Pollinator diversity and crop pollination services are at risk

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In a recent opinion article in *TREE*, Ghazoul [1] questions the existence of a global pollinator crisis and, in doing so, raises some important points about the uncertainty of human dependence upon pollination services. We agree with Ghazoul [1] that much uncertainty remains regarding pollinator–pollination declines. However, we think that his assessment draws biased conclusions for pollinator declines from existing studies, misrepresents the extent of agricultural reliance on animal pollination, and underestimates the extent of pollination reduction in intensive monocultures.

In his article [1], Ghazoul suggests that a pollinator crisis is driven mainly by reported declines of honeybees in North America, and bumblebees and butterflies in Europe. However, local and regional declines of solitary wild bees, bumblebees and honeybees owing to habitat loss, agricultural intensification and pesticide use have been reported in both Europe and America [2–5], and the impact of habitat loss, measured by species–area relationships, is much stronger for native bees than for other insect groups [6]. For genetic reasons alone, bees are more extinction prone than are other taxa, because single-locus sex determination makes them particularly sensitive to the effects of small population size through the production of sterile diploid males [7]. Pollinators, other than honeybees and bumblebees, have many Red Data Book entries (e.g. for 11 European countries, an average of 27.4% of the national bee fauna is listed*) because they are known to be threatened or declining. Thus, there is convincing evidence for negative impacts of habitat loss and agricultural intensification on pollinator diversity for a range of taxa across continents, although some species might profit regionally from climate warming [1].

Ghazoul assumes that a few remaining generalist pollinators will ensure pollination services in the future [1]; however, even crops with generalized pollination systems have been shown to profit from high pollinator diversity [8], and specialized crops can be expected to rely more on diverse pollinator assemblages. Furthermore, self-compatible plants, as well as self-incompatible plants, can profit from insect pollination [8–11]. Historical reports of crop vulnerability to pollinator loss (e.g. date, figs and oil palm) demonstrate the dependence of crops on animal pollination; according to an extensive literature survey by Free [9], the majority of the most important crops providing fruits or seeds for human consumption benefit from animal pollination. In addition, many vegetative crops (e.g. carrot) and forage crops (e.g. alfalfa and clover) largely depend upon insect pollination for seed production [9], an aspect that Ghazoul does not adequately consider [1]. Simply comparing staple cereals with other crops ignores the value of food diversity and the nutritional (proteins, vitamins and minerals) contribution of animal-pollinated crops. We agree with Ghazoul that current monetary valuations of pollination services are imprecise [1], but we disagree that only economically minor crops are of concern.

It is misleading to imply that most pollinator-dependent crops are grown in diversified agro-ecosystems that are likely to support healthy pollinator communities [1]. Small-scale diversified agro-ecosystems are globally threatened by agricultural intensification [12] and the above-mentioned pollinator-dependent cash crops are increasingly grown in intensive monocultures. Thus, it is also misleading to state that highly managed agro-ecosystems are largely independent of wild pollinators [1]. Distance from natural or semi-natural habitats has been found to have negative effects on species richness and abundance of crop pollinators in America [4,10], Asia [8] and Europe [9]. Even extensive agro-ecosystems depend on pollinator sources from neighbouring natural habitats for high fruit-set [8], although appropriate management practices could enhance local pollinator diversity [1]. Other recent studies demonstrate that fruit set within monocultures varies in relation to availability of wild pollinators [4,10,11]. These studies contradict Ghazoul's assumption that, in highly managed systems, pollination services either persist or do not limit production [1], and suggest that agricultural intensification will increase the dependence of animal-pollinated crops either on wild pollinators in remaining natural habitats [4,10] or on managed pollinators [9].

The existing studies demonstrate the loss of pollination services for some major crops and imply a more general

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risk for pollination services in the future, in both agricultural and natural ecosystems. The evidence to date is more than sufficient to justify management actions and underlines the importance of the ongoing large-scale initiatives on five continents to assess the magnitude, mechanisms and consequences of pollinator declines.

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Letters Response

Response to Steffan-Dewenter *et al.*: Questioning the global pollination crisis

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In both the academic literature and the wider media, concerns about declining pollinator populations, loosely termed 'the global pollination crisis', have been recently highlighted [1–3]. It is implied by such reports that a consequence of these declines is the degradation of pollination as an ecosystem service: in other words, a loss of crop productivity. In my Opinion article in *TREE* [4], I comment on the foundation upon which these concerns are based, and argue that, although evidence for declines is strong for several pollinator species, others show considerable resistance to environmental change and disturbance. These mixed responses are largely ignored by proponents of the global pollination crisis, but need to be highlighted in any balanced treatment of pollinator community dynamics.

Thus, I do not question reported declines among solitary and social bees (as well as pollinating birds, bats and other taxa), citing the same studies in my article [4] that Steffan-Dewenter *et al.* refer to in their response [5]. Rather, I argue that a high dependency on honeybees for crop pollination in North America, coupled with the unquestioned decline in managed honeybee colonies, has galvanized a portrayal in media outlets of a 'pollinator crisis' that reflects neither the complexity of pollinator responses to disturbances nor the differential dependencies of crops on pollinators. Academics, myself included, recognize declines in less familiar pollinator taxa, as Steffan-Dewenter *et al.* emphasize [5], but should not ignore examples of resistance and long-term population stability in changing landscapes when evaluating the extent and impact of the 'crisis'.

I agree with the second point of Steffan-Dewenter *et al.* [5] that many crops, including self-compatible varieties, benefit from pollination, and that pollinator diversity, abundance and distance of the crop from semi-natural habitats can enhance productivity [4]. However, the broader issue that encompasses their second and third points [5] is that justifying the conservation of pollinators on the basis of the services that they provide to agriculture is open to criticism if crop productivity does not, in fact, decline with wild pollinator losses. Examples of declining productivity that can be attributed to pollinator losses exist (e.g. almonds and alfalfa [6,7]) but these belong mainly to intensive agricultural systems whose pollination demands cannot, as has long been recognized [8], be met by wild pollinators alone and which rely instead on imported and managed pollinators. The decline of wild

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