

9. “Biological microphones”

Heiner Römer, Graz, Austria

Sensory ecology is mainly concerned with the mechanisms that enable an animal to produce or utilize signals within its specific environment, and how the information about identity or location of the sender is transmitted to the receiver(s). The evolution of the physical properties of sound signals or the signalling behaviour of an animal may result from various selective forces and constraints, one of which is the environment with its biotic and abiotic factors influencing sound transmission and perception. By focussing on acoustic insects, which often use high sonic or ultrasonic frequencies, we will learn how this affects the range of communication and directional hearing.

We often ignore the fact, that any animal, including ourselves, interpret the outside world by analysing action potential discharges in afferent nerves. Therefore, this lecture also emphasizes an alternative method of studying sound communication and hearing in natural environments, by using the sensory or central nervous system of a receiver as a “biological microphone”. This method, first introduced by Kenneth Roeder when working on the bat – moth – interaction, enables the investigator to determine directly, what kind of information a receiver will be able to analyse. I will present examples from my own work in various habitats, and extend the field to communication by substrate vibration.

10. Sound propagation in the biotope

Heiner Römer, Graz, Austria

NB! The following abstract gives some basic themes for the topic, but is NOT for Heiner Römer's talk, but from a talk on the same topic given by:

Axel Michelsen, Centre for Sound Communication, Institute of Biology, University of Southern Denmark, 5230 Odense M, Denmark, A.Michelsen@biology.sdu.dk (Ph.D. course 2006)

- Sound waves spread in three dimensions when the sound source is small compared to the distances being considered. At twice the distance from the source, the surface area is four times as large, and the sound energy passing a unit surface area decreases to one quarter (by 6 dB). The sound pressure level also decreases by 6 dB, that is to one half. The geometrical spreading loss is thus 6 dB per distance doubled.
- Sound loses energy by molecular absorption (sound energy is converted into heat). The process is insignificant at low frequencies, but it increases much with frequency and is often important at ultrasonic frequencies.
- Reflection of sound from hard ground is simple (no loss, no phase shift), but reflection from a soft ground is much more complicated (some loss, some phase shift). For example, when the sound wave is traveling just above ground, the interaction between the sound wave and the soft ground may cause a heavy attenuation of the sound above a certain frequency (review: TFW Embleton (1996) J Acoust Soc Am 100: 31- 48).
- Vertical gradients of temperature and/or wind lead to corresponding gradients of sound speed relative to the stationary ground (refraction). This phenomenon often has a considerable effect on the effective range of sound communication.
- The presence of vegetation causes an excess attenuation (that is, attenuation in addition to the geometrical spreading loss), in most cases of a number of dB pr. meter. The excess attenuation is generally very frequency dependent (for example, in many insect songs frequencies up to 8-10 kHz penetrate herbal vegetation, but higher frequencies are heavily attenuated; small animals that can only radiate high frequencies may therefore have to switch to other strategies than airborne sounds, e.g., substrate vibrations). The attenuation is partly caused by multiple scattering of sound. In vegetation and especially close to ground, the directional amplitude cue may get lost. The phase cue is more robust and can be exploited by pressure difference receiving ears.
- Some correlations between the vegetation of habitats and the frequency bands that dominate the animals' calls are well documented, but the physical mechanisms involved are not well understood. Several investigators have reported the existence of "sound windows", that is narrow frequency bands with very little attenuation. They are probably artifacts, created by ground reflections between the loudspeaker and the first microphone during the measurements.
- Air turbulence is present near the ground. It increases with wind and strong temperature gradients. Turbulence affects the use of rhythms in animal calls, and it can also limit phenomena that depend on phase relationships (as frequency filtering due to reflection).
- Much research needs to be done before we begin to understand how animals living in different acoustical environments manage to communicate by means of sounds.