Received: 31 October 2025 | Accepted: 26 January 2026
DOI: 10.1111/1365-2664.70311

BRITISH ECOLOGICAL SOCIETY Journal of Applied Ecology

PERSPECTIVE

Preventing the next invasion: Lessons from aquaculture for the safe expansion of insect farming

Eléna Manfrini[1,2] | Franck Courchamp[1] | Boris Leroy[2] | Åsa Berggren[3]

[1]Laboratoire des Organismes et des Ecosystèmes Aquatiques-BOREA, Museum National d'Histoire Naturelle (MNHN), SU, CNRS, IRD, UA, Paris, France
[2]Université Paris Saclay, CNRS, Agroparistech, Ecologie Systématique Evolution, Gif-sur-Yvette, France
[3]Department of Ecology, Swedish University of Agricultural Sciences, Uppsala, Sweden

Correspondence
Eléna Manfrini
Email: elena.manfrini@universite-paris-saclay.fr

Handling Editor: Maria Fernanda Peñaflor

Abstract

1. Insect farming is rapidly emerging as a sustainable alternative to conventional livestock, praised for its lower environmental impact and potential to enhance food system resilience. Yet, the ecological risks of large-scale insect cultivation remain underexamined—especially the threat of biological invasions following unintentional escapes.
2. This synthesis examines current knowledge of invasion pathways from both terrestrial and aquatic farming systems, drawing on the well-documented case of aquaculture to identify lessons for the insect farming sector.
3. We highlight shared risk factors across sectors, including the widespread farming of species with invasive traits, production outside native ranges and insufficient management frameworks. Aquaculture of crustaceans, as a close taxonomic and ecological analogue, illustrates how poorly managed industrial growth can result in significant ecological and economic costs.
4. *Policy implications*: We argue that preemptive risk assessments, species screening and transferable, adaptive regulatory frameworks developed for aquaculture offer a critical foundation for safeguarding against insect-driven invasions. Proactive governance that embeds these safeguards before large-scale expansion offers a rare opportunity to prevent invasion outcomes observed in other farmed taxa and to guide the insect farming sector towards genuinely sustainable growth.

KEYWORDS
aquaculture, biological invasions, insect farming, management, policies, prevention, sustainable farming, sustainable food production

1 | INTRODUCTION

The farming of animals for food has long shaped both terrestrial and aquatic ecosystems (Zeder, 2012). With a growing global population (Msangi & Batka, 2015; Pelletier & Tyedmers, 2010), the demand for animal-based food is projected to rise sharply, requiring a 35%–56% increase in global food production by 2050 (van Dijk et al., 2021). In response, aquaculture production tripled from 34 to over 100 million tonnes between 1997 and 2017 (Naylor et al., 2021), and terrestrial livestock production is expected to double by mid-century (FAO, 2006). However, the sustainability of both these food production systems is raising critical concerns about their long-term environmental impacts (Jiang et al., 2022; Tilman et al., 2011). In this context, this piece critically examines the ecological risk of biological invasions emerging from insect farming, an issue that has received little attention. We draw on insights from aquaculture, particularly crustacean farming, to identify parallels in species traits, farming practices and escape mechanisms that elevate invasion potential. By synthesizing lessons from aquatic systems and assessing their transferability to terrestrial arthropod farming, we aim to inform proactive biosecurity, regulatory strategies and sustainability planning on a still nascent insect farming sector.

2 | ENVIRONMENTAL IMPACTS OF TERRESTRIAL AND AQUATIC FARMING

Terrestrial livestock farming dominates global agriculture, occupying approximately 80% of all agricultural land—equivalent to nearly 30% of Earth's terrestrial surface (Poore & Nemecek, 2018). This sector is a major contributor to climate change, responsible for 44% of anthropogenic methane emissions, 29% of nitrogen emissions and 27% of CO_2 emissions (Gerber et al., 2013). It is also a significant driver of water scarcity, accounting for over 41% of agricultural water use, mainly for irrigating feed crops (FAO, 2019; Heinke et al., 2020). Furthermore, livestock farming contributes to severe water pollution, producing 74–88% of nitrogen, phosphorus and pathogen pollutants in rivers (Li et al., 2022). Lastly, livestock farming is also linked to biodiversity loss and ecosystem degradation, with domesticated livestock comprising around 62% of the total biomass of all mammals on Earth (Bar-On et al., 2018).

Aquatic livestock farming imposes similar environmental pressures. These include greenhouse gas emissions, land use changes and habitat loss—particularly through mangrove deforestation for pond construction, which reduces carbon sequestration and threatens coastal biodiversity (FAO, 2023b). Additionally, the release of antibiotics, fertilizers and hormones contributes to water pollution and eutrophication (Hamilton, 2020). Although aquaculture is often promoted as an alternative to wild capture fisheries, it frequently relies on feeds derived from wild fish stocks, sustaining pressure on marine ecosystems (Ahmed et al., 2019). High-density farming systems also facilitate the emergence and transmission of infectious diseases, posing risks to both farmed and wild populations (Diana, 2009; Naylor et al., 2021). These findings reveal that both terrestrial and aquatic farming systems contribute to increasing ecological pressures and therefore require improvement to achieve environmental sustainability and alignment with the United Nations Sustainable Development Goals for 2030 (United Nations, 2015). In light of these challenges, the search for more sustainable and environmentally responsible food production methods has intensified.

3 | THE SUSTAINABILITY PROMISE AND GLOBAL EXPANSION OF INSECT FARMING

In terrestrial systems, interest is growing in insect farming as a potential substitute for conventional livestock (FAO, 2021). Insects have been part of traditional diets, particularly in countries across the southern hemisphere such as Mexico, South Africa and Thailand (Jansson et al., 2019; Siddiqui et al., 2023; van Huis, 2022). Today, insect farming is rapidly expanding beyond traditional practices and is increasingly promoted as a sustainable alternative to conventional livestock production (Berggren & Low, 2024).

Insects generally exhibit superior feed conversion efficiency, and their farming demands significantly less land, water and energy (Guiné et al., 2021). Some species can even be reared on food waste, reducing dependence on conventional feed inputs and contributing to solve the problem of waste accumulation (Madau et al., 2020; Scherhaufer et al., 2018). Additionally, insect farming generates substantially lower greenhouse gas emissions compared to ruminant and poultry production (Oonincx et al., 2010; Vauterin et al., 2021). Insects are not only used as food for humans, but also as animal feed, for organic waste recycling and for producing by-products that can be utilized as fertilizers (Capitan et al., 2025; Guiné et al., 2021). While the exact number of insect species farmed globally remains uncertain, it is estimated that 1 to 1.2 trillion individual insects are raised annually for food and feed purposes (Rowe, 2020). Driven primarily by demand from the aquaculture, poultry and pet food sectors, the global insect farming industry is expanding rapidly, and the production for human consumption in Europe alone is projected to triple between 2025 and 2030 (Hancz et al., 2024; IPIFF (International Platform of Insects for Food and Feed), 2020; Makkar et al., 2014).

