

New frontiers in animal welfare science: an introduction to (farmed) insects

Meghan Barrett

INSECTS are animals belonging to the group Insecta. However, besides having six legs and three body segments at the adult life stage and a common arthropod ancestor, there is little else that unifies this group. Indeed, there are an estimated 5.5 million species of insects, but they vary in nearly every dimension, including lifespan, behaviour, cognitive capacity and physiology.¹

Despite their abundance and ecological importance, insects are poorly understood in ways that may lower our intuitive interest in – and understanding of – their welfare. For instance, we often forget that insects are closely related to groups of animals whose welfare we tend to take more seriously, such as decapod crustaceans (ie, crabs and lobsters). In fact, insects are a part of the clade Pancrustacea, meaning they are crustaceans themselves and derived from a common ancestor shared with decapods.²

We may intuitively think that all insects are small with simple brains compared to vertebrates. However, insects vary in body mass by a factor of 5.2 million, resulting in insects that can weigh over six times more than a mouse (Fig 1). They can even have the same brain size and number of neurons as some reptiles.³

Although insects are commonly thought of as cognitively unsophisticated and behaviourally inflexible, insect species engage in rescue and wound-tending behaviours (including the application of antimicrobial secretions to injury sites), numerical cognition, individual facial recognition, problem solving, tool use, play-like behaviours and even monogamous biparental care that can last for up to 20 years.⁴ Their lives can thus be behaviourally rich and cognitively complex.

How plausible is insect sentience?

In 2021, the Foundations of Animal Sentience project, led by Jonathan Birch at the London School of Economics, created an empirically guided framework for evaluating the plausibility of invertebrate sentience and applied that

WHAT YOU NEED TO KNOW

- There are an estimated 5.5 million species of insects, and they vary in nearly every dimension, including lifespan, behaviour, cognition, morphology, physiology and much more.
- We manage quadrillions of insects in the wild, farm trillions of them for food, feed, silk and more, and use billions in research each year. However, there is little guidance on their welfare needs in any context.
- Despite this lack of guidance, there is reasonable cause to care about insect welfare. Using a popular framework for assessing the plausibility of invertebrate sentience produced by the London School of Economics, adult insects of the orders Diptera and Blattodea scored higher than even decapod crustaceans, which were included in the UK's 2022 Animal Welfare (Sentience) Act.
- Alongside its intrinsic ethical value, a greater focus on insect welfare will also be essential to the maturation of the farmed insect industry, improving its economic productivity and maintaining its social licence to operate.

framework to decapods and cephalopods.⁵ This framework, based on popular frameworks used for assessing vertebrate sentience,⁶ contains four neurobiological and four behavioural criteria. Cephalopods met seven criteria to a high or very high degree of confidence, while decapods met five.⁵ Both groups were subsequently included in the UK's Animal Welfare (Sentience) Act 2022, legislatively recognising the plausibility of their sentience.

In 2022, this framework was extended to insects, with evidence reviewed separately for six orders at both the juvenile and adult life stages.⁷ In this review of several hundred studies, it was determined that adult insects of two orders (Blattodea: cockroaches and termites; Diptera: flies and mosquitoes) met six criteria to a high or very high degree of confidence, while adult insects of the order Hymenoptera (bees, ants, wasps and termites) met four criteria (Fig 2).

A striking result of the review was how few criteria had ever been researched at any life stage



Fig 1: Giant Malaysian katydids (*Arachnacris corporalis*) – one of the largest known insect species in the world

in any order (resulting in a confidence grade of ‘no research found’ for that criterion), suggesting empirical disinterest in candidate markers for the plausibility of sentience in these animals.⁷ The fact that Blattodea and Diptera meet more criteria than other orders should thus not necessarily suggest an increased plausibility of their sentience compared to other insect orders. Instead, it may simply reflect increased empirical attention to these groups, as the American cockroach (*Periplaneta americana*) and the fruit fly (*Drosophila melanogaster*) are standard model systems for nociceptive neurobiology and behaviour.

These results were recapitulated by the recent New York Declaration on Animal Consciousness, which states that ‘the empirical evidence indicates at least a realistic possibility of conscious experience in all vertebrates (including reptiles, amphibians and fishes) and many invertebrates (including, at minimum, cephalopod molluscs, decapod crustaceans and insects)’.⁸ This declaration has been signed by many leading comparative cognition experts, consciousness scientists, philosophers of animal minds and neuroethologists from around the world.

Overall, and despite many gaps in the literature that must be addressed with additional research, these data suggest insect sentience is at least as plausible as decapod sentience and, given the prior legislative use of the Foundations of Animal Sentience framework in the UK, that at least some adult insects warrant similar legislative protections. However, there is currently little guidance on insects’ welfare needs in any context where they are used or managed.

