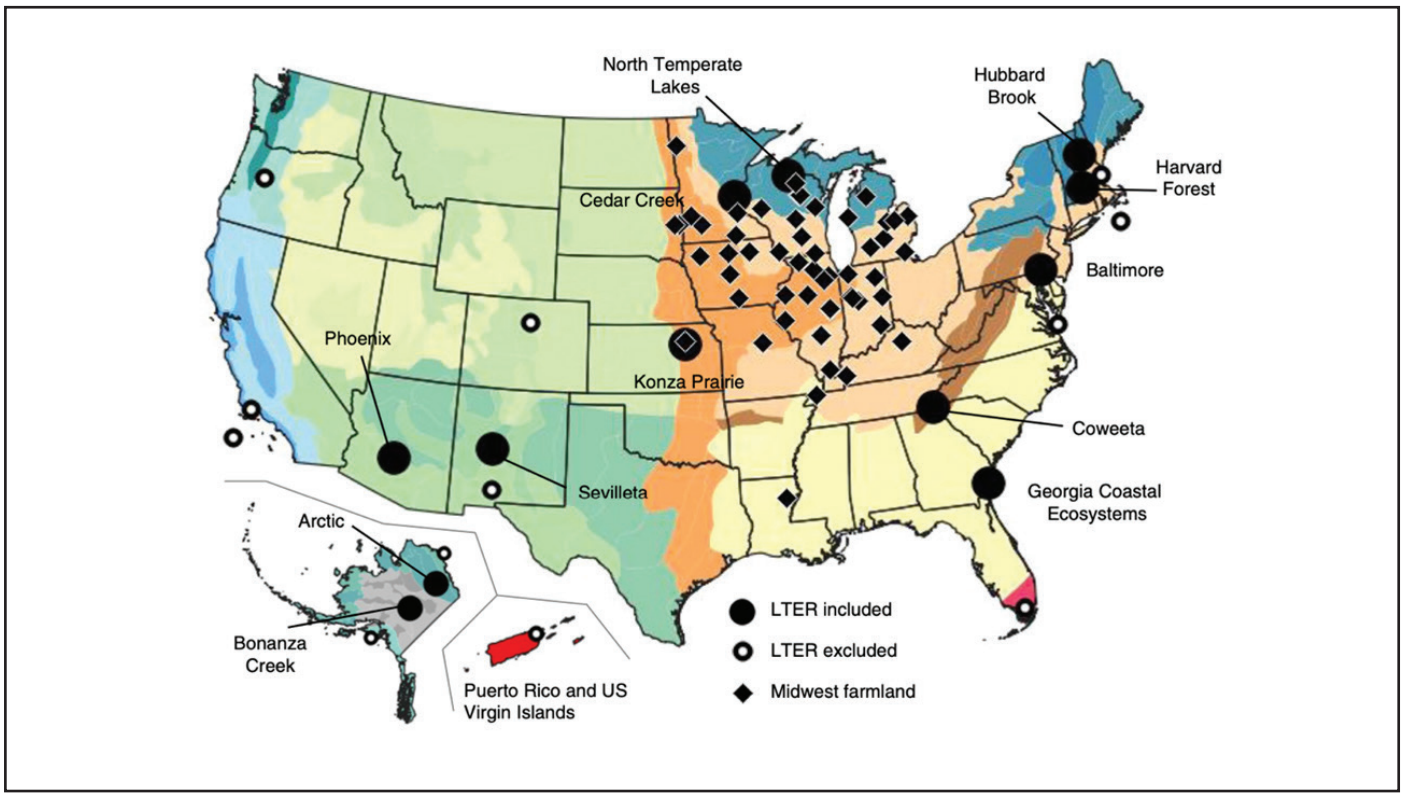

Figure 1 – Map of LTERs. Larger black circles show the Long-Term-Ecological Research sites (LTERs) included in the meta-analysis (Crossley et al. 2020). Colors indicate different ecoregions defined by climate, precipitation, temperature, and vegetation by the United States Department of Agriculture Forest Service (USDA, n.d.).

ty. Some insect populations may also fluctuate naturally through genetic drift (Davies, 1988). Distinguishing these from recent, human driven declines could be challenging.

Despite the US study finding no net abundance and diversity declines, the stories of an insect apocalypse continue to develop. Publication bias suggests that studies with more significant findings are more likely to be published (Dickersin, 1990). Readers are more likely to be interested in papers with dramatic results, like populations declining rapidly, rather than results showing no changes at all. Therefore, scientists may execute studies that have the desire to find evidence supporting novel results. Chances are, if you go looking for species in decline, you will find them.

The future for insect populations

The reassuring results from the North American study show that insect populations are more stable and robust in the US, than previously suggested. It is therefore tempting to assume that insects are resilient enough to withstand any changes made by humans. However, this is a naïve and potentially dangerous way of thinking. While they found no clear indication of widespread insect declines in the US, this does not rule out the possibility of any subtle changes in species composition or local extinctions (Krno et al., 2018). There is evidence that some species are in decline, as previously noted with the monarch butterfly and Bombus occidentalis (Fox et al., 2015; Thogmartin et al., 2017). Changes in species composition, especially when

keystone species are involved, could hurt ecosystems, and influence the services they provide (Cardoso et al., 2020; Jordan, 2009). There is also a possibility of more recent declines, but at a subtle rate not yet being detected.

As we have seen, changes in insect populations are a complex issue. The discoveries from these studies underpin the need for further research and monitoring. Almost no quantitative data is available in the tropics where rates of deforestation are high (Wagner, 2019). Many species of insects are yet to be described, with some estimates suggesting that 80-90% of terrestrial arthropods are undescribed (Stork, 2018). As a result, declines and extinctions may be outpacing our effort to collect data (Wagner, 2019). In the future we will need more researchers collecting material at sites all over the world, as well as more awareness of how our actions influence ecosystems. Although some changes in insect abundance and diversity may be occurring, the results from Crossley et al. (2020) suggests a future not as bleak as the media have made it seem. Insects have been around for 479 million years, surviving several mass extinctions, so a complete disappearance any time soon is unlikely (Misof et al., 2014). Still, the disappearance of some species might bring cascading effects, accelerating the extinction of other species (Kehoe et al., 2021). In conclusion, an insect apocalypse is certainly a cause for concern, although the scope and rate of insect declines may be exaggerated by the media.

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