4 | RECOGNIZED RISKS AND IMPACTS OF BIOLOGICAL INVASIONS FROM WILD SPECIES FARMING

Farming wild species is a well-documented pathway for biological invasions, significantly contributing to the introduction and spread of non-native species (Kumschick et al., 2016; Turbelin et al., 2022). Farmed species may be introduced intentionally or escape unintentionally during transport, handling or from production facilities. Such introductions span various farming sectors and taxonomic groups. Documented examples, include feral livestock such as pigs, buffalo and goats farmed for food in Australia (Burrows, 2018; Mihailou & Massaro, 2021); mammals such as American minks (*Mustela vison*) and raccoon dogs (*Nyctereutes procyonoides*) farmed for fur (Warwick et al., 2023), species cultivated in aquaculture (Oficialdegui et al., 2025); and insects introduced for biological control (e.g. the Asian ladybird (*Harmonia axyridis*); Roy et al., 2016) or food production (e.g. black soldier fly (*Hermetia illucens*) and honey bee (*Apis mellifera*); Geslin et al., 2017; Kumschick et al., 2016). These introductions resulted in substantial ecological and economic impacts.

For example, invasive feral livestock have caused an estimated $90.03 billion in damages between 1960 and 2022, primarily due to agricultural losses (Soto et al., 2024). These species impose even greater economic costs than wild invasive species from the same taxonomic classes (*Mammalia* and *Aves*). Their environmental impacts

Journal of Applied Ecology

are also severe, altering soil properties, hydrology, water quality, fire regimes and habitat structure (Mihailou & Massaro, 2021). In Australia, feral goats (*Capra hircus*) alone threaten 57 native species across a broad range of taxa, including birds, plants, insects, mammals and reptiles (Burrows, 2018).

5 | INVASION OUTCOMES FROM AQUACULTURE: EVIDENCE OF ECOLOGICAL AND ECONOMICAL COSTS

In aquaculture, invasive farmed species have caused significant ecological and socio-economic damages. These impacts arise through mechanisms such as competition, predation, disease transmission and hybridization with native species. These impacts have resulted in an estimated minimum of USD 19.2 billion in damages between 1960 and 2020 (Oficialdegui et al., 2025). For example, silver carp (*Hypophthalmichthys molitrix*) negatively affect native sport fish populations, while tilapias (*Oreochromis* spp.) have contributed to the collapse of local aquaculture systems (Chick et al., 2020; Russell et al., 2012). Other major aquaculture species have also driven biodiversity loss: frogs (*Rana* spp.), carps (*Carassius* spp.) and the farmed algae Japanese kelp (*Laminaria japonica*) have displaced or cause declines in native species (Innal, 2011; Li & Xu, 2024; Orchard & Stéfani, 2009); and invasive species such as Wakame (*Undaria pinnatifida*) and largemouth bass (*Micropterus salmoides*) have altered food webs, reshaped community structures and degraded habitats (James, 2017; Pereira & Vitule, 2019).

These examples highlight the critical role that animal farming for human consumption—both terrestrial and aquatic—plays in facilitating biological invasions. They also raise growing concerns about the risks associated with the rapidly expanding terrestrial arthropod farming sector, which currently focuses almost exclusively on insects. To better assess these risks, it is informative to examine comparatively the farming of the two closely related taxonomic groups, crustaceans and insects, as the former provides valuable insights from the longer and better documented history of aquaculture, including its invasion outcomes, on insect farming (Figure 1).

6 | COMPARATIVE RISK FACTORS IN AQUATIC AND TERRESTRIAL ARTHROPOD FARMING

6.1 | Arthropod farming practices favour species with high invasive potential

Although practiced in distinct environments, aquatic and terrestrial arthropod farming systems share key structural and operational features that elevate the risk of biological invasions. Both sectors are shaped by global demand for high-yield, rapid food production, relying heavily on high-density rearing systems (FAO, 2021, 2024). To support such production models, farmed species are typically selected for traits such as rapid growth, early reproduction, high fecundity, generalist diets, disease resistance and broad environmental tolerance (Brauner & Richards, 2020; FAO, 2024; Hänfling et al., 2011; van Huis, 2013; Morales-Ramos et al., 2019). While these traits are advantageous for farming, they are also widely recognized as predictors of invasive potential, especially when species are introduced outside their native ranges (Brauner & Richards, 2020; Hänfling et al., 2011; Mally et al., 2025; Novoa et al., 2020; Renault et al., 2018). This risk is particularly relevant for insect farming; some species, such as the black soldier fly, the yellow mealworm (*Tenebrio molitor*), the house cricket and the lesser mealworm, are now cultivated globally (Niyonsaba et al., 2021), indicating that they are frequently reared in non-native environments. In aquaculture, nearly half of all farmed crustacean species are produced outside their native ranges, with non-native production already exceeding native production—and expected to continue rising (Oficialdegui et al., 2025). Although aquatic insects are rarely reported to be invasive and some are already traditionally consumed—with potential interest for farming due to their fatty acid content—the cultivation of these species poses invasion risks comparable to those associated with the farming of terrestrial insects or crustaceans (Fenoglio et al., 2016; Fontaneto et al., 2011; Ramos-Elorduy et al., 2009).

6.2 | Ecological and economic impacts of invasive arthropods are massive

In their natural environment, arthropods play essential roles in maintaining ecosystem structure, processes and stability across terrestrial and aquatic systems (Meadows et al., 2012; Noriega et al., 2018). They contribute to soil formation, nutrient cycling, water regulation, are the basis of many food chains, and many are considered ecosystem engineers (Macadam & Stockan, 2015; Meadows et al., 2012; Weisser & Siemann, 2008). Consequently, when introduced to non-native regions, invasive insects and crustaceans can cause severe ecological disruptions. These include displacing native species, driving local extinctions and altering population dynamics through mechanisms like predation, competition, disease transmission and hybridization (Hänfling et al., 2011; Kenis et al., 2009; Manfrini et al., 2024).

To date, no ecological impacts have been documented from farmed insect species, probably due to a well-known lack of ecological studies in this group (Kenis et al., 2009). However, escapes have already occurred, for example the accidental release of one million cockroaches from a Chinese medicinal insect farm (Kumschick et al., 2016; information found in grey literature—Nuwer, 2013).

In contrast, the invasion history of crustaceans farmed in aquaculture is well documented. Among the 63 crustacean species used in aquaculture, 22 are currently classified as invasive, and 19 of these were introduced from farming (Manfrini et al., 2024). These invasive

