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Informing policy and practice on insect pollinator declines: Tensions between conservation and animal welfare

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Climate change, agricultural intensification, and other anthropogenic ecosystem challenges have caused declines in the diversity and abundance of insect pollinators. In response to these declines, entomologists have called for greater attention to insect pollinator conservation. Conservation primarily aims to protect groups of non-human animals—populations or species—with only secondary concern for the welfare of individual animals. While conservation and animal welfare goals are sometimes aligned, they often are not. And because animal welfare comes second, it tends to be sacrificed when in tension with conversation priorities. Consider, for example, lethal sampling to monitor many pollinator populations. Growing evidence suggests that the welfare of individual insect pollinators may be morally significant, particularly in the Hymenoptera and Diptera. Considering insect welfare in conservation practices and policies presents many challenges as, in the face of rapid, anthropogenic change, it may be impossible to avoid harming individual animals while promoting diverse populations. We suggest some practical, implementable strategies that can allow for more robust integration of animal welfare goals into insect pollinator conservation. By following these strategies, entomologists may be able to find policies and practices that promote the health of ecosystems and the individual animals within them.

KEYWORDS

ethics, pollinator conservation, insects, animal welfare, monitoring programs, green infrastructure, policy

Introduction

Insect pollinators are in peril: anthropogenic climate and habitat changes have caused abundance, diversity, and body size declines, as well as range, phenology, and ecological relationship shifts (Cane et al., 2006; Bartomeus et al., 2011; Kuhlmann et al., 2012; Burkle et al., 2013; Barrett and Johnson, 2022; Turley et al., 2022). In the face of this rapid and unprecedented biodiversity crisis (Schachat and Labandeira, 2021), entomologists have called for greater attention to pollinators in conservation and policymaking.

Conservationists aim to maintain biological diversity, ecological health, and ecosystem integrity (Trombulak et al., 2004). These goals require focusing on populations and species—groups of non-human animals—with secondary concern for the welfare of the individual members of those groups. Although conservation goals are sometimes aligned with individual welfare—that is, how a single organism is faring from its own subjective perspective—they can conflict too. For instance, population control measures may enhance ecosystem integrity while causing harm to the individual animals being controlled. While such measures may be necessary, conservationists are increasingly concerned with minimizing such harms (Dubois et al., 2017; Sekar and Shiller, 2020). Our aim here is to consider the prospects for harm minimization in the context of conserving insect pollinators.

The welfare of sentient organisms—i.e., organisms with the capacity to feel pain (Singer, 2002)—matters morally. There is currently no scientific consensus on insect sentience (Adamo, 2016; Klein and Barron, 2016; Birch, 2020; Chittka, 2022; Gibbons et al., 2022). However, two important groups of insect pollinators– the Hymenoptera (including wasps and bees), and the Diptera (including flies) –meet many of the criteria in the Birch et al. (2021) framework for assessing animal sentience. Using this framework to review over 300 scientific studies of insect neurobiology and behavior, Gibbons et al. (2022) found "substantial evidence for sentience" in Hymenoptera and "strong evidence for sentience" in Diptera. There is also "strong evidence for sentience" in decapod crustaceans, which guaranteed their protection by the UK government in the 2022 Animal Welfare (Sentience) Act (Birch et al., 2021). Though not decisive, there is reason to take the possibility of insect sentience, and thus welfare, seriously. A precautionary approach could involve making efforts to minimize possible harm by treating insects as though they are sentient while collecting additional data (Fischer, 2016, 2019; Birch, 2017). Since most insect conservation efforts are not structured around a precautionary approach, adopting such a stance could have significant implications for the design and implementation of interventions, programs, and policies—as we will demonstrate in the following section.

Potential conservation-welfare conflicts for insect pollinators

Coordinated action to improve wild pollinator conservation first became highly publicized in the United States through "The Forgotten Pollinators" book and Arizona-Sonora Desert Museum pollinators' campaign (Buchmann and Nabhan, 1996). Since the 1990s, numerous pollinator conservation actions and policies have been implemented or proposed (Williams, 2003; Byrne and Fitzpatrick, 2009; Hall and Steiner, 2019; Marselle et al., 2020; Stout and Dicks, 2022). In the next two subsections, we briefly review two examples that highlight tensions between conservation goals and individual insects' welfare. We also suggest some ways that those tensions might be reduced *via* adjustments to standard practices or policies.

