Big Time for Small Singers

Use and benefit of laser vibrometry in insect research

A planthopper (Hyalesthes obsoletus). This species is a vector of a plant-disease in vineyards and therefore of scientific and economic interest.

Cicadas, leafhoppers, planthoppers and spittlebugs (also called Auchenorrhyncha) are a very diverse group of animals within the insect world. Nevertheless, relatively little is known about their behavior and phylogeny. Vibrational signals play an important role in species recognition and mating behavior. Here, the use of laser vibrometer is extremely helpful.

Cicadas and their songs are familiar to many people who live or vacation in the USA, Mediterranean or tropics. The “true bugs” (Hemiptera), which not only include Auchenorrhyncha but also bugs, aphids and whiteflies, are a very successful and diverse insect order. To date, about 42,000 species of Auchenorrhyncha have been described worldwide. Most of these species are leafhoppers or planthoppers (cover picture) with a body length of less than 5 mm. They play a significant role as primary consumers and consequently as a food source for other animals. Some leafhoppers and planthoppers are pests, for example in vineyards or rice fields, and are therefore of economic importance.

THE PROBLEM

In contrast to cicada songs, which are easily heard unaided by humans, leafhoppers and planthoppers use substrate-born signals. They produce vibrations (100 - 3,000 Hz) that can only be registered on the plant the animal is sitting on. Substrate-born signals were ignored for a long time although they are widespread among insects. The songs, often sounding like drums, are produced by so-called tympal organs, plates on the abdomen, set into vibration by muscles. Duets can often be observed between males and females. Because this communication is mainly used to find mates, it is believed that the songs are species specific and therefore a barrier to other species (biological species concept).

Species differentiation is difficult for many groups of Auchenorrhyncha, and until now the identification is mainly based on anatomical characteristics. However these are often very small, so other features are needed for identification. Aside from molecular methods, it turns out that bioacoustics is a helpful solution.

EXPERIMENTAL SETUP

In the past, vibration signals were recorded using very simple methods. The vibrations were made audible by touching the host plant with a gramophone stylus. More recently, piezoelectric transducers were used. The signals could then be recorded on magnetic tape or later on computers. The biggest disadvantage of these methods was that the pickup system had ▶

Figure 1: Experimental setup for recording planthopper songs. The vibrations are registered with a PDV-100 laser vibrometer either directly on the animal or on its host plant.

to either be in direct contact with the host plant, or at least so close to the animal that it could possibly disturb its natural behavior. Laser vibrometers offer incomparable advantages by measuring vibrations directly on the animal or the plant without direct contact (Figure 1). In addition, the measurement recording locations are more precisely defined and therefore more easily reproduced.

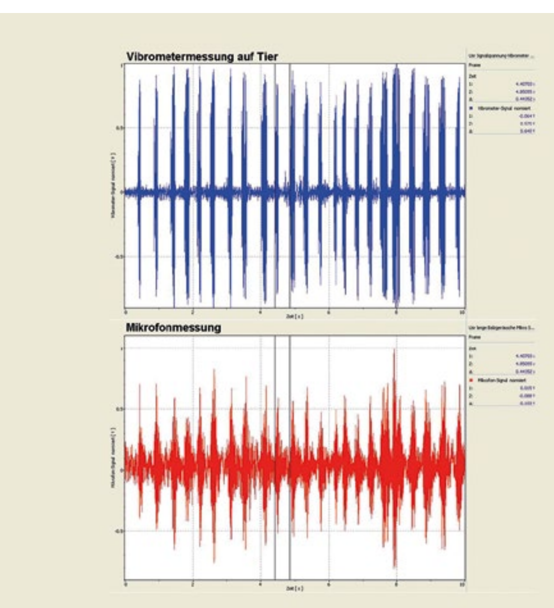

Figure 2: Laser vibrometer and microphone measurements compared. Above: The clear vibrational signal from a male planthopper (*Hyalesthes obsoletus*). Below: Simultaneously recorded airborne sound close to the animal.

OUTLOOK

Additional questions can be addressed with laser vibrometer measurements. It is unclear for example if only structure-borne vibrational signals are important or, at least in close-up range, if airborne sound also plays a role in planthopper communication. Our initial experiments have shown that a feeble airborne sound can be measured, but the signal is weaker and noisier (Figure 2). The flow of the vibrational sound into the host plant and its vibrational behavior can be studied thanks to the scanning laser vibrometer (Figure 3). Important considerations are the position of the insect during the diffusion and the characteristics of the plant material as well as the relation between the generated frequency and resonance of the plant. Further studies will reveal possible evolutionary adaptations of insects to their host plants, which will lead to a better understanding of speciation processes in Auchenorrhyncha. ■

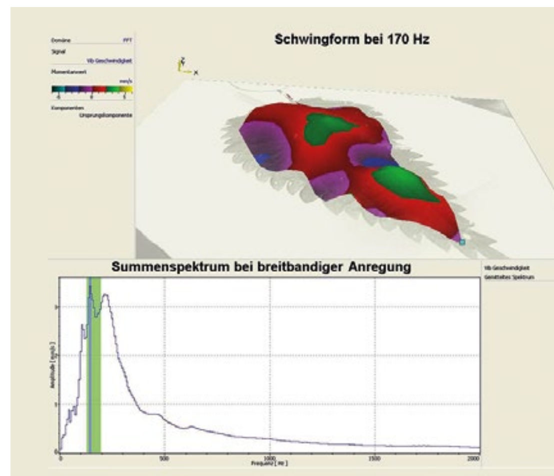

Figure 3: Deflection shape of a plant leaf (nettle) induced by a artificial signal (170 Hz) and the corresponding frequency spectrum.

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Photo
Title: E. Wachmann, Berlin.
Figure 1: S. Grube/V. Hartung, Berlin.

Acknowledgements
We are very grateful to Dr Reinhard Behrendt and Samy Monsched from Polytec for their intellectual and technical support.