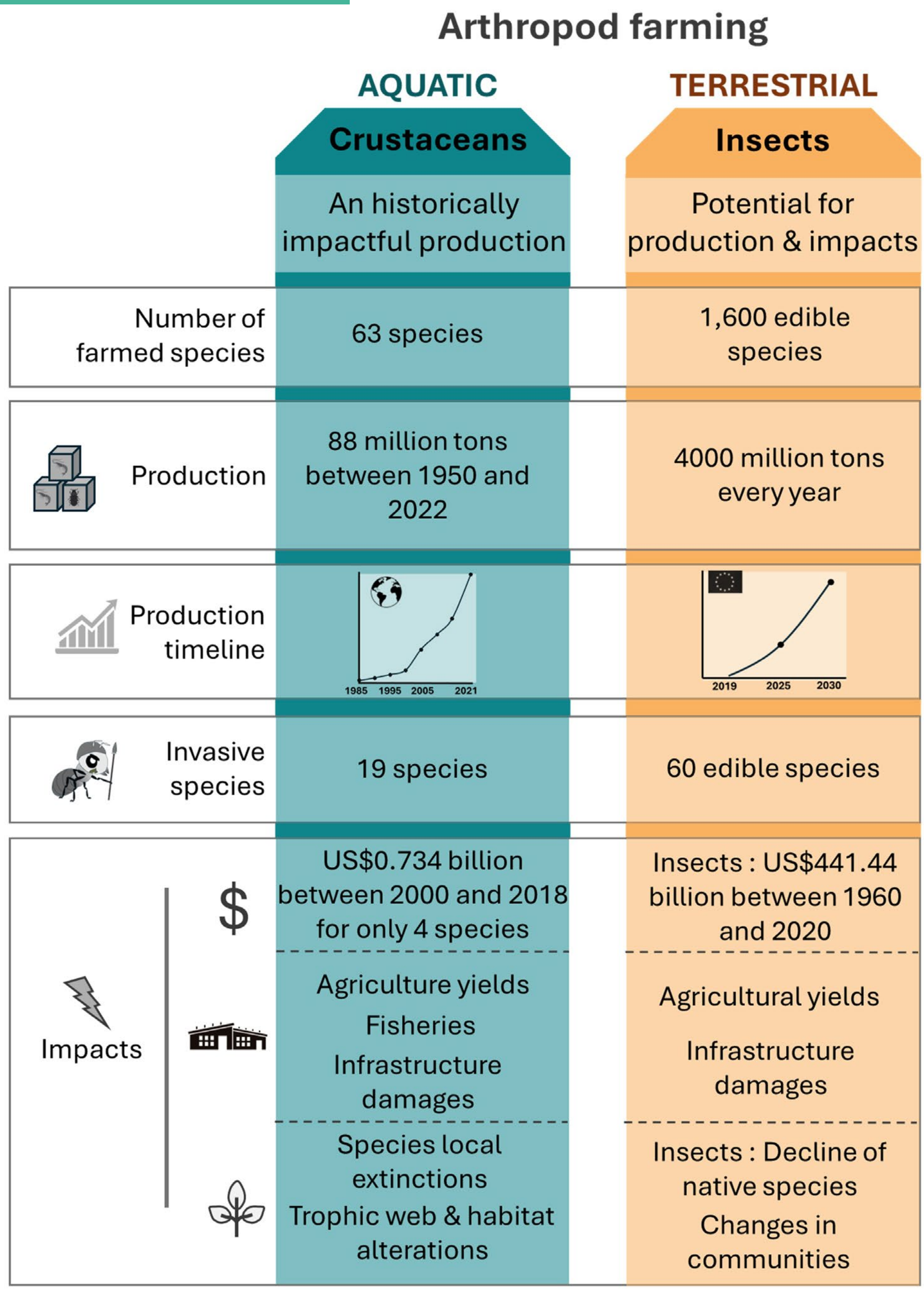

FIGURE 1 Overview of arthropod farming practices and invasion risks: Crustacean farming as a historically impactful sector and insect farming as a sector with high potential for production and impacts. For crustaceans, all information is based on observed data. The number of farmed and invasive species is reported in Manfrini et al. (2024), while the production timeline is adapted from the database of Oficialdegui et al. (2025) (available at https://github.com/Elena-Manfrini/Production-timeline-of-crustaceans or on Zenodo; Manfrini et al., 2026), and all other data are directly extracted from that source. For insects, most values are proxies, except for the production timeline in Europe (adapted from IPIFF (International Platform of Insects for Food and Feed), 2020) and infrastructure damage caused by the farmed lesser mealworm (*Alphitobius diaperinus*; Tufan-Cetin & Cetin, 2025). The potential number of farmed and invasive species is estimated from known edible insects across six orders (Manfrini, Leroy, et al., 2025). Yearly production is inferred from the estimated number of individuals produced (1 trillion; Rowe, 2020) and the average body mass of the house cricket (*Acheta domesticus*, 0.4 g; Collavo et al., 2005). Economic and ecological impacts are extrapolated from known impacts of insects (Renault et al., 2022; Kenis et al., 2009).

crustaceans have diverse and often severe ecological effects. For example, the common yabby (*Cherax destructor*) threatens endemic fauna by predation or competition (Coughran et al., 2009), the red claw crayfish (*Cherax quadricarinatus*) alters food web dynamics (Oficialdegui, 2022), and the whiteleg shrimp (*Penaeus vannamei*) changes nutrient regimes in native ecosystems (Briggs & Fox, 2007). Nearly all have negative impacts on biodiversity and ecosystem functioning (Manfrini et al., 2024).

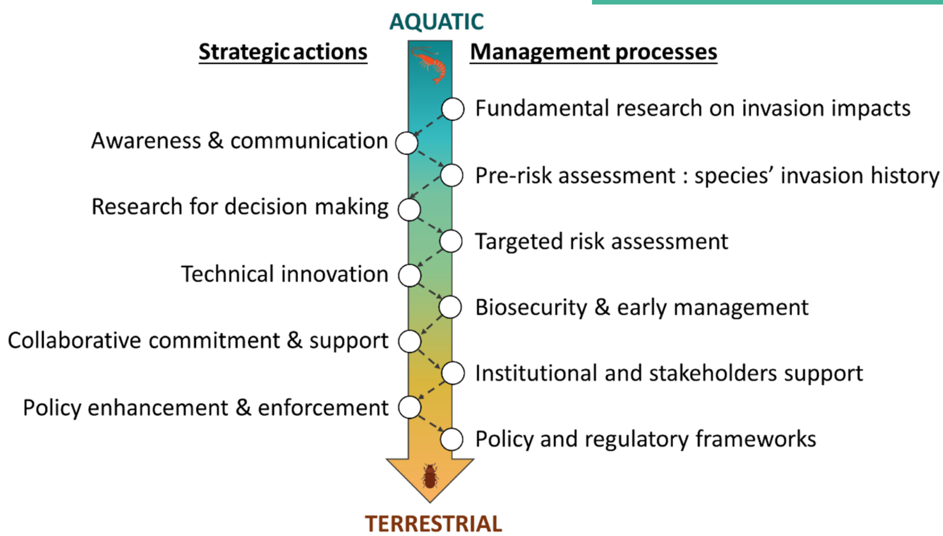

FIGURE 2 Transfer of management processes and associated strategic actions from aquatic to terrestrial arthropod farming to prevent and manage biological invasions. Knowledge transfer is indicated by the large central arrow, through a series of alternating processes and actions, linked by dashed arrows. The management process starts with fundamental research on invasion impacts, which underpins awareness-raising and risk communication efforts. This is followed by a two-step risk assessment: An initial screening based on a species' invasion history and a more detailed evaluation requiring targeted research to determine whether farming should proceed. Where farming is planned or already operational, technical innovations are essential to strengthen biosecurity and enable early containment measures to prevent escapes. These actions must be supported by coordinated stakeholder engagement and institutional support to promote sustainable farming practices. Ultimately, policy development and enforcement at national, regional and global levels are essential to regulate farming activities when the risk of biological invasion is high.

Invasive arthropods also impose significant socio-economic costs. Four invasive farmed crustacean species alone are associated with an estimated US$734 million in damages between 2000 and 2018 (Oficialdegui et al., 2025). For instance, the burrowing behaviour of the spinycheek crayfish (*Faxonius limosus*) damages water infrastructure and affects fisheries (Tricarico, 2019) while the red swamp crayfish (*Procambarus clarkii*) causes crop losses, particularly in soybean and rice systems (Ballinger, 2022).

Similarly, insects are estimated to have caused over US$441.44 billion between 1960 and 2020 (Renault et al., 2022). A notable example is the lesser mealworm (*Alphitobius diaperinus*), one of the most widely farmed insect species, which has become a major pest in poultry farming. It damages infrastructure, contaminates food supplies and affects both animal health and food safety (Tufan-Cetin & Cetin, 2025).