Monitoring programs that include lethal sampling

Most proposals for conserving insect pollinators include the need to increase community-level monitoring efforts (Dicks et al., 2016; Woodard et al., 2020; but see Tepedino and Portman, 2021) to inform interventions and assess their impact. Monitoring programs often include passive lethal sampling methods, such as pan traps, that keep field labor, expenses, and expertise relatively low while allowing for subsequent species-level identifications. Biweekly tests of pan traps, combined with sweep-netting, suggest that they do not affect long-term trends in bee abundance or diversity (Gezon et al., 2015; but see vane traps, Gibbs et al., 2017).

However, lethal monitoring programs present obvious welfare problems (Fischer and Larson, 2019). Insects drown, starve/desiccate, or die *via* poisoning, all of which may induce pain and stress. This is a special problem for "bycatch" insects, which comprised nearly 63% of individual captured arthropods in pan traps in Gonzalez et al. (2020). These insects are rarely used to generate data and are often discarded, offering no clear conservation benefit and constituting a negative welfare impact. Additionally, conservationists are increasingly concerned about the impact of lethal monitoring on target species (Tepedino and Portman, 2021; Montero-Castaño et al., 2022), particularly those that are vulnerable or threatened: a case study of North American bumble bees showed an increase in the number of lethal collections since the 1990s, even though data demonstrating taxonomic resilience of many recently imperiled bumble bee species are sparse (Miller et al., 2022).

There are several ways to reduce the welfare costs of monitoring initiatives. First, researchers could focus on developing protocols that minimize bycatch. For example, smaller pan traps reduce bycatch without changing bee monitoring efficacy (Gonzalez et al., 2020). Second, making bycatch (and target; Montero-Castaño et al., 2022) specimens/data more accessible could reduce the necessity for other lethal sampling studies (Spears and Ramirez, 2015;

