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Bug talk trends & biases: literature survey and meta-analyses of vibratory sensing and communication in insects

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With 5 figures and 1 box

Abstract: Research on insect biotremology has resulted in a burgeoning body of literature over the past few decades. Despite this, several biases and knowledge gaps have been proposed, but not quantified. Therefore, a systematic literature review and meta-analyses were carried out to summarize the temporal trends and test for biases regarding taxa, developmental stages, and research topics reported in scientific papers spanning 75 years. The survey tracked 831 papers, which exhibited exponential growth since the 1990s and covered 17 insect orders. Among these studies, 70.4% were associated with adaptive behaviors, while the remaining (29.6%) focused on applied entomology and sensory organs. Three main biases were detected: (i) a prevalence of studies on Hemiptera, Hymenoptera, and Coleoptera, (ii) a focus on adults, and (iii) a preponderance of studies on reproductive behaviors. Considering only adaptive behaviors, the likelihood of studies with adults was 3× higher than for juveniles. Studies documenting receiver response were 2× higher than not. Still, few insect orders (9 of 17) included reports on vibrations used in an adaptive context, while studies reported in the remaining orders focused on mechanisms of vibration production or vibration characteristics. The results of this study highlight knowledge gaps worthy of future investigations. In particular, further research is necessary on the role of vibratory sensing and communication in juveniles (eggs, larvae, pupae, and nymphs), testing hypotheses on the adaptive roles of vibrations in a broader range of taxa, characterization of vibratory landscapes, and research on sensory receptors.

Keywords: biotremology, development, substrate-borne vibrations, vibroacoustic, behaviour, Insecta

1 Introduction

Vibratory sensing and communication are considered to be the most ubiquitous and ancient sensory modalities in insects (Hill 2009; Endler 2014). By vibration, we refer to mechanical waves transmitted through solids (e.g., soil, plant material, silk, wax), in contrast to those transmitted through air or water and commonly referred to as "sounds" (see Hill 2008; Hill & Wessel 2016). Solid-borne vibrations are widely available to insects in the environment and originate from both abiotic (e.g., rain, wind) and biotic (e.g., conspecifics, predators) sources. Vibrations arising from biotic sources can be produced incidentally as cues, such as when an insect walks, or directly as signals, such as when an insect communicates to a mate (Maynard-Smith & Harper 2003; Yack 2016; Giunti et al. 2018). Vibratory sensing and communication (or biotremology, a recently coined term) in insects has received increasing research attention over the past few decades and this field of study has been variously described as a 'gold mine' with 'unsurpassed opportunities' (Cocroft et al. 2014a), and an 'unchartered territory' (Yack 2016), with 'many opportunities for ground-breaking study' (Cocroft & Rodríguez 2005). Despite the progress of this field, there are questions unanswered and gaps in our knowledge that deserve scrutiny.

A number of reviews have covered the topic of vibratory sensing and communication in insects to varying degrees. These include comprehensive reviews that focus on the distribution of taxa and contexts in general (e.g., Virant-Doberlet & Čokl 2004; Cocroft & Rodríguez 2005), or specific taxonomic groups (e.g., Plecoptera [Stewart 1997], Neuroptera [Devetak 1998; Henry et al. 2012; 2013], Hemiptera [Gogala et al. 1974; Claridge 1985; Čokl & Virant-Doberlet 2003; Cocroft & Mcnett 2006], Hymenoptera [Schneider & Lewis

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