6.3 | Control of invasive arthropods is costly and eradication often ineffective

Detecting and controlling invasive arthropods present significant challenges due to their small size, high mobility and general low visibility in existing policy and management frameworks (Bertelsmeier et al., 2025; Giakoumi et al., 2019; Hänfling et al., 2011; Renault et al., 2018; Turbelin et al., 2017). In addition, invasive arthropod populations are often difficult, costly and often impossible to eradicate when established (Hoffmann et al., 2016; Liebhold et al., 2016; Simberloff, 2021). Chemical control often lacks species specificity, posing risks to native species and ecosystems. Biological control carries the potential for unintended consequences, such as the introduction of additional invasive species, as illustrated by the release of the Asian ladybird to control aphids (Roy et al., 2016). Adding to the complexity, an important time lag often exists between the initial introduction of an invasive species and its detection (Essl et al., 2011). This delay reduces the likelihood of successful management and heightens the risk of long-term ecological and economic damage.

7 | LEARNING FROM EXISTING PREVENTION, MANAGEMENT AND POLICY TO AVOID INSECT FARMING INVASIONS

To avoid repeating the costly ecological and economic consequences associated with past biological invasions (Diagne et al., 2021; Kenis et al., 2009), there is an urgent need to proactively address the risks posed by the growing insect farming industry. If these risks are not addressed properly, we will pay the cost of inaction, which, as evidenced by data, is a much higher price than the cost of proactive management (Ahmed et al., 2022). Fortunately, we can draw on existing lessons from related sectors, particularly aquatic arthropod farming, where management frameworks and associated strategic actions are well established (Figure 2).

Several levels of prevention strategies can be applied to assess the invasion potential of farmed arthropods prior to the establishment of new farming facilities. A simple yet effective approach relies on two key screening criteria (Manfrini et al., 2024): (1) whether the species has a documented invasion history and (2) whether it is farmed outside its native range. Based on these factors, species can be categorized into four risk categories: from low (native species with no invasion history) to high risk (non-native species with known invasion history). Farming species within their native range is the best practice to minimize invasion risk. This is especially relevant as regions with high food insecurity, primarily in the Global South, are where insect consumption is most widespread (van Huis, 2013).

When species are farmed outside their native ranges, more comprehensive risk assessments are necessary. In aquaculture, the European Non-native Species in Aquaculture Risk Analysis Scheme (ENSARS) provides a comprehensive risk assessment and decision-making framework that incorporates multiple criteria, including the likelihood of escape and establishment, to assess facility-level risks (Copp et al., 2009). Complementary analyses could include species distribution modelling to estimate habitat suitability under current and projected climatic conditions (Barbet-Massin et al., 2018; Manfrini, Courchamp, et al., 2025; Zhang et al., 2019) as well as assessments of ecological impacts through interactions with native species (Frost et al., 2019). Identifying current and future regions at risk of invasion, along with the potential impacts on native species, is essential for guiding geographically targeted monitoring and enabling early warning and rapid response (IPBES, 2023). These approaches offer strong candidates for adaptations to the specific context of insect farming to prevent future biological invasions.

For existing insect farms, particularly those cultivating non-native species, biosecurity must be prioritized. This includes the implementation of strict facility protocols and ongoing intensive monitoring of surrounding environments to detect escapes. In aquaculture, the Food and Agriculture Organization (FAO) has developed risk assessment frameworks, including surveillance and monitoring protocols, to support the management of non-native species (FAO, 2023a). Given that some insect species are already being farmed in ecologically suitable but non-native regions, such protocols are immediately relevant to the insect sector (Manfrini, Courchamp, et al., 2025).

Together, these prevention and monitoring strategies highlight the critical roles of researchers, industry and international organizations. Researchers are essential in conducting invasion risk assessments to identify, for example, high-risk species and/or populations and to determine the most effective biosecurity measures (Haubrock et al., 2024). Industry plays a key role in proactively implementing biosecurity measures and enabling rapid management of invasive species populations. International organizations are important for guiding responsible farming practices, supporting research and facilitating invasive species control.

Complementing technical measures, strong and enforceable policy frameworks at multiple governance levels are essential for effective control of biological invasions (Roy et al., 2024). In Europe, for example, four crustacean species commonly farmed in aquaculture have been banned from import or cultivation due to their ecological risks (Brundu et al., 2022). However, such regulations are more commonly found in high-income countries. Many low- and middle-income countries, despite being disproportionately vulnerable to invasive species impacts (Bradshaw et al., 2024), still lack comprehensive legal frameworks addressing these threats (Ju et al., 2020; Turbelin et al., 2017). Given the prevalence of insect consumption in the Global South, strengthening regulatory systems to govern non-native insect farming should be considered a global policy priority.

8 | CONCLUSION: A CRITICAL JUNCTURE FOR SUSTAINABLE INSECT FARMING

As the global food system seeks more sustainable and resource-efficient solutions, insect farming has emerged as a promising alternative to conventional livestock. Its potential to reduce land use, emissions and feed demand positions it as a good candidate for climate-resilient food production. Yet this promise must not obscure the ecological risks that come with scaling any animal farming system, especially the risk of biological invasions from escaped individuals.

Here, we highlight that insect farming shares several structural and ecological features with aquaculture, a sector with a long-documented history of biological invasions. The farming of high-performance species outside their native ranges, combined with minimal regulatory oversight and insufficient biosecurity, has repeatedly facilitated harmful species introductions in aquatic systems. These same risk factors are now emerging in the insect sector. The key lesson is that invasions are not an inevitable consequence of innovation—they are the result of policy gaps, delayed governance and insufficient risk planning. Existing tools from aquaculture, such as species screening frameworks, biosecurity standards and spatial risk modelling, offer readily adaptable strategies for insect farming. But these must be implemented proactively, not reactively, especially since it is well established in biological invasions that the costs of inaction are much higher than the costs of prevention (Ahmed et al., 2022).

Moving forward, there is a clear need for internationally coordinated regulation, particularly to support countries in the Global South where insect farming is most established and food security challenges are greatest. Strong institutional support, industry engagement and targeted research on species-specific risk are essential for ensuring that ecological sustainability is not compromised in the pursuit of food system innovation. Insect farming now stands at a critical juncture: its potential to contribute meaningfully to the Sustainable Development Goals—such as *Zero Hunger* (2), *Economic Growth* (8) and *Industry and Infrastructure* (9)—must not be realized at the expense of others, notably *Sustainable Consumption and Production* (12) and *Life on Land* (15) (United Nations, 2015). With the benefit of historical insight and proven risk mitigation strategies, the sector can chart a different path, one that avoids replicating the ecological costs of past farming expansions. Preventing invasions before they occur is not only feasible but necessary to maintain the environmental integrity and social licence of this emerging industry.

AUTHOR CONTRIBUTIONS

Eléna Manfrini, Åsa Berggren, Boris Leroy and Franck Courchamp contributed to the conceptualization of the study. Visualization was carried out by Eléna Manfrini and Franck Courchamp. Eléna Manfrini wrote the original draft of the manuscript. Funding acquisition was undertaken by Franck Courchamp. Eléna Manfrini, Åsa Berggren, Boris Leroy and Franck Courchamp contributed critically to the review and editing of the manuscript and gave final approval for publication.

ACKNOWLEDGEMENTS

This study received support from the AXA Research Fund Chair for Biological Invasions at the University of Paris-Saclay. Open access publication funding provided by COUPERIN CY26.