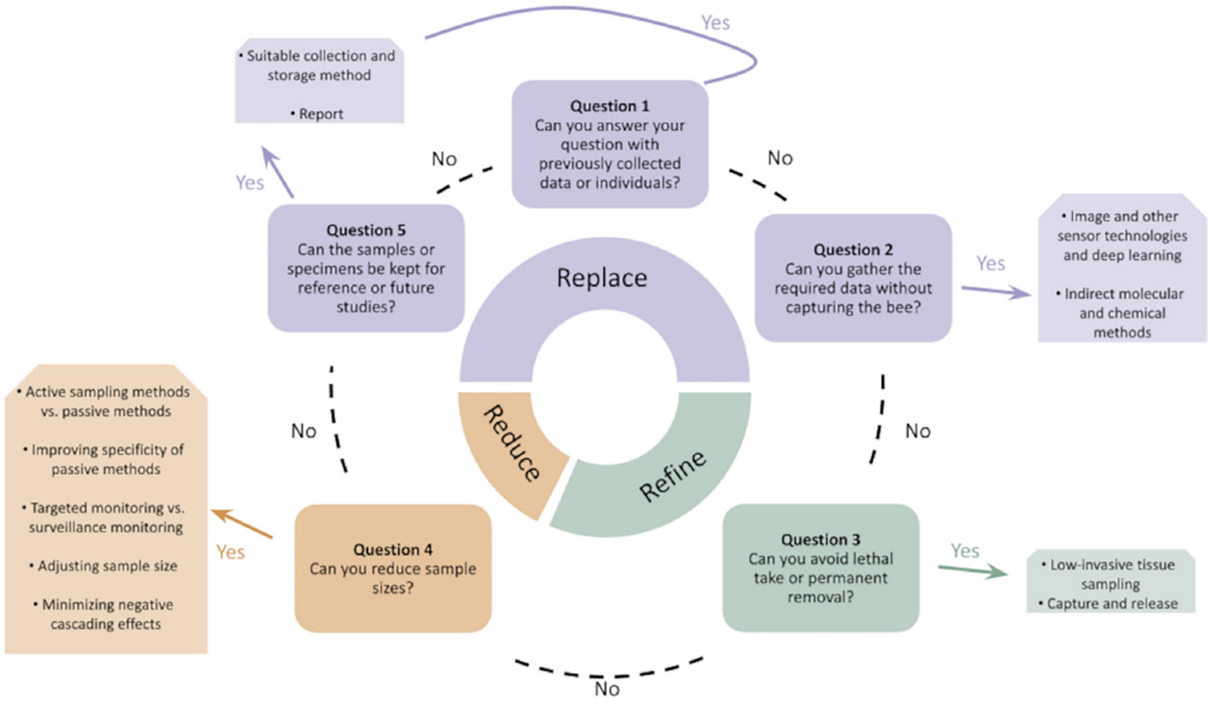

FIGURE 1
Decision-making framework for replacing, refining, and reducing lethal bee captures in monitoring programs, reproduced from Montero-Castaño et al. (2022) (CC BY 4.0).

Fischer and Larson, 2019). Third, scientists could reduce suffering in lethal monitoring programs by hastening insect time-to-death *via* different (or increased concentrations of) lethal agents.

There is little guidance available about the appropriate level of temporal or spatial sampling effort for many monitoring initiatives (but see: Lebuhn et al., 2013). Likewise, there is little guidance about how to handle biases and deficiencies in particular methodologies (Cane et al., 2000; Baum and Wallen, 2011; Didham et al., 2020), which may lead to "more is better" or "all of the above" approaches (Rhoades et al., 2017; Portman et al., 2020). However, sampling that does not provide additional, action-relevant information to support conservation goals should be avoided for welfare, conservation, and cost/storage/effort reasons (Droege et al., 2016; Tepedino and Portman, 2021). Consider the thousands of *Dialictus* (Halictidae) that are collected in pan traps and often go unidentified to species due to the lack of available taxonomic expertise. Most of these individual bees offer little value to monitoring and conservation efforts (Portman et al., 2020), yet represent a significant negative welfare impact. To avoid over collection, models built from meta-analyses of capture data in different habitats with different methods could be used to estimate the actual sampling effort (temporal frequency, sites, methods) required to answer specific questions of interest before establishing a sampling protocol.

Additionally, scientists could switch wholly or partially to non-lethal sampling methods depending on research needs; when new methods are non-invasive, this may support both welfare and conservation goals (Montero-Castaño et al., 2022; **Figure 1**). Expert transects, where taxonomic experts go into the field to collect data on insect diversity using transects, can produce similar species accumulation curves as pan traps for hoverflies and bees in some habitats while collecting far fewer individuals (O'Connor et al., 2019; but see Rhoades et al., 2017). Conservation and insect welfare goals are thus also aligned in the need to train additional taxonomic experts (Hopkins and Freckleton, 2006) that could support less-lethal monitoring programs. Developing/validating new, non-invasive methods (like eDNA; Thomsen and Sigsgaard, 2019) or using a community- (e.g., "citizen")-science-driven photographic BioBlitz (Bickerman-Martens et al., 2017; or iNaturalist-style databases, Gazdic and Groom, 2019) could also support conservation-relevant data collection. Barlow and O'Neill (2020) and Miller et al. (2022) review other non-lethal techniques not yet widely employed for pollinator monitoring, including: telemetry/radar, automated visual monitoring, machine-learning identification, molecular analyses, acoustic monitoring, and fecal sampling.

Finally, some scientists have suggested that large-scale, community-level monitoring may be overemphasized for obtaining conservation-relevant data on pollinator ecology (Tepedino and Portman, 2021). Population-level studies of a few, carefully chosen pollinator species that are field- or photograph-identifiable could serve just as well for answering *many* action-relevant questions (Portman et al., 2020; Tepedino and Portman, 2021; Dorian and Crone, 2022). Visual monitoring is already used for some large and easily identifiable groups such as bumble bees and certain butterflies (Montgomery et al., 2021), alongside netting in areas where lethal sampling might harm endangered species (Portman et al., 2020; and see non-lethal protein mark-recapture for vulnerable species, Boyle et al., 2018).

