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COMMENTARY

Insect Conservation and Diversity

Removing non-crop flowers within orchards promotes the decline of pollinators, not their conservation: A comment on McDougall et al. (2021)

Diego N. Nabaes Jodar[1,2] | Néstor Pérez-Méndez[3] | Cristina Botías[4] | Lucas A. Garibaldi[1,2] | Pablo L. Hunicken[1,2] | Elena Velado-Alonso[5] | Carlos Zaragoza-Trello[5]

[1]Universidad Nacional de Río Negro, Instituto de Investigaciones en Recursos Naturales, Agroecología y Desarrollo Rural, Río Negro, Argentina

[2]Consejo Nacional de Investigaciones Científicas y Técnicas, Instituto de Investigaciones en Recursos Naturales, Agroecología y Desarrollo Rural, San Carlos de Bariloche, Río Negro, Argentina

[3]Sustainable Field Crops Program, IRTA-Amposta, Tarragona, Spain

[4]Departamento de Ciencias de la Vida, Universidad de Alcalá, Madrid, Spain

[5]Estación Biológica de Doñana (EBD-CSIC), Seville, Spain

Correspondence

Diego N. Nabaes Jodar, Anasagasti 1463, San Carlos de Bariloche (8400), Argentina.

Email: diegonabaes@gmail.com

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Abstract

1. Abundant and diverse floral resources are needed for the preservation of pollinator populations and the services they provide to human societies. However, pollinators are negatively affected by several agricultural practices, among which pesticide use and 'weed' removal stand out.
2. McDougall et al. (2021) published a paper titled 'Managing orchard groundcover to reduce pollinator foraging post-bloom', where they propose removing the within-field flowering ground vegetation after the mass flowering period of the crop ends, to reduce pesticide exposure.
3. They consider this is a bee conservation strategy, after observing it reduces the abundance and diversity of pollinators within the crop. However, despite assuming this implied a realisation of an expected reduction in pesticide exposure, this was not quantified.
4. Here, we give three main arguments against the proposal of the authors, that is, the need for providing accessible, sufficient, safe and seasonally-spread feeding resources to crop pollinators, the potential role of diverse floral resources in their pesticide tolerance, and the urgent need to reduce pesticide use and impact in agriculture.

KEYWORDS

hedgerows, pesticides, pollination service, sustainable agriculture, wild flower strips

INTRODUCTION

Reducing the exposure of pollinators to pesticides is an important issue aimed at preserving biodiversity and ecosystem functioning in agroecosystems (Gill et al., 2012; Goulson et al., 2015). In order to prevent this and other related issues like human exposure to dangerous agrochemicals (Castiello et al., 2023; Vanbergen et al., 2020), the main principles for improving the sustainability of agriculture include fostering the development of existing natural processes, as well as the internal cycling of nutrients and energy. This can be done, for example, by reducing the use of herbicides and insecticides, increasing the biodiversity within crop fields, and avoiding bare soil with permanent vegetation cover (Brodt et al., 2011; Garibaldi et al., 2017; Horrigan et al., 2002; Kleijn et al., 2019; Kremen et al., 2012). In a recent paper by McDougall et al. (2021) published in the journal '*Pest Management Science*' entitled 'Managing orchard groundcover to reduce pollinator foraging post-bloom', the authors propose removing flowering ground herbs once the mass flowering period of the crop ends as a bee conservation strategy. With a multiyear field-experimental approach, they conclude this practice reduces the abundance and diversity of pollinators within the crop during the post-bloom stage, thus, reducing their exposure to pesticides. Nevertheless, though this reduced pesticide exposure is expected, it was not quantified, limiting the understanding about the effectiveness of this management to really protect pollinators from insecticides and fungicides. We instead advocate for providing feeding resources to farm-associated pollinators and other beneficial fauna through the promotion of flowering herb cover within crop fields (Requier et al., 2015), as well as reducing herbicide and pesticide use (EC, 2022; Goulson et al., 2015). In the following paragraphs, we give arguments against the proposal of McDougall et al. (2021):

Removing flowering ground cover reduces the feeding habitat for pollinators

Habitat loss is among the main drivers of pollinator decline in agricultural landscapes, which is mainly mediated by the reduction of floral and nesting resources associated with intensive agriculture (González-Varo et al., 2013; Parreño et al., 2021; Potts et al., 2010). The strategy proposed by McDougall et al. (2021) entails the removal of ground cover through the application of herbicide after the mass flowering of crops, therefore, shortening the availability of nectar and pollen to the broad range of pollinators distributed within crop fields. McDougall et al. (2021) defend this management practice as a conservation tool by assuming a relocation of pollinators from orchards to surrounding nominally pesticide-free seminatural areas after removal of ground cover. Yet, in our opinion, this assumption has several flaws:

Limited home-ranges for most solitary bee species: The authors argue that 'Many important pollinators have relatively long foraging ranges, such as honey bees, which can forage several kilometres from their hives', therefore pollinators can track floral resources in surrounding seminatural areas. However, evidence shows that, apart from the *Apis* genus and some bumblebees, most bee species exhibit typical foraging ranges below 1 km from nesting areas (Greenleaf et al., 2007; Hofmann et al., 2020; Zurbuchen, Cheesman et al., 2010; Zurbuchen, Landert, et al., 2010). Moreover, individual farmers may not be able or allowed to manage vegetation outside their establishments to preserve or promote flowering vegetation at the landscape scale (possibly excepting, e.g., large farms that encompass landscape scales on their own). Therefore, we expect that in many contexts this proposed mitigation measure cannot be applied in the same fashion, nor is it as feasible, as the promotion of within-field ground cover flowering vegetation.

Orchard boundaries likely offer significantly less area than orchard access rows: Besides landscape-scale enhancements, McDougall et al. (2021) suggest the use of flowering vegetation surrounding the orchards (e.g., hedgerows) as a mitigating measure to compensate for the negative effects of their proposed strategy. However, despite the great potential of surrounding vegetation to support pollinators (e.g., through perennial species) and the importance of combining multiple types of semi-natural habitats (Maurer et al., 2022), access rows between crop-rows offer a much larger area for flowering vegetation, especially in intensive perennial orchards. For example, in a square-shaped apple orchard with typical 20 crop rows per hectare, the ratio between hallways to edges is *c*. 5:1 in a 1 ha field, *and* it grows to *c*. 40:1 in a 16 ha field (considering a typical 5-m-wide access rows and field edges). As found recently in apple orchards (Bishop et al., 2023; von Königslöw et al., 2022), it is not clear that hedgerows alone, or associated with more distant surrounding vegetation, would be able to support the number and diversity of potential crop-flower visitors feeding from the ground cover vegetation within-field. Furthermore, in terms of ecosystem service provision, although floral enhancements in the edges have been found beneficial for pollinators there, a meta-analysis observed inconsistent effects within crop fields in terms of yield (Zamorano et al., 2020), therefore, the removal of ground-covering flowers could have an economic impact.

Pesticides everywhere: In spite of being proposed as a mitigating measure, flowering plants around the orchard can also be a path of pesticide exposure to pollinators, since pesticide drift into field edges and beyond is very common (Otto et al., 2009). Moreover, the authors suggest that the elimination of flowering ground cover and the continued use of pesticides should be applied at a larger scale in order to see stronger effects (i.e. fewer pollinators within crops); this could result in irreversible losses of landscape-scale biodiversity and ecosystem services, as many of the fleeing pollinators would probably not be able to find suitable habitat.

Long-term matters: removing flowering ground cover can have long-lasting effects on pollinator communities and crop yield: Management actions applied after crop blooming can impact the pollinator community of the following years, both before, during and after crop bloom (Schellhorn et al., 2015 and references therein). For example, Blaauw and Isaacs (2014) reported that blueberry fields with added wildflower plantings only showed effects on pollinators after 3 years. However, McDougall et al. (2021) focused the sampling effort as well as the interpretation of their results only in the period after crop bloom (across 3 years), not acknowledging that pollinator populations depend on the whole growing season to maintain or increase their abundance (Timberlake et al., 2019). Therefore, practices decreasing the availability of food during a large part of the year could negatively impact their numbers in the following seasons (Nicholls & Altieri, 2013; Westphal et al., 2003). Available nectar and pollen sources should be maintained as long as possible throughout the growing season, especially before the bloom of early flowering temperate crops, with little time between pollinator emergence and crop bloom (Campbell et al., 2017). Considering the great importance that diverse communities of pollinators can have to crop pollination, as highlighted by McDougall et al. (2021) for their own study system, eliminating a large portion of pollinator food resources could negatively impact their contribution to crop yields.

Diverse food sources could mitigate the effects of pesticides

The negative effects of the exposure to a fungicide in several metrics of *Bombus terrestris* colony performance under a mono-floral diet were not detected when offered a mix of flower species, showing that besides the direct positive effect on fitness, diverse floral resources increase bumblebee fungicide tolerance (Wintermantel et al., 2022). A similar result was found for *Bombus vosnesenskii* colonies, with the negative effects of exposure to common pesticides on reproduction being ameliorated in sites with flower plantings (Rundlöf et al., 2022). Furthermore, studies on *Osmia lignaria* showed additive effects of food resource stress and insecticide exposure on behaviour (Stuligross et al., 2023), reproduction and survival (Stuligross & Williams, 2020). These findings suggest that an augmented pesticide tolerance of pollinators achieved by access to diverse floral resources is another important reason to increase flower abundance and diversity within crop fields; this means that pesticides and more flowers are better than pesticides and less flowers. However, if the remaining landscape offers enough food resources, *some* individuals (or colonies) nesting at pesticide-safe distances from the crop, and belonging to highly mobile species, could be benefited by not having wild flowers to visit within an orchard treated with pesticides after crop bloom. But even in this scenario, other individuals from the same species, as well as from other less mobile species, could attempt to nest inside the orchard, and suffer the impacts of pesticides in a flower-poor environment. Therefore, the potential for a net benefit of removing non-crop flowering plants is not clear.