CONFLICT OF INTEREST STATEMENT

The authors declare no actual or potential conflict of interest.

DATA AVAILABILITY STATEMENT

The code used to construct the timeline of total crustacean production in Figure 1 is available on GitHub (https://github.com/Elena-Manfrini/Production-timeline-of-crustaceans) and Zenodo https://doi.org/10.5281/zenodo.18418442 (Manfrini et al., 2026).

ORCID

Eléna Manfrini https://orcid.org/0000-0002-9382-6973
Åsa Berggren https://orcid.org/0000-0002-4998-5723

REFERENCES

Ahmed, D. A., Hudgins, E. J., Cuthbert, R. N., Kourantidou, M., Diagne, C., Haubrock, P. J., Leung, B., Liu, C., Leroy, B., Petrovskii, S., Beidas, A., & Courchamp, F. (2022). Managing biological invasions: The cost of inaction. *Biological Invasions*, *24*(7), 1927–1946. https://doi.org/10.1007/s10530-022-02755-0

Ahmed, N., Thompson, S., & Glaser, M. (2019). Global aquaculture productivity, environmental sustainability, and climate change adaptability. *Environmental Management*, *63*(2), 159–172. https://doi.org/10.1007/s00267-018-1117-3

Ballinger, A. (2022). *Procambarus clarkii (red swamp crayfish)*. CABI Compendium. https://doi.org/10.1079/cabicompendium.67878

Barbet-Massin, M., Rome, Q., Villemant, C., & Courchamp, F. (2018). Can species distribution models really predict the expansion of invasive species? *PLoS One*, *13*(3), e0193085. https://doi.org/10.1371/journal.pone.0193085

Bar-On, Y. M., Phillips, R., & Milo, R. (2018). The biomass distribution on earth. *Proceedings of the National Academy of Sciences*, *115*(25), 6506–6511. https://doi.org/10.1073/pnas.1711842115

Berggren, Å., & Low, M. (2024). Conservation benefits and threats from insects as food. In J. S. Pryke, M. J. Samways, T. R. New, P. Cardoso, & R. Gaigher (Eds.), *Routledge handbook of insect conservation* (1st ed., pp. 210–220). Routledge. https://doi.org/10.4324/9781003285793-19

Bertelsmeier, C., Bonnamour, A., Garnas, J. R., Liu, T., Perreault, R., & Ollier, S. (2025). Temporal dynamics and global flows of insect invasions in an era of globalization. *Nature Reviews Biodiversity*, *1*(2), 90–103. https://doi.org/10.1038/s44358-025-00016-1

Bradshaw, C. J. A., Hulme, P. E., Hudgins, E. J., Leung, B., Kourantidou, M., Courtois, P., Turbelin, A. J., McDermott, S. M., Lee, K., Ahmed, D. A., Latombe, G., Bang, A., Bodey, T. W., Haubrock, P. J., Saltré, F., & Courchamp, F. (2024). Damage costs from invasive species exceed management expenditure in nations experiencing lower economic activity. *Ecological Economics*, *220*, 108166. https://doi.org/10.1016/j.ecolecon.2024.108166

Brauner, C. J., & Richards, J. G. (2020). Physiological performance in aquaculture: Using physiology to help define optimal conditions for growth and environmental tolerance. In C. J. Brauner & J. G. Richards (Eds.), *Fish physiology* (Vol. *38*, pp. 81–121). Elsevier. https://doi.org/10.1016/bs.fp.2020.10.001

Briggs, M., & Fox, J. (2007). *Litopenaeus vannamei (whiteleg shrimp)*. CABI Compendium. https://doi.org/10.1079/cabicompendium.71097

Brundu, G., Costello, K. E., & Maggs, G. (2022). *An introduction to the invasive Alien species of union concern. 2022 European Union*. European Union. https://europa.eu/european-union/index_en

Burrows, N. D. (2018). Feral animals in the semi-arid and arid regions of Austalia: Origins, impacts and control. In *On the ecology of Australia's arid zone* (pp. 331–374). Springer International Publishing. https://escholarship.org/uc/item/2ss54969

Capitan, S., Berggren, Å., & Weih, M. (2025). Frass pre-treatment and application method impact spring wheat vegetative growth and nutrient concentration. *Journal of Insects as Food and Feed*, *1*, 1–10. https://doi.org/10.1163/23524588-bja10245

Chick, J. H., Gibson-Reinemer, D. K., Soeken-Gittinger, L., & Casper, A. F. (2020). Invasive silver carp is empirically linked to declines of native sport fish in the upper mississippi river system. *Biological Invasions*, *22*(2), 723–734. https://doi.org/10.1007/s10530-019-02124-4

Collavo, A., Glew, R. H., Huang, Y. S., Chuang, L. T., Bosse, R., & Paoletti, M. G. (2005). House cricket small-scale farming. In *Ecological implications of minilivestock: Potential of insects, rodents, frogs and snails* (Vol. *27*, pp. 515–540). CRC Press.

Copp, G. H., Robert Britton, J., Jeney, G., Joly, J.-P., Gherardi, F., Gollasch, S., Gozlan, R. E., Jones, G., Macleod, A., Midtlyng, P. J., Miossec, L., Nunn, A. D., Occhipinti-Ambrogi, A., Oidtmann, B., Olenin, S., Peeler, E., Russell, I. C., Savini, D., Tricarico, E., & Thrush, M. (2009). *Risk assessment protocols and decision making tools for use of alien species in aquaculture and stock enhancement*. https://doi.org/10.13140/RG.2.2.16281.77923

Coughran, J., McCormack, R., & Daly, G. (2009). Translocation of the Yabby *Cherax destructor* into eastern drainages of New South Wales, Australia. *Australian Zoologist*, *35*(1), 100–103. https://doi.org/10.7882/AZ.2009.009

Diagne, C., Leroy, B., Vaissière, A.-C., Gozlan, R. E., Roiz, D., Jarić, I., Salles, J.-M., Bradshaw, C. J. A., & Courchamp, F. (2021). High and rising economic costs of biological invasions worldwide. *Nature*, *592*(7855), 571–576. https://doi.org/10.1038/s41586-021-03405-6

Diana, J. S. (2009). Aquaculture production and biodiversity conservation. *Bioscience*, *59*(1), 27–38. https://doi.org/10.1525/bio.2009.59.1.7

Essl, F., Dullinger, S., Rabitsch, W., Hulme, P. E., Hülber, K., Jarošík, V., Kleinbauer, I., Krausmann, F., Kühn, I., Nentwig, W., Vilà, M., Genovesi, P., Gherardi, F., Desprez-Loustau, M.-L., Roques, A., & Pyšek, P. (2011). Socioeconomic legacy yields an invasion debt. *Proceedings of the National Academy of Sciences*, *108*(1), 203–207. https://doi.org/10.1073/pnas.1011728108

FAO. (2006). *Livestock's long shadow: Environmental issues and options*.

FAO. (2019). *Water use in livestock production systems and supply chains*. Guidelines for assessment (version 1). Livestock Environmental Assessment and Performance (LEAP) Partnership.

