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Editorial: Ladybirds: Conservation, ecology and interactions with other organisms

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Editorial on the Research Topic
Ladybirds: Conservation, ecology and interactions with other organisms

Human impact on the natural world has expanded enormously over the past century and a half, with rapid population growth and an increasingly globalized economy causing pollution, habitat destruction, and climate change (Johnson et al., 2017). This threatens biodiversity and proper functioning of natural ecosystems, which we depend on for resources (wood, food, etc.) and ecological services (water storage and purification, waste treatment, pollination, etc.) (Vilà et al., 2006; Newbold et al., 2015; Dasgupta, 2021). One major problem is the ecological disturbance caused by organisms invading ecosystems outside their natural ranges—these invasions may occur inadvertently, for example through international trade, or be the result of deliberate introductions that have got out of control (e.g., Allendorf and Lundquist, 2003; Dunn and Hatcher, 2015; Pfliegler et al., 2018). Invading species disrupt the normal functioning of ecosystems by directly outcompeting native species, destabilizing food webs, or affecting the cycling of nutrients through the ecosystem. Almost without exception, invading species set in motion a chain of ecological effects that eventually result in ecosystems that are less healthy and less productive. Invasive alien species (IAS) are often considered pests and can drive biodiversity declines globally (Mollot et al., 2017). A prime example of one such deliberate introduction that has gone awry is that of *Harmonia axyridis*, the harlequin ladybird (Brown et al., 2011; Roy et al., 2016).

Ladybirds (Coleoptera, Coccinellidae) are primarily predaceous insects. They play a crucial role in the regulation of herbivorous insect populations in natural and managed

systems. For decades, a countless number of individuals of different species have been introduced in regions to which they were not native as part of classical biological control strategies. However, from a conservationist viewpoint, these approaches have been revealed to have negative effects on native biota (Soares et al., in press; Rondoni et al., 2021). In the last 30 years, populations of many formerly common native species of ladybird have declined in several countries in North and South America and Europe. This occurred in tandem with increasing populations of two IAS, *Coccinella septempunctata* (seven-spotted ladybird) in North America and *H. axyridis* globally (e.g., Evans et al., 2011; Roy et al., 2016; Brown and Roy, 2018; Camacho-Cervantes et al., 2017; Hiller and Haelewaters, 2019).

Ladybirds face many threats. Some species might be at risk of extinction due to habitat loss and fragmentation, invasive species, pollution by agrochemicals, climate change, and overexploitation of resources (e.g., Harvey et al., 2020). In light of this, the International Union for Conservation of Nature (IUCN) Species Survival Commission (SSC) Ladybird Specialist Group consisting of 50 members was recently established, with the following goals: (*i*) identify ladybird species with high extinction risk, (*ii*) determine the factors leading to high extinction risk, (*iii*) develop strategies to manage risk and improve the conservation status of these species, and (*iv*) implement conservation management for threatened ladybird species (IUCN SSC Ladybird Specialist Group, 2018). As a first major output from this group, Soares et al. (in press) reviewed the major ecological threats currently facing ladybirds and identified actions contributing to the conservation and recovery of ladybird populations. These authors proposed a roadmap for ladybird conservation strategies at different timescales. Conservation of locally native ladybirds does not only depend on the collation of existing information (for IUCN Red List assessments), but also on active collaborations among stakeholders (researchers, citizen scientists, conservation practitioners) to share data, coordinate standardized surveying efforts, and efficiently disseminate results.

The eleven papers in this Research Topic contribute directly to this conservation effort, through actions and solutions at short-term, mid-term, and long-term timescales (Soares et al., in press). Three papers address short-term, so-called "no-regret" solutions towards education for awareness, citizen science, and capacity building. The European Ladybirds smartphone application (Skuhrovec et al.) is a collaborative citizen science project to compile records of ladybirds across Europe and assess distributional changes over time, while connecting and engaging people in nature and increasing awareness about the diversity and ecological importance of ladybirds. Weyman et al. evaluate the role of citizen scientists in collecting distribution data in Ireland based on the submission of pictures through social media channels, using ladybirds as a case example. Stowe et al. demonstrate that pollen and nectar increase reproductive success and alter oviposition patterns in *Hippodamia convergens*, highlighting the importance of floral resources in the agricultural landscape to the conservation of this aphid predator and its biocontrol services.

