Study shows invertebrate decline reduces natural pest control and decomposition of organic matter

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The iDiv Ecotron consists of several controlled mini-ecosystems, so-called EcoUnits. Credit: Anja Schmidt

The decline in invertebrates also affects the functioning of ecosystems, including two critical ecosystem services: aboveground pest control and belowground decomposition of organic material, according to a new study published in *Current Biology* and led by researchers at the German Centre for Integrative Biodiversity Research (iDiv) and Leipzig University.

The study provides evidence that loss of invertebrates leads to a reduction in important ecosystem services and to the decoupling of ecosystem processes, making immediate protection measures necessary.

Invertebrates, such as insects and also other arthropods, snails, slugs and nematodes, represent ~75% of all species described on Earth and are a fundamental part of ecosystems, providing many critical ecosystem functions and services, such as pollination, decomposition, and natural pest control.

Human-caused environmental changes, in particular land-use change, landscape simplification, and urbanization, including habitat loss and chemical pollution, have been driving the global decline of invertebrates in recent decades. However, measuring the potential effect of this loss has so far proven difficult.

"The manipulation of aboveground invertebrate communities has been a major challenge in ecological research, because of their functional diversity and mobility," explains Nico Eisenhauer, lead author and professor for Experimental Interaction Ecology at iDiv and Leipzig University.

A team of researchers used the iDiv Ecotron, a joint research platform of iDiv and the Helmholtz Centre for Environmental Research (UFZ). It consists of several controlled mini-ecosystems (so-called EcoUnits), to study the effects of these complex communities.

"Apart from offering a bridge between small-scale experiments under highly controlled conditions and less controllable large-scale field experiments or monitoring programs, the goal of the iDiv Ecotron was to enable experiments manipulating biodiversity changes at different levels of food webs in above- and belowground ecosystem compartments," says iDiv Honorary Member Francois Buscot, professor emeritus at Leipzig University and former head of the UFZ department for Soil Ecology.

Prof Nico Eisenhauer conducting an analysis of a grassland ecosystem in one of the EcoUnits. Credit: S. Reichhold

The researchers simulated and tested how various ecosystem services and plant diversity respond in 24 distinct grassland ecosystems across three levels of aboveground invertebrate biomass (100%, 36%, and 0%). A biomass level of 36% reflects the dramatic decline of invertebrates reported across German grasslands in the last decade.

All plant and invertebrate species were collected from the same adjacent hay meadow, and the researchers simulated the natural turnover of aboveground invertebrate communities by exchanging invertebrate communities three times from May until November 2018. "I am particularly excited about this simulation of the phenology of invertebrate communities—something that has, to my knowledge, not been done before," Nico Eisenhauer, head of the iDiv Ecotron, adds.

The researchers found that as the biomass of invertebrates decreases, so does the number of ecosystem services. For example, aboveground invertebrates play an important role in natural pest control. The researchers observed that declines in invertebrates went hand in hand with aphid outbreaks indicating that pest outbreaks may be a widespread consequence of biodiversity loss at higher trophic levels, with significant cascading effects on crop production and other ecosystem services.

Further, loss of aboveground invertebrates led to a significant reduction in belowground decomposition. "Aboveground and belowground processes are connected by invertebrates that consume plants and leaf litter. Loss of those connections will change nutrient cycling and how much carbon can be sequestered in ecosystems," explains Ecotron coordinator Dr. Jes Hines from iDiv and Leipzig University.

Declines in invertebrates went hand in hand with aphid outbreaks. Credit: Anja Schmidt

The amount of invertebrate biomass also affected the plants that were growing in the experimental grassland ecosystems. Aboveground plant biomass increased in the EcoUnits with reduced invertebrate biomass. This could be because invertebrates usually eat more of the plant aboveground.

"This way, energy is channeled up from plants to higher trophic levels in intact invertebrate communities," explains Jes Hines. The researchers also found that the concentration of carbon and nitrogen in plant tissue

significantly decreased, which, in turn, may alter the quality of resources and nutrients fueling biological activity in soils.

"In a healthy ecosystem, biotic and biogeochemical properties are coupled. This study shows that a decrease in aboveground invertebrate biomass reduces this coupling, which might threaten species diversity, as well as animal, plant, and microbial nutrition," says Nico Eisenhauer.

Despite these alarming findings, ecosystems may recover following legislative changes that favor invertebrate diversity. For example, there is evidence of freshwater insect populations increasing following the Clean Water Act. Immediate protection measures stand to turn the tide on safeguarding diverse invertebrate communities and important ecosystem functions.

More information: Nico Eisenhauer et al, Ecosystem consequences of invertebrate decline, *Current Biology* (2023). DOI: 10.1016/j.cub.2023.09.012

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