FAO. (2021). *Looking at edible insects from a food safety perspective: Challenges and opportunities for the sector*. FAO. https://doi.org/10.4060/cb4094en

FAO. (2023a). *Guidelines on assessing and minimizing the possible impacts from the use of non-indigenous species in aquaculture*. General Fisheries Commission for the Mediterranean. https://doi.org/10.4060/cc3207en

FAO. (2023b). *The world's mangroves 2000–2020*. FAO. https://doi.org/10.4060/cc7044en

FAO. (2024). *The state of world fisheries and aquaculture 2024*. FAO. https://doi.org/10.4060/cd0683en

Fenoglio, S., Bonada, N., Guareschi, S., López-Rodríguez, M. J., Millán, A., & de Tierno Figueroa, J. M. (2016). Freshwater ecosystems and aquatic insects: A paradox in biological invasions. *Biology Letters*, *12*(4), 20151075. https://doi.org/10.1098/rsbl.2015.1075

Fontaneto, D., Tommaseo-Ponzetta, M., Galli, C., Risé, P., Glew, R. H., & Paoletti, M. G. (2011). Differences in fatty acid composition between aquatic and terrestrial insects used as food in human nutrition. *Ecology of Food and Nutrition*, *50*(4), 351–367. https://doi.org/10.1080/03670244.2011.586316

Frost, C. M., Allen, W. J., Courchamp, F., Jeschke, J. M., Saul, W.-C., & Wardle, D. A. (2019). Using network theory to understand and predict biological invasions. *Trends in Ecology & Evolution*, *34*(9), 831–843. https://doi.org/10.1016/j.tree.2019.04.012

Gerber, P. J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A., & Tempio, G. (2013). *Tackling climate change through livestock: A global assessment of emissions and mitigation opportunities*. FAO.

Geslin, B., Gauzens, B., Baude, M., Dajoz, I., Fontaine, C., Henry, M., Ropars, L., Rollin, O., Thébault, E., & Vereecken, N. J. (2017). Massively introduced managed species and their consequences for plant–pollinator interactions. In *Advances in ecological research* (Vol. *57*, pp. 147–199). Elsevier. https://doi.org/10.1016/bs.aecr.2016.10.007

Giakoumi, S., Katsanevakis, S., Albano, P. G., Azzurro, E., Cardoso, A. C., Cebrian, E., Deidun, A., Edelist, D., Francour, P., Jimenez, C., Mačić, V., Occhipinti-Ambrogi, A., Rilov, G., & Sghaier, Y. R. (2019). Management priorities for marine invasive species. *Science of the Total Environment*, *688*, 976–982.

Guiné, R. P. F., Correia, P., Coelho, C., & Costa, C. A. (2021). The role of edible insects to mitigate challenges for sustainability. *Open Agriculture*, *6*(1), 24–36. https://doi.org/10.1515/opag-2020-0206

Hamilton, S. E. (2020). *Mangroves and aquaculture: A five decade remote sensing analysis of Ecuador's estuarine environments* (Vol. *33*). Springer International Publishing. https://doi.org/10.1007/978-3-030-22240-6

Hancz, C., Sultana, S., Nagy, Z., & Biró, J. (2024). The role of insects in sustainable animal feed production for environmentally friendly agriculture: A review. *Animals*, *14*(7), 1009. https://doi.org/10.3390/ani14071009

Hänfling, B., Edwards, F., & Gherardi, F. (2011). Invasive alien Crustacea: Dispersal, establishment, impact and control. *BioControl*, *56*(4), 573–595. https://doi.org/10.1007/s10526-011-9380-8

Haubrock, P. J., Soto, I., Ahmed, D. A., Ansari, A. R., Tarkan, A. S., Kurtul, I., Macêdo, R. L., Lázaro-Lobo, A., Toutain, M., Parker, B., Błońska, D., Guareschi, S., Cano-Barbacil, C., Dominguez Almela, V., Andreou, D., Moyano, J., Akalın, S., Kaya, C., Bayçelebi, E., … Cuthbert, R. N. (2024). Biological invasions are a population-level rather than a species-level phenomenon. *Global Change Biology*, *30*(5), e17312. https://doi.org/10.1111/gcb.17312

Heinke, J., Lannerstad, M., Gerten, D., Havlík, P., Herrero, M., Notenbaert, A. M. O., Hoff, H., & Müller, C. (2020). Water use in global livestock production—Opportunities and constraints for increasing water productivity. *Water Resources Research*, *56*(12), e2019WR026995. https://doi.org/10.1029/2019wr026995

Hoffmann, B. D., Luque, G. M., Bellard, C., Holmes, N. D., & Donlan, C. J. (2016). Improving invasive ant eradication as a conservation tool: A review. *Biological Conservation*, *198*, 37–49. https://doi.org/10.1016/j.biocon.2016.03.036

Innal, D. (2011). Distribution and impacts of Carassius species (Cyprinidae) in Turkey: A review. *Management of Biological Invasions*, *2*(1), 57–68. https://doi.org/10.3391/mbi.2011.2.1.06

IPBES. (2023). In H. E. Roy, A. Pauchard, P. Stoett, & T. Renard Truong (Eds.), *Thematic assessment report on invasive Alien species and their control of the intergovernmental science-policy platform on biodiversity and ecosystem services*. IPBES Secretariat. https://doi.org/10.5281/zenodo.7430682

IPIFF (International Platform of Insects for Food and Feed). (2020). *Edible insects on the European market*. https://ipiff.org/wp-content/uploads/2020/06/10-06-2020-IPIFF-edible-insects-market-factsheet.pdf

James, K. (2017). *A review of the impacts from invasion by the introduced kelp Undaria Pinnatifida*. Waikato Regional Council Technical Report 2016, 40.

Jansson, A., Hunter, D., & Berggren, Å. (2019). *Insects as food—An option for sustainable food production?* Swedish University of Agricultural Sciences. http://rgdoi.net/10.13140/RG.2.2.13530.08646

Jiang, Q., Bhattarai, N., Pahlow, M., & Xu, Z. (2022). Environmental sustainability and footprints of global aquaculture. *Resources, Conservation and Recycling*, *180*, 106183. https://doi.org/10.1016/j.resconrec.2022.106183

Ju, R., Li, X., Jiang, J., Wu, J., Liu, J., Strong, D. R., & Li, B. (2020). Emerging risks of non-native species escapes from aquaculture: Call for policy improvements in China and other developing countries. *Journal of Applied Ecology*, *57*(1), 85–90. https://doi.org/10.1111/1365-2664.13521

Kenis, M., Auger-Rozenberg, M.-A., Roques, A., Timms, L., Péré, C., Cock, M. J. W., Settele, J., Augustin, S., & Lopez-Vaamonde, C. (2009). Ecological effects of invasive alien insects. *Biological Invasions*, *11*(1), 21–45. https://doi.org/10.1007/s10530-008-9318-y

Kumschick, S., Devenish, A., Kenis, M., Rabitsch, W., Richardson, D. M., & Wilson, J. R. U. (2016). Intentionally introduced terrestrial invertebrates: Patterns, risks, and options for management. *Biological Invasions*, *18*(4), 1077–1088. https://doi.org/10.1007/s10530-016-1086-5

Li, X., & Xu, P. (2024). Sustainable cultivation and environmental impact of Laminaria japonica farming. *International Journal of Aquaculture*, *14*(4), 211–220. https://doi.org/10.5376/ija.2024.14.0021

Li, Y., Wang, M., Chen, X., Cui, S., Hofstra, N., Kroeze, C., Ma, L., Xu, W., Zhang, Q., Zhang, F., & Strokal, M. (2022). Multi-pollutant assessment of river pollution from livestock production worldwide. *Water Research*, *209*, 117906. https://doi.org/10.1016/j.watres.2021.117906