Creating diverse habitats in agricultural areas

Habitat fragmentation/simplification caused by agricultural intensification can negatively impact pollinator foraging activity and movement, thereby reducing abundance and diversity. This has led to calls for increasing "green infrastructure" for biodiversity maintenance in agricultural areas (Brown and Paxton, 2009; Dicks et al., 2016), which may include native plants alongside agricultural fields (Williams et al., 2015) or creating habitat corridors to allow for increased movement across resource-poor areas (Blüthgen et al., 2022). Green infrastructure may provide welfare benefits to wild pollinators by increasing resource availability and diversity, with positive impacts on health (St. Clair et al., 2020). However, increasing the proximity of wild pollinators to agricultural areas also harms the many animals newly inhabiting these spaces through increased exposure to agrochemicals with lethal or sublethal welfare effects (Susan et al., 2019) and other anthropogenic welfare challenges (e.g., exposure to light pollution and vehicle strikes near road verges; Phillips et al., 2019; Owens et al., 2020).

Some of these welfare effects could be mitigated by incentivizing simultaneous reductions in agrochemical usage, alongside the diversification of agricultural systems and creation of pollinator protection zones in areas where green infrastructure will be created (which may also support honey bee welfare; St. Clair et al., 2020). While this additional incentive structure may reduce the total amount of green infrastructure that can be created, each incentive is both a conservation and welfare benefit to the pollinators in that area. This holistic approach to improving pollinator conservation *via* multiple means demonstrates one of the ways that policy might be re-structured (and re-budgeted) if welfare and conservation were considered simultaneously. Notably, some of these same issues (and urban heat island effects) will also affect wild bee populations in urbanized areas with greenspace development (Baldrock, 2020), but different incentive structures will be needed in these spaces.

Discussion

There is significant value in conserving species, populations, and ecosystems. It is also morally important to consider the welfare of non-human animals (Fischer, 2021), including many invertebrates (Koperski, 2022). We have demonstrated that conservation and welfare goals may sometimes conflict, as in the expansion of lethal pollinator monitoring programs and the creation of green infrastructure near some agricultural habitats. In many cases, it is not possible to achieve conservation goals without some harm to non-human animals. However, there appear to be ways for researchers, conservationists, farmers, and policymakers to reduce harms to non-human animals while pursuing their conservation goals. So, a precautionary approach to insect welfare is compatible with their aims (and, in some cases, may even help them achieve their aims: Capozzelli et al., 2020).

One way to promote harm reduction is to encourage welfare-oriented cost-benefit analyses in grant applications and conservation management plans—a practice that is familiar from environmental cost-benefit analysis (Atkinson and Mourato, 2008). In some cases, making the costs explicit may be sufficient to show that they are negligible relative to the potential welfare benefits.

In other cases, of course, it will be less clear what to prioritize. Eventually, then, it will be important to develop frameworks for comparing the relative importance of various costs (financial, temporal, etc.), specific conservation goals, and welfare impacts (e.g., more resource-intensive monitoring methods and the particular welfare impacts of those methods). One path forward involves developing tools that allow stakeholders to express the value they assign to avoiding negative welfare impacts in monetary terms, which could then be aggregated to determine how much stakeholders ought to be willing to pay to avoid causing those impacts (Lusk and Norwood, 2011). While economists, animal welfare scientists, and philosophers are in the early days of creating such tools—for insects and non-insects alike—entomologists can contribute to these efforts by studying insect welfare and quantifying the insect welfare impacts of different conservation practices.

In the interim, it is important simply to make welfare impacts on insects salient in discussions of conservation practices and policies. Insects warrant some consideration and we can reduce many harms to them without compromising conservation goals.

Author contributions

MB: conceptualization. MB, BF, and SB: writing/editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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