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Insect sentience and the rise of a new inclusive ethics

Commentary on **Mikhalevich & Powell** on *Invertebrate Minds*

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Abstract: Welfare protections for vertebrates are grounded in the belief that vertebrates are sentient and capable of feeling whereas invertebrates are not. We agree with Mikhalevich & Powell that the exclusion of small-brained invertebrates from bioethics is not warranted by the current state of the scientific evidence. The choice to promote protection for certain invertebrates should be based on the Animal Sentience Precautionary Principle (ASPP). This principle should not prevent us from conducting experimental research with non-human animals to advance knowledge. However, we believe that it is important to outline practical guidelines to manage the wellbeing of invertebrates, while accumulating further evidence on their inner life.

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The idea that all matter and living creatures could be classified in a hierarchy of "perfection," a *scala naturae* — with non-living categories such as minerals at the very base, followed by plants, invertebrates, vertebrates, and culminating with humans — dominated science until the mid-1850s. This view was undermined by biologists following the publication of Darwin's *Origin of Species* and the proposal that the mechanism of natural selection has shaped a "Tree of Life" from a common descent. Yet, as highlighted by Mikhalevich & Powell (2020) (M&P), bioethics and welfare policy have been slower to embrace this view. This might have contributed to the *a priori* exclusion of some species, including invertebrates, from ethical and welfare considerations. In this commentary, we discuss some of the experimental evidence on complex

cognition, metacognition, self-awareness, emotions and pain in invertebrates and propose that the time has come to ask whether specific ethical standards should be extended to some invertebrates too. A related argument for the need to start this conversation is the recent change in the "theory of the invertebrate mind" (Spence et al. 2017). This change in public attitude probably originates from the increasingly widespread dissemination of scientific findings, such as those about bees being able to pull strings or play a ball game. This advance in general knowledge provides us with the unique opportunity to engage the public in a scientifically informed conversation about ethics and welfare in invertebrates.

Recent decades have provided increasing experimental evidence that invertebrates have high-level cognitive capacities, some reaching those of large-brained animals, including mammals and primates. Most cephalopods such as octopuses, squids and cuttlefish excel in spatial navigation and planning ahead (Mather 1991; Graindorge et al. 2006), learning and memory (Edelman et al. 2005; Jozet-Alves et al. 2013), behavioral flexibility (Zarrella et al. 2015; Mather & Dickel 2017; Mather 2019), and problem solving including rudiments of tool use (Finn et al. 2009). Insects like social Hymenoptera share these cognitive capabilities with cephalopods, showing cognitive capacities such as numerosity (Howard et al. 2018), categorization-like processing (Giurfa et al. 2001; Avarguès-Weber et al. 2011), attention-like processes (Nityananda 2016) and other extraordinary abilities including transitive inference (Tibbetts et al. 2019), multimodal and individual recognition abilities (Tibbetts 2002; D'Ettorre & Heinze 2005; Baracchi et al. 2015), cross-modal object recognition (Solvi et al. 2020), holistic processing (Avarguès-Weber et al. 2018), symbolic communication (Frisch 1946; Lindauer 1955) and causal reasoning (Loukola et al. 2017). Bees, in particular, seem to master mental representation of space and time, which are among the main hallmarks of consciousness (Chittka & Wilson 2019).

Although sophisticated cognitive feats alone say little about sentience and do not necessarily imply eligibility for moral status (Vallortigara 2017), they demonstrate that small-brained insects are not machine-like organisms. This should not be surprising, as neither absolute nor relative brain size and organization are not necessarily informative about computational and cognitive capacities (Menzel & Giurfa 2001; Chittka & Niven 2009). Other features, such as total neuron number, neuron density, connectivity, and modularity are better indicators of the computational power of brains (Chittka & Niven 2009; Peng & Chittka 2017). Judging a species by its appearance has already proved misleading in comparative psychology. Birds, for example, once considered "dumb" and capable only of instinctive behaviors based on Edinger's assumption that the avian brain was primitive, have now reached the status of "feathered apes" (Emery 2004).

A stronger argument for a more inclusive ethics than the mere existence of advanced cognition (Vallortigara 2017, 2020) is provided by the handful of recent studies investigating metacognition (Perry & Barron 2013), emotion-like states (Perry et al. 2016; but cf. Baracchi et al. 2017), sentience (Barron & Klein 2016; Klein & Barron 2016) and pain (Elwood et al. 2009; Gherardi 2009; Elwood 2011) in Pancrustacea. Empirical studies and cognitive theorists have begun to support the existence of very basic forms of consciousness, such as subjective experience in invertebrates. Barron & Klein speculated about commonalities between the brain structures and functions of insects and those of sentient animals, including humans. They discussed how the central complex of insects, which is functionally analogous to the midbrain of vertebrates, is involved in sensory reafference and allows true navigation. This structure is likely to build an egocentric representation of the world and support a capacity for subjective experience. From a behavioral perspective, consciousness

can be inferred on the basis of the opt-out response in a metacognitive task. For example, when bees are confronted with a difficult task, they avoid making a decision when they are uncertain (Perry & Barron 2013). Similarly, the idea that invertebrates may have basic forms of emotions is growing in the scientific community. There is evidence that positive or negative emotions can be induced in some invertebrates and that these affect their judgment (Bateson et al. 2011; Perry & Barron 2013; Fossat et al. 2014; Gibson et al. 2015). Crustaceans may feel pain (Elwood et al. 2009; Gherardi 2009; Elwood 2011), and the behavioral and physiological responses of crayfish to electric shocks are analogous to those of mammals, suggesting that they might experience fear (Fossat et al. 2014).

On one hand, it is undeniable that the evidence presented above supports at least in part the need to extend ethical and welfare considerations to invertebrates. On the other hand, this evidence is limited by a number of caveats. First, most of these findings have been gathered with a comparative approach using a "standard" paradigm across a limited number of species (see Baciadonna et al.'s 2020 critical discussion of the mirror mark test in birds). Second, assessing subjective experiences in nonverbal animals still awaits further theoretical and methodological elaboration (Perry and Baciadonna 2017). This is true also in the study of pain. Although physiological and behavioral responses to noxious stimuli provide a valid operative framework for testing whether a species is sentient, the experience of pain, like emotion, is subject to huge variability (Jones 2013). The same noxious stimuli can generate different pain responses within the same individual and across individuals. There are several ways in which pain and emotion can be expressed; for example, some species are less prone to show signs of pain. Third, even among invertebrates, some are being treated differently from others on the basis of a biased approach to the scientific literature: if cephalopod mollusks have been considered "honorary vertebrates" for their cognitive abilities, it would seem logical, if not imperative, to attribute the same status to bumblebees and honeybees, based on the evidence available.

Considering these limitations, we agree with M&P that the "*exclusion of invertebrates with central nervous systems from bioethics and science policy is not justified by the current state of the evidence*." In our view, the decision to promote protection to invertebrates with central nervous systems should be based on the ASPP (Birch 2017), which states that "*where there are threats of serious, negative animal welfare outcomes, lack of full scientific certainty as to the sentience of the animals in question shall not be used as a reason for postponing cost-effective measures to prevent those outcomes*" (Birch 2017). This principle should not prevent us from conducing experimental research with non-human animals to advance knowledge. However, we believe that it is important to outline practical guidelines to protect the welfare of invertebrates while gathering further evidence on their inner lives. The scientific community does seem to be moving in this direction (Carere & Mather 2019).

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