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Editorial: The decline of wild bees: Causes and consequences

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Editorial on the Research Topic
The decline of wild bees: Causes and consequences

Concern over declines of bee populations worldwide has captured the attention of scientists, governments, media, and the general public. Being the primary pollinators of most wild plants and many crops, bees are crucial to both ecosystem stability and agricultural productivity (Potts et al., 2010; Willmer et al., 2017). Despite their abundance and richness, comprising more than 20,500 species worldwide (Ascher and Pickering, 2020; Zattara and Aizen, 2021), most scientific effort on bee losses has focused on a single species, the western honey bee *Apis mellifera* (Wood et al., 2020). Much of the public and media also tend to associate the term "bee" solely with this species (Smith and Saunders, 2016; Christ and Dreesmann, 2022). There are several reasons for this, including the omnipresence of *A. mellifera* in most terrestrial ecosystems (Requier et al., 2019), and the extensive use of this species for beekeeping and crop pollination. Consequently, protective legislations, investments by shareholders, and conservation efforts often focus on the domesticated honey bee (Hipólito et al., 2021).

In the present Research Topic, we call attention to the importance of studying the causes and consequences related to the decline of wild bees, which are the main pollinators of the majority of plants (Garibaldi et al., 2013; Willmer et al., 2017). Here, the term "wild bees" is not restricted to wild species in their natural habitats. We also consider non-*Apis* species more recently managed for honey production, crop pollination, or hobby activities—such as stingless bees, bumble bees, and some solitary bees—besides feral populations and rare subspecies of *Apis* spp. in their native environments.

Several anthropogenic drivers have been associated with declining bee populations, such as disturbances of their natural habitats as result of agricultural intensifications and urbanization, climate change, pesticides, management practices, and invasive alien species (Potts et al., 2010). In their article, Maebe et al. advocate for considering a "holobiont" approach for future risk assessments of different stressors on bee populations. Given that various anthropogenic manipulations of the environment, such as the application of pesticides or other xenobiotics, may have deleterious effects on the bees' microbiota, it important to study bees together with their microbiomes (bee holobiont) for understanding on how changes during the Anthropocene affect bee populations.

Habitat loss and fragmentation are considered a major drivers of pollinator declines (Winfree et al., 2009; Tonietto and Larkin, 2017). Climate changes can cause significant alterations in natural habitats, thus reducing their suitability for wild bee populations (Schweiger et al., 2010). In their article, Hu et al. developed models to assess how changes in temperature, rainfall, and radiation, predicted for coming decades, may modify natural habitats, thereby interfering with the distribution of bumble bees. Their results illustrate that, despite expansion of potential distribution areas for *Bombus pyrosoma*, highly suitable areas for the maintenance of populations of this endemic bumble bee species may be reduced in the near future. Data and models like these could be key for development of conservation strategies for these wild pollinators in China.

Given the increase in competition over floral resources, the presence of managed honey bee colonies in the environment may compromise habitat suitability for wild bees (Schweiger et al., 2010). In their contribution, Demeter et al. tested whether an increase in honey bee hives alters the richness and abundance of wild bees populations in Europe. They found an overall increase in wild bee richness, particularly that of small species, with distance from managed honey bee colonies, confirming the impact of artificially increased competition on wild pollinator diversity and community structure.

Pesticides have received much attention for their potential effects on bees. The meta-analysis by Bernardes et al. reviews important agrochemicals with demonstrated deleterious effects on eusocial bees. Using artificial intelligence tools, the authors explore how pesticide exposure contributes to declines in populations of honey bees, bumble bees, and stingless bees. Moreover, their study reveals important gaps in knowledge concerning non-*Apis* bees in toxicological studies. In an experimental approach, Boff et al. provide data about how colony treatment with the pesticide Sulfoxaflor reduces the pollen collection efficiency of *Bombus terrestris* workers. Workers from the exposed colonies were significantly smaller than those from unexposed colonies, probably due to reduced pollen availability in nests during their development, associated with the pesticide contamination.

A Research Topic that has received little attention concerns potential effects of management techniques on bee declines. In their study, Panziera et al. address the importance of improving beekeeping techniques and conservation strategies to avoid reduction of genetic diversity in both managed and wild honey bees. The authors conclude that artificial and natural selection are needed to maintain genetic diversity in honey bees to combat, for example, the bee susceptibility to pathogens.

Regarding the consequences of the decline of wild bee populations, Raiol et al. analyzed how the loss of wild bees can harm plant-pollinator interactions in tropical biomes. In this context, reduction in specialist bee populations can, in particular, have negative impacts on mutualistic interactions between wild bees and the plants they pollinate.

The articles published in this Research Topic demonstrate the range of approaches possible to study decline of wild bee populations. Nevertheless, many knowledge gaps remain. Future studies should continue to increase their focus and sophistication when tackling questions concerning the causes of wild bee losses in their natural environment; understanding how wild bees respond to different anthropogenic stressors; clarifying how different stressors interact in wild bee populations; exploring alternatives to reduce the susceptibility of bees to different stressors; investigating consequences of wild bee losses for the conservation of natural areas and crop production; how to best mitigate wild bee losses; and knowing which species or bee groups are at higher risk and the consequences of their extinction.

It is important to emphasize that scientific efforts alone are not enough. Additional strategies should be encouraged, including improvements of environmental education programs, increased use of non-*Apis* bees in risk assessments, changes in public awareness about wild bees through appropriate media coverage, and improvements in dialogue between scientists, industry, stakeholders, and legislators. Only comprehensive approaches, discussed by different societal actors, will result in efficient and long-term strategies to reduce the decline of wild bee populations.

Author contributions

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Conflict of interest

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