Several papers address mid-term actions. Zakharov et al. present new records of *H. axyridis* in Eastern Europe, showing occupation of new territory from the western borders of Russia to the Volga River, mainly in 2018–2020 and with a dispersal rate of 200 km/year. Two studies discuss the species composition and abundance of ladybirds in the center and outskirts of Prague, Czechia. Honek et al. reveal that the warm urban mesoclimate significantly supports the seasonal dynamics of IAS *H. axyridis*, whereas Skuhrovec et al. show that species richness and abundance of native ladybirds are lower in the urban center compared to the outskirts. Farrow et al. explore why *Coccinella quinquepunctata* is restricted to exposed riverine sediments in Wales and Scotland. The authors rule out an effect exerted by *H. axyridis*, but, instead, highlight negative impacts by an invasive alien herbaceous plant, *Impatiens glandulifera*: its shallow roots lead to increased susceptibility to erosion, and its effect on soil microbial communities results in homogenization of the native plant community. In their second contribution, Farrow et al. present the results of their standardized sampling in rural woodland sites in the UK and find that (1) *H. axyridis* does not dominate ladybird communities in these habitats and (2) there are distinct native ladybird communities associated with woodland type.

Systematic long-term monitoring of ladybirds, based on standardized sampling protocols, is a fundamental tool to understand species population dynamics. The study by Hesler and Beckendorf summarizes results from 14 years of sampling ladybirds in five field crops and restored prairie in eastern South Dakota, USA. Sample rates of ladybirds in alfalfa, spring grains, and corn are decreased compared to those of a previous long-term survey. Native adult ladybirds show a significant declining trend in corn but not in other habitats. The authors discuss their findings in light of prey availability in various crops and landscape variables.

Two papers of the Research Topic focus on natural enemies of *H. axyridis*. de Groot and Haelewaters review what is known about simultaneous infections of *H. axyridis*, highlighting the importance of incorporating multiple species interactions in future studies of this ladybird. Finally, Haelewaters et al. evaluate the effects of selected host, climate, and landscape variables on infection probability of *H. axyridis* with the microfungal ectoparasite *Hesperomyces harmoniae* (Haelewaters et al., in press). This community ecology work may prove vital for integrated pest management.

Author contributions

DH and AS drafted and revised the manuscript. All authors edited and approved the final version of the manuscript.

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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.

Publisher's note

References

Allendorf, F. W., and Lundquist, L. L. (2003). Introduction: Population biology, evolution, and control of invasive species. *Conserv. Biol.* 17, 24–30. doi: 10.1046/j.1523-1739.2003.02365.x

Brown, P. M. J., and Roy, H. E. (2018). Native ladybird decline caused by the invasive harlequin ladybird *Harmonia axyridis*: Evidence from a long-term field study. *Insect Conserv. Divers.* 11 (3), 230–239. doi: 10.1111/icad.12266

Brown, P. M. J., Thomas, C. E., Lombaert, E., Jeffries, D. L., Estoup, A., and Lawson Handley, L.-J. (2011). The global spread of *Harmonia axyridis* (Coleoptera: Coccinellidae): Distribution, dispersal and routes of invasion. *BioControl* 56, 623–641. doi: 10.1007/s10526-011-9379-1

Camacho-Cervantes, M., Ortega-Iturriaga, A., and Del-Val, E. (2017). From effective biocontrol agent to successful invader: The harlequin ladybird (*Harmonia axyridis*) as an example of good ideas that could go wrong. *PeerJ* 5, e3296. doi: 10.7717/peerj.3296

Dasgupta, P. (2021). *The economics of biodiversity: The dasgupta review* (London, UK: HM Treasury).

