

## **BANQUET TALK**

### **Effects of environmental sounds on bat sonar**

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Echolocating bats respond to different kinds of environmental sounds in ways that illustrate general principles of noise effects on hearing and behavior. Big brown bats broadcast wideband ultrasonic (~20-100 kHz) frequency-modulated (FM) sounds and perceive objects from echoes that return to their ears. They emerge in the dark, which limits the usefulness of vision and makes echolocation critical for all aspects of their orientation. Bats use 'active' sonar to detect and track flying insects, to avoid obstacles, especially while flying through vegetation, to follow landmarks on flight paths through familiar surroundings, and to guide bat-to-bat 'dogfights', which also involve hearing other bats' sounds. For a single echolocating bat, environmental sound consists largely of noise that masks weak echoes from targets at long range or actual echoes reflected by extraneous objects (clutter), such as vegetation or the ground. However, bats also use 'passive' hearing, listening for the sounds of prey and