Welfare of insects farmed as food or feed

While insects are farmed for many applications, the food and feed industry is growing most rapidly.⁹ As such, this industry has been the focus of significant recent academic attention regarding animal welfare.¹⁰⁻¹²

Trillions of insects are currently farmed as food for human consumption or as feed for vertebrate livestock, with the goal of providing more sustainable protein to feed a growing human population.¹³ The major species farmed are black soldier flies (*Hermetia illucens*; Diptera), yellow mealworms (*Tenebrio molitor*; Coleoptera) and several species of crickets (the most popular being the house cricket *Acheta domesticus*; Orthoptera). The industry is global and constantly innovating, meaning there is tremendous variation in the scale of facilities and their practices. This variation can result in significant welfare-relevant differences across facilities and contexts for these mini-livestock animals.¹⁴

There are some general welfare concerns that affect all insect species farmed as food and feed in most industrial settings, such as inhumane slaughter methods,¹⁵ high stocking densities, epidemic disease outbreaks and inappropriate abiotic conditions (eg, light use when many species are photophobic). There are also many species-specific welfare concerns. For instance, cannibalism and aggression are frequently reported issues for crickets, which also appear to be more sensitive to transport – sometimes resulting in high mortality, known as ‘shipping sickness’.¹⁶ Lack of access to food or water can cause adult black soldier flies used as breeders to starve or desiccate to death prematurely,¹⁷ and lethal overheating may result from yellow mealworm larvae (or black soldier fly larvae) aggregating at too high densities in feed.¹⁸

In addition, there are plausible future welfare concerns that may affect these mini-livestock animals as the industry grows.¹⁶⁻¹⁸ For example, artificial selection or genetic modifications may result in reduced animal health or ability to perform natural behaviours, novel feeds may induce toxicity or spread disease, and the rate of the search for new species to farm may make it challenging for welfare science to provide guidance on high welfare practices at the pace of industry growth.¹⁴

RESEARCH COMMENT

Taken together, these welfare concerns highlight the importance of collaborations between producers, welfare scientists, veterinarians and other stakeholders in making progress towards improving the welfare of insects using empirically supported best practices. Groups like the Veterinary Invertebrate Society, Insect Welfare Research Society and the Welfare and Ethics Special Interest Group of the Royal Entomological Society may be essential in researching these welfare improvements.

Furthermore, these collaborations are essential to ensure that welfare recommendations are practical for the industry as it grows. Alongside its intrinsic ethical value, a robust field of insect welfare science will be essential to the industry's maturation, improving economic productivity, maintaining its social licence to operate and allowing for increased product differentiation.¹²

Meghan Barrett, Department of Biology, Indiana University – Indianapolis, Indianapolis, Indiana, USA

email: meghbarr@iu.edu

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Adult	Criterion 1 Nociception	Criterion 2 Sensory integration	Criterion 3 Integrated nociception	Criterion 4 Analgesia	Criterion 5 Motivational trade-offs	Criterion 6 Flexible self-protection	Criterion 7 Associative learning	Criterion 8 Analgesia preference
Blattodea	High Confidence	Very High Confidence	Very High Confidence	High Confidence	Very Low Confidence (No Research Found)	High Confidence	Very High Confidence	Very Low Confidence (No Research Found)
Coleoptera	Very High Confidence	Very High Confidence	Very Low Confidence (No Research Found)	Very Low Confidence (No Research Found)	Very Low Confidence (No Research Found)	Very Low Confidence (No Research Found)	Very Low Confidence (No Research Found)	Very Low Confidence (No Research Found)
Diptera	Very High Confidence	Very High Confidence	Very High Confidence	Very High Confidence	High Confidence	Very Low Confidence (No Research Found)	Very High Confidence	Very Low Confidence (No Research Found)
Hymenoptera	Very High Confidence	Very High Confidence	Very Low Confidence (No Research Found)	Medium Confidence	High Confidence	Very Low Confidence (No Research Found)	Very High Confidence	Very Low Confidence (No Research Found)
Lepidoptera	Very High Confidence	Very High Confidence	Very Low Confidence (No Research Found)	Very Low Confidence (No Research Found)	Very Low Confidence (No Research Found)	Very Low Confidence (No Research Found)	Very High Confidence	Very Low Confidence (No Research Found)
Orthoptera	High Confidence	Very High Confidence	Very Low Confidence (No Research Found)	Low Confidence	Very Low Confidence (No Research Found)	Very Low Confidence (No Research Found)	Very High Confidence	Very Low Confidence (No Research Found)

■ Very High Confidence
 ■ High Confidence
 ■ Medium Confidence
 ■ Low Confidence
 Very Low Confidence
 Very Low Confidence (No Research Found)

Fig 2: Table summarising the confidence levels with which each order of insects fulfills each sentence criterion at the adult life stage, adapted from Gibbons et al.⁷ **Blattodea (cockroaches, termites), Coleoptera (beetles), Diptera (flies, mosquitoes), Hymenoptera (bees, ants, wasps, sawflies), Lepidoptera (butterflies, moths), Orthoptera (crickets, katydid, grasshoppers)**

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