Dunn, A. M., and Hatcher, M. J. (2015). Parasites and biological invasions: Parallels, interactions, and control. *Trends Parasitol.* 31, 189–199. doi: 10.1016/j.pt.2014.12.003

Evans, E. W., Soares, A. O., and Yasuda, H. (2011). Invasions by ladybugs, ladybirds, and other predatory beetles. *BioControl* 56, 597–611. doi: 10.1007/s10526-011-9374-6

Haelewaters, D., Van Caenegem, W., and De Kesel, A. (in press). hesperomyces harmoniae, a new name for a common ectoparasitic fungus on the invasive alien ladybird *Harmonia axyridis*. *Sydowia*. doi: 10.12905/0380.sydowia75-2023-0053

Harvey, J. A., Heinen, R., Klein, A.-M., Armbrecht, I., Basset, Y., Baxter-Gilbert, J. H., et al. (2020). International scientists formulate a roadmap for insect conservation and recovery. *Nat. Ecol. Evol.* 4, 174–176. doi: 10.1038/s41559-019-1079-8

Hiller, T., and Haelewaters, D. (2019). A case of silent invasion: Citizen science confirms the presence of *Harmonia axyridis* (Coleoptera, coccinellidae) in central America. *PloS One* 14, e0220082. doi: 10.1371/journal.pone.0220082

IUCN SSC Ladybird Specialist Group (2018) *2018 report*. Available at: https://www.iucn.org/sites/dev/files/2018_ladybird_sg_report_-_publication.pdf (Accessed June 1, 2022).

Johnson, C. N., Balmford, A., Brook, B. W., Buettel, J. C., Galetti, M., Guangchun, L., et al. (2017). Biodiversity losses and conservation responses in the anthropocene. *Science* 356 (6335), 270–275. doi: 10.1126/science.aam9317

Mollot, G., Pantel, J. H., and Romanuk, T. N. (2017). Chapter two - the effects of invasive species on the decline in species richness: A global meta-analysis. *Adv. Ecol. Res.* 56, 61–83. doi: 10.1016/bs.aecr.2016.10.002

Newbold, T., Hudson, L. N., Hill, S. L. L., Contu, S., Lysenko, I., Senior, R. A., et al. (2015). Global effects of land use on local terrestrial biodiversity. *Nature* 520, 45–50. doi: 10.1038/nature14324

Pfliegler, W. P., Báthori, F., Wang, T. W., Tartally, A., and Haelewaters, D. (2018). *Herpomyces* ectoparasitic fungi (Ascomycota, laboulbeniales) are globally distributed by their invasive cockroach hosts and through the pet trade industry. *Mycologia* 110, 39–46. doi: 10.1080/00275514.2017.1418567

Rondoni, G., Borges, I., Collatz, J., Conti, E., Costamagna, A., Dumont, F., et al. (2021). Exotic ladybirds for biological control of herbivorous insects – a review. *Entomol. Exp. Appl.* 169, 6–27. doi: 10.1111/eea.12963

Roy, H. E., Brown, P. M. J., Adriaens, T., Berkvens, N., Borges, I., Clusella-Trullas, S., et al. (2016). The harlequin ladybird, *Harmonia axyridis*: Global perspectives on invasion history and ecology. *Biol. Invasions* 18, 997–1044. doi: 10.1007/s10530-016-1077-6

Soares, A. O., Haelewaters, D., Ameixa, O. M. C. C., Borges, I., Brown, P. M. J., Cardoso, P., et al. (in press). A roadmap for ladybird conservation and recovery. *Conserv. Biol.* doi: 10.1111/cobi.13965

Vilà, M., Tessier, M., Suehs, C. M., Brundu, G., Carta, L., Galanidis, A., et al. (2006). Local and regional assessments of the impacts of plant invaders on vegetation structure and soil properties of Mediterranean islands. *J. Biogeogr.* 33, 853–861. doi: 10.1111/j.1365-2699.2005.01430.x