Biotremology: from basic research to application

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The increased awareness that substrate vibrations are an ancient and widespread form of animal communication, and that vibration receptors are ubiquitous in organisms, led to the establishment of biotremology as a new discipline of study of mechanical communication (Hill & Wessel, 2016). Surface-borne mechanical waves provide organisms with information about their environment that is crucial for their survival and reproduction. This information is not limited to intraspecific vibrational communication, but also includes prey detection, predator avoidance and information about habitat quality.

While all insects possess highly sensitive vibration receptors, it is currently estimated that around 200,000 insect species use vibrational communication in a variety of intraspecific interactions (Cocroft & Rodríguez, 2005; Virant-Doberlet & Čokl, 2004). Vibrational signalling is particularly common in Hemiptera, which includes numerous major insect pests, like psyllids, leafhoppers, planthoppers and stink bugs. Reproductive behaviour in psyllids and stink bugs includes both, chemical and vibrational signals. However, in leafhoppers and planthoppers, mate recognition and location of the partner are mediated exclusively by substrate-borne vibrational signals (Čokl & Virant-Doberlet, 2003). During pair formation both sexes emit species- and sex-specific vibrational signals and vibrational interactions include continuous emission of vibrational songs and/or reciprocal exchange of male and female signals in a precisely coordinated duet. Competitive behaviour in males is expressed as emission of disruptive vibrational signals to interfere with ongoing duet and satellite behaviour, where intruding males silently approach the female duetting with another male (Mazzoni et al. 2009).

As a result of a growing realisation of the ubiquitous nature of vibrations in the environment and about the importance of vibrational signals and cues in insect behavioural decisions, the interest to exploit substrate vibrations in pest management also increased in recent years (Čokl & Millar 2009; Mankin, 2012; Polajnar et al. 2015). Every movement of the insect body or its parts induces vibrations in the substrate and such incidental vibrations induced by walking and feeding can be used for monitoring. Detailed knowledge of the biology, ecology and behaviour of the target species is essential in order to exploit or manipulate insect behaviour. Current applications include the use of species-specific vibrational signals emitted in sexual communication for automatic detection (Korinšek et al., 2016) or for playback to attract insects to traps (Mazzoni et al. 2017) and interruption of mating behaviour by playback of natural or synthesized disruptive vibrational signals (Mazzoni et al., 2009). Although vibrational mating disruption is a novel approach (Eriksson et al. 2012), it has been already transferred to the field in the vineyards (Polajnar et al. 2016; Krugner & Gordon, 2018).

Exploitation and manipulation of chemical signals is an integral part of IPM in several important crops and applied biotremology can provide innovative and efficient approaches in pest management of insects in which vibrational signals are an essential part of reproductive behaviour. Besides in depth studies of pest ecology and behaviour, implementation of such

approach involves solving several technical challenges that include development of reliable and affordable sensors and playback devices, algorithms for automatic recognition of vibrational signals, as well as optimization of energy consumption, tailored to specific pests and specific field conditions. Taking into account that substrate vibrations are one of the most important and widespread sensory modalities guiding insect behavioural decisions, we believe that with more concentrated effort to solve current technical constraints, exploitation and manipulation of vibrational signals can be successfully included in IPM strategies and provide sustainable solutions in both, open field and greenhouse crop systems.

Key words: biotremology, substrate-borne vibrations, vibrational communication, Hemiptera, IPM

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