Compliance with regulations should occur through reductions in insecticide and herbicide use, and via improvements in their safety to non-target organisms

McDougall et al. (2021) suggest that compliance with US-EPA regulations ('minimize exposure of this product to bees and other pollinators when they are foraging on pollinator attractive plants around the application site') would be facilitated to farmers by reducing the abundance and diversity of pollinators in their crop fields via eliminating flowering ground cover. In the introduction, the authors state: 'There is growing recognition that IPM tactics should be combined with pollinator management strategies (…) and thus if this technique can meet both objectives it would be a potentially valuable tool in the repertoire of crop managers'. However, the objective of crop managers is generally to maintain or increase crop productivity and profit (hopefully in a sustainable manner), not to reduce pesticide exposure per se. We fear that the practice proposed by the authors could be used by practitioners as a justification for more simplified agriculture with high pesticide and herbicide use, and less diversity (both plants and animals). Abundant and diverse flower resources are needed for preserving and improving the health of pollinator communities in agroecosystems and enhancing yields of pollinator-dependent crops (Garibaldi et al., 2014). A possible short-term benefit to producers might be an increase in compliance with legal restrictions (e.g., US-EPA). However, in this case, the compliance would occur as a result of the elimination (by displacement and/or death) of pollinators from local orchards, which is not a desirable outcome from a conservation nor a productivity perspective. Furthermore, although habitat loss and decreasing plant diversity are the most significant indirect effects of herbicides impacting on pollinator species, there is growing evidence showing that herbicides have harmful direct impacts on the health of pollinators (Battisti et al., 2021; Blot et al., 2019; Motta et al., 2018, 2022). The idea of using pollinator-harmful compounds to conserve them seems contradictory, and against the principles of 'Integrated Pest and Pollinator Management (IPPM)' strategies.

CONCLUSIONS

The main cause of pollinator decline is intensive agriculture (Dicks et al., 2021; IPBES, 2016; Vanbergen et al., 2020), dominated by monocultures and pesticide use, which generates landscapes with low plant diversity (Goulson et al., 2008; Ollerton et al., 2014; Potts et al., 2010, 2016). The opportunities to increase plant diversity in agroecosystems both temporally and spatially must be seized (Mandelik et al., 2012). One opportunity is the promotion of ground cover flowering plants in access rows between perennial crop rows, which can provide food resources for diverse pollinators and other beneficial fauna (García & Minarro, 2014; Karamaouna et al., 2019; Peris-Felipo et al., 2021). Reducing herbicide and insecticide use is a key complementary strategy to that of diversifying ground cover vegetation in the path to (i) preserve and recover pollinator populations in croplands, and (ii) to promote a more sustainable form of agriculture as a whole (EC, 2022; Goulson et al., 2015).

More productivity of pollinator-dependent crops is generally associated with higher pollinator abundance and diversity within crop fields (Garibaldi et al., 2016; Garratt et al., 2023; Reilly et al., 2020). As McDougall et al. (2021) found, the elimination of ground flowering plants and the use of pesticides removes pollinators from crop fields. No benefit to biodiversity and ecosystem function is thus expected if a reduction in pesticide exposure is achieved via a reduction in plant diversity at orchard scale. Rather, upscaling these practices could trigger negative impacts at large spatio-temporal scales on the diversity of pollinators, and of many other important fauna, ultimately affecting important ecosystem services such as crop pollination.

AUTHOR CONTRIBUTIONS

Diego N. Nabaes Jodar: Conceptualization; writing – review and editing; writing – original draft; investigation; supervision. **Néstor Pérez-Méndez:** Writing – original draft; writing – review and editing. **Cristina Botías:** Writing – review and editing. **Lucas A. Garibaldi:** Writing – review and editing. **Pablo L. Hunicken:** Writing – review and editing. **Elena Velado-Alonso:** Writing – review and editing. **Carlos Zaragoza-Trello:** Writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

ORCID

Diego N. Nabaes Jodar https://orcid.org/0000-0002-8572-9495
Néstor Pérez-Méndez https://orcid.org/0000-0001-6264-2920
Cristina Botías https://orcid.org/0000-0002-3891-9931
Lucas A. Garibaldi https://orcid.org/0000-0003-0725-4049
Pablo L. Hunicken https://orcid.org/0000-0001-8878-6092
Elena Velado-Alonso https://orcid.org/0000-0003-4805-2929
Carlos Zaragoza-Trello https://orcid.org/0000-0002-6824-3143

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