



Doomsday for Insects? The Alarming Decline of Insect Populations around the World

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Editorial

Of about 1,500,000 extant species that have been described to date, more than 900,000 (>60%) are insects [1-3]. However, recent estimates predict a total number of 5,500,000 (range: 2.6-7.8), or about 81% of all arthropods [4,5]. It has been estimated that the number of individual insects at any time is 1018 with the largest biomass of all terrestrial animals [6]. In this sense, insects constitute the most successful group of eukaryotic organisms on Earth dominating all terrestrial and freshwater ecosystems. The antiquity of insects is also staggering: the oldest known insect (basal Ectognatha) is *Rhyniognatha hirsti*, a possibly winged insect collected at Rhynie, Scotland's Old Red Sandstone (396-407 million years old) [7]. In fact, modern phylogenomic analyses have traced the origin of insects to the Early Ordovician (~479 million years ago), coincident with the apparition of the first terrestrial faunas. Major extant lineages were already present ~345 million years ago [8,9].

Insects are not charismatic animals such as tigers, pandas or birds of paradise, thus they receive much less consideration and empathy from humans [10,11]. However, their relationship with humans is of such importance that few lay people realize it [12-14]. The general public tends to dislike insects for multiple reasons: some species are vectors of serious diseases (mosquitoes, fleas), others destroy their crops (locusts, beetles, true bugs) or attack livestock (flies, lice), although some are considered objects of beauty (butterflies) or even revered in Pre-Classical, Classical and even modern times [15]. A world without insects is unconceivable. They have essential roles in terrestrial and freshwater ecosystems as herbivores, carnivores, and decomposers [16,17]; they are the pollinators par excellence [18], and represent an extraordinarily promising source of proteins for the continuously-and alarmingly- growing human populations [19,20].

However, despite their evolutionary success, their sheer numbers, and their economic importance for humans [21] insects are also victims of the Sixth Extinction [22]. Although five massive extinctions of life on Earth have occurred in the distant geological past, it is considered that present-day biodiversity is the largest in all the history of life [23]. At the same time the extinction rate due to anthropogenic causes (habitat destruction, overharvesting, pathogens, pesticides, pollution, urbanization, transport of invasive species, and greenhouse gases emissions) is probably thousands of times larger than the background rate [22]. Insects have not been immune to this unprecedented wave of extinctions although due to the reasons indicated above, they have been rather neglected in this respect in relation to other, more charismatic species [24-27]. A few recent examples will suffice to show the seriousness of this problem.

There is a global decline in pollinators both wild and domesticated including honey bees, bumble bees, hoverflies, butterflies, and other

insects [28]. Pollinators provide extraordinary ecosystem services to wild plants and agricultural crops and their loss could result in an outcome of catastrophic consequences to the biosphere and to human welfare, while the drivers of these declines are in fact of anthropogenic origin [28]. For example, a recent 3-year interdisciplinary study of eight bumble bee species (*Bombus*) in the United States, revealed that the relative abundance of four species have declined by up to 96% while their ranges contracted between 23 and 87% in the last 20 years, and populations have a higher infection level with *Nosema bombi* pathogen and are less genetically diverse than non-declining populations [29]. An important study published in 2017 [30] tracked the variation in flying insect biomass in 63 nature protection areas during 27 years. Their results showed 76% and 82% seasonal and mid-summer declines respectively, of insect biomass along the mentioned period. Changes of weather, land use or habitat characteristics cannot explain this extraordinary decline. Growing urbanization, the continuous building-up and elimination of green areas, is also a powerful cause of insect decline and extinction. A study performed in Rome analyzed the decline and extinction of populations of butterflies, coprophagous and non-coprophagous scarabeids, and tenebrionids between 1885 and 1999, showing impressive declines in species richness.

Insects are key components for the functioning of the world's ecosystems. Their accelerated decline in numbers and extinction due to anthropogenic activities could cause unpredictable negative consequences for the biosphere. It is a duty of all entomologists to attack this enormous problem and educate the public on the importance of saving our fantastic insects. Their conservation is mandatory [31-34]. As poet Munia Khan put it: "Bugs never bug my head. They are amazing. It is the activities of humans which actually bug me all the time."

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