Liebhold, A. M., Berec, L., Brockerhoff, E. G., Epanchin-Niell, R. S., Hastings, A., Herms, D. A., Kean, J. M., McCullough, D. G., Suckling, D. M., Tobin, P. C., & Yamanaka, T. (2016). Eradication of invading insect populations: From concepts to applications. *Annual Review of Entomology*, *61*(1), 335–352. https://doi.org/10.1146/annurev-ento-010715-023809

Macadam, C. R., & Stockan, J. A. (2015). More than just fish food: Ecosystem services provided by freshwater insects. *Ecological Entomology*, *40*(S1), 113–123. https://doi.org/10.1111/een.12245

Madau, F. A., Arru, B., Furesi, R., & Pulina, P. (2020). Insect farming for feed and food production from a circular business model perspective. *Sustainability*, *12*(13), 5418. https://doi.org/10.3390/su12135418

Makkar, H. P. S., Tran, G., Heuzé, V., & Ankers, P. (2014). State-of-the-art on use of insects as animal feed. *Animal Feed Science and Technology*, *197*, 1–33. https://doi.org/10.1016/j.anifeedsci.2014.07.008

Mally, R., Turner, R. M., Nahrung, H. F., Yamanaka, T., Fenn-Moltu, G., Bertelsmeier, C., Roques, A., Brockerhoff, E. G., Pureswaran, D. S., & Liebhold, A. M. (2025). Insect invasion success depends on taxon and trophic group. *NeoBiota*, *99*, 19–43. https://doi.org/10.3897/neobiota.99.151227

Manfrini, E., Courchamp, F., & Leroy, B. (2024). Mitigating the role of aquaculture in crustacean invasions. *Reviews in Aquaculture*, *17*(1), e12952. https://doi.org/10.1111/raq.12952

Manfrini, E., Courchamp, F., Leroy, B., & Berggren, Å. (2026). Preventing the next invasion: Lessons from aquaculture for the safe expansion of insect farming. *Zenodo repository* https://doi.org/10.5281/zenodo.18418441

Manfrini, E., Courchamp, F., Maquart, P.-O., Lamboley, Q., & Leroy, B. (2025). Predicting the biological invasion risks of the most farmed insect for food and feed. *bioRxiv*. https://doi.org/10.1101/2025.10.30.685499

Manfrini, E., Leroy, B., Courchamp, F., Sauvion, N., Renault, D., Geslin, B., Zakardjian, M., Maquart, P.-O., Hanot, C., Berggren, Å., Goebel, R., Blight, O., Duquesne, E., Fournier, D., Javal, M., Angulo, E., & Bang, A. (2025). InsecTrait database: A public database of insect species characteristics worldwide. [Data set]. *Zenodo* https://doi.org/10.5281/zenodo.16931808

Meadows, P. S., Meadows, A., & Murray, J. M. H. (2012). Biological modifiers of marine benthic seascapes: Their role as ecosystem engineers. *Geomorphology*, *157*, 31–48. https://doi.org/10.1016/j.geomorph.2011.07.007

Mihailou, H., & Massaro, M. (2021). An overview of the impacts of feral cattle, water buffalo and pigs on the savannas, wetlands and biota of northern Australia. *Austral Ecology*, *46*(5), 699–712. https://doi.org/10.1111/aec.13046

Morales-Ramos, J. A., Kelstrup, H. C., Rojas, M. G., & Emery, V. (2019). Body mass increase induced by eight years of artificial selection in the yellow mealworm (Coleoptera: Tenebrionidae) and life history trade-offs. *Journal of Insect Science*, *19*(2), 4. https://doi.org/10.1093/jisesa/iey110

Msangi, S., & Batka, M. (2015). Major trends in diets and nutrition: A global perspective to 2050. In *Frontiers of economics and globalization* (pp. 227–241). Emerald Group Publishing.

Naylor, R. L., Hardy, R. W., Buschmann, A. H., Bush, S. R., Cao, L., Klinger, D. H., Little, D. C., Lubchenco, J., Shumway, S. E., & Troell, M. (2021). A 20-year retrospective review of global aquaculture. *Nature*, *591*(7851), 551–563. https://doi.org/10.1038/s41586-021-03308-6

Niyonsaba, H. H., Höhler, J., Kooistra, J., Van Der Fels-Klerx, H. J., & Meuwissen, M. P. M. (2021). Profitability of insect farms. *Journal of Insects as Food and Feed*, *7*(5), 923–934. https://doi.org/10.3920/JIFF2020.0087

Noriega, J. A., Hortal, J., Azcárate, F. M., Berg, M. P., Bonada, N., Briones, M. J. I., Del Toro, I., Goulson, D., Ibanez, S., Landis, D. A., Moretti, M., Potts, S. G., Slade, E. M., Stout, J. C., Ulyshen, M. D., Wackers, F. L., Woodcock, B. A., & Santos, A. M. C. (2018). Research trends in ecosystem services provided by insects. *Basic and Applied Ecology*, *26*, 8–23. https://doi.org/10.1016/j.baae.2017.09.006

Novoa, A., Richardson, D. M., Pyšek, P., Meyerson, L. A., Bacher, S., Canavan, S., Catford, J. A., Čuda, J., Essl, F., Foxcroft, L. C., Genovesi, P., Hirsch, H., Hui, C., Jackson, M. C., Kueffer, C., Le Roux, J. J., Measey, J., Mohanty, N. P., Moodley, D., … Wilson, J. R. U. (2020). Invasion syndromes: A systematic approach for predicting biological invasions and facilitating effective management. *Biological Invasions*, *22*(5), 1801–1820. https://doi.org/10.1007/s10530-020-02220-w

Nuwer, R. (2013). *One million cockroaches escaped from a traditional Chinese medicine farm*. Smithsonian magazine. https://www.smithsonianmag.com/smart-news/one-million-cockroaches-escaped-from-a-traditional-chinese-medicine-farm-1766394/

Oficialdegui, F. (2022). *Cherax quadricarinatus (redclaw crayfish)*. CABI Compendium: 89135. https://doi.org/10.1079/cabicompendium.89135

Oficialdegui, F. J., Soto, I., Balzani, P., Cuthbert, R. N., Haubrock, P. J., Kourantidou, M., Manfrini, E., Tarkan, A. S., Kurtul, I., Macêdo, R. L., Musseau, C. L., Roy, K., & Kouba, A. (2025). Non-native species in aquaculture: Burgeoning production and environmental sustainability risks. *Reviews in Aquaculture*, *17*(3). https://doi.org/10.1111/raq.70037

Oonincx, D. G. A. B., Van Itterbeeck, J., Heetkamp, M. J. W., Van Den Brand, H., Van Loon, J. J. A., & Van Huis, A. (2010). An exploration on greenhouse gas and ammonia production by insect species suitable for animal or human consumption. *PLoS One*, *5*(12), e14445. https://doi.org/10.1371/journal.pone.0014445

Orchard, S., & Stéfani, M. (2009). *Rana Catesbeiana (American bullfrog)*. CABI Compendium. https://doi.org/10.1079/cabicompendium.66618

Pelletier, N., & Tyedmers, P. (2010). Forecasting potential global environmental costs of livestock production 2000–2050. *Proceedings of the National Academy of Sciences*, *107*(43), 18371–18374. https://doi.org/10.1073/pnas.1004659107

Pereira, F. W., & Vitule, J. R. S. (2019). The largemouth bass Micropterus salmoides (Lacepède, 1802): Impacts of a powerful freshwater fish predator outside of its native range. *Reviews in Fish Biology and Fisheries*, *29*(3), 639–652. https://doi.org/10.1007/s11160-019-09570-2

Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science*, *360*(6392), 987–992. https://doi.org/10.1126/science.aaq0216

Ramos-Elorduy, J., Moreno, J. M. P., & Camacho, V. H. M. (2009). Edible aquatic Coleoptera of the world with an emphasis on Mexico. *Journal of Ethnobiology and Ethnomedicine*, *5*(1), 11. https://doi.org/10.1186/1746-4269-5-11

Renault, D., Angulo, E., Cuthbert, R. N., Haubrock, P. J., Capinha, C., Bang, A., Kramer, A. M., & Courchamp, F. (2022). The magnitude, diversity, and distribution of the economic costs of invasive terrestrial invertebrates worldwide. *Science of the Total Environment*, *835*, 155391. https://doi.org/10.1016/j.scitotenv.2022.155391

Renault, D., Laparie, M., McCauley, S. J., & Bonte, D. (2018). Environmental adaptations, ecological filtering, and dispersal central to insect invasions. *Annual Review of Entomology*, *63*(1), 345–368. https://doi.org/10.1146/annurev-ento-020117-043315

Rowe, A. (2020). *Insects farmed for food and feed: Global scale, practices and policy*. OSF Preprints. https://doi.org/10.31219/osf.io/nh6k3

Roy, H. E., Brown, P. M. J., Adriaens, T., Berkvens, N., Borges, I., Clusella-Trullas, S., Comont, R. F., De Clercq, P., Eschen, R., Estoup, A., Evans, E. W., Facon, B., Gardiner, M. M., Gil, A., Grez, A. A., Guillemaud, T., Haelewaters, D., Herz, A., Honek, A., … Zhao, Z. (2016). The harlequin ladybird, Harmonia axyridis: Global perspectives on invasion history and ecology. *Biological Invasions*, *18*(4), 997–1044. https://doi.org/10.1007/s10530-016-1077-6

Roy, H. E., Pauchard, A., Stoett, P., & Renard Truong, T. (2024). *IPBES invasive alien species assessment: Full report*. (Version 4). *Zenodo*. https://doi.org/10.5281/ZENODO.7430682

Russell, D. J., Thuesen, P. A., & Thomson, F. E. (2012). A review of the biology, ecology, distribution and control of Mozambique tilapia, *Oreochromis mossambicus* (Peters 1852) (Pisces: Cichlidae) with particular emphasis on invasive Australian populations. *Reviews in Fish Biology and Fisheries*, *22*(3), 533–554. https://doi.org/10.1007/s11160-011-9249-z

Scherhaufer, A., Moates, G., Hartikainen, H., Waldron, K., & Obersteiner, G. (2018). Environmental impacts of food waste in Europe. *Waste Management*, *77*, 98–113. https://doi.org/10.1016/j.wasman.2018.04.038

Siddiqui, S. A., Osei-Owusu, J., Yunusa, B. M., Rahayu, T., Fernando, I., Shah, M. A., & Centoducati, G. (2023). Prospects of edible insects as sustainable protein for food and feed—A review. *Journal of Insects as Food and Feed*, *10*(2), 191–217. https://doi.org/10.1163/23524588-20230042

Simberloff, D. (2021). Maintenance management and eradication of established aquatic invaders. *Hydrobiologia*, *848*(9), 2399–2420. https://doi.org/10.1007/s10750-020-04352-5

Soto, I., Balzani, P., Oficialdegui, F. J., Molinero, C., Kouba, A., Ahmed, D. A., Turbelin, A. J., Hudgins, E. J., Bodey, T. W., Gojery, S. A., Courchamp, F., Cuthbert, R. N., & Haubrock, P. J. (2024). The wild cost of invasive feral animals worldwide. *Science of the Total Environment*, *912*, 169281. https://doi.org/10.1016/j.scitotenv.2023.169281

Tilman, D., Balzer, C., Hill, J., & Befort, B. L. (2011). Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences*, *108*(50), 20260–20264. https://doi.org/10.1073/pnas.1116437108

Tricarico, E. (2019). *Faxonius limosus (spiny-cheek crayfish)*. CABI Compendium. https://doi.org/10.1079/cabicompendium.7203

Tufan-Cetin, O., & Cetin, H. (2025). A review of biological and sustainable management approaches for *Alphitobius diaperinus*, a Major Pest in poultry facilities. *Veterinary Sciences*, *12*(2), 158. https://doi.org/10.3390/vetsci12020158

Turbelin, A. J., Diagne, C., Hudgins, E. J., Moodley, D., Kourantidou, M., Novoa, A., Haubrock, P. J., Bernery, C., Gozlan, R. E., Francis, R. A., & Courchamp, F. (2022). Introduction pathways of economically costly invasive alien species. *Biological Invasions*, *24*(7), 2061–2079. https://doi.org/10.1007/s10530-022-02796-5

Turbelin, A. J., Malamud, B. D., & Francis, R. A. (2017). Mapping the global state of invasive alien species: Patterns of invasion and policy responses. *Global Ecology and Biogeography*, *26*(1), 78–92. https://doi.org/10.1111/geb.12517

United Nations. (2015). General Assembly (70th sess.: 2015-2016). *Transforming Our World: The 2030 Agenda for Sustainable Development: Resolution / Adopted by the General Assembly.*

van Dijk, M., Morley, T., Rau, M. L., & Saghai, Y. (2021). A meta-analysis of projected global food demand and population at risk of hunger for the period 2010–2050. *Nature Food*, *2*(7), 494–501. https://doi.org/10.1038/s43016-021-00322-9

van Huis, A. (with Food and Agriculture Organization of the United Nations). (2013). *Edible insects: Future prospects for food and feed security*. Food and Agriculture Organization of the United Nations.

van Huis, A. (2022). Edible insects: Challenges and prospects. *Entomological Research*, *52*(4), 161–177. https://doi.org/10.1111/1748-5967.12582

Vauterin, A., Steiner, B., Sillman, J., & Kahiluoto, H. (2021). The potential of insect protein to reduce food-based carbon footprints in Europe: The case of broiler meat production. *Journal of Cleaner Production*, *320*, 128799. https://doi.org/10.1016/j.jclepro.2021.128799

Warwick, C., Pilny, A., Steedman, C., & Grant, R. (2023). One health implications of fur farming. *Frontiers in Animal Science*, *4*, 1249901. https://doi.org/10.3389/fanim.2023.1249901

Weisser, W. W., & Siemann, E. (2008). *Insects and ecosystem function*. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-74004-9

Zeder, M. A. (2012). The domestication of animals. *Journal of Anthropological Research*, *68*, 161–190.

Zhang, Z., Capinha, C., Usio, N., Weterings, R., Liu, X., Li, Y., Landeria, J. M., Zhou, Q., & Yokota, M. (2019). Impacts of climate change on the global potential distribution of two notorious invasive crayfishes. *Freshwater Biology*, *65*(3), 353–365. https://doi.org/10.1111/fwb.13429

How to cite this article: Manfrini, E., Courchamp, F., Leroy, B., & Berggren, Å. (2026). Preventing the next invasion: Lessons from aquaculture for the safe expansion of insect farming. *Journal of Applied Ecology*, *63*, e70311. https://doi.org/10.1111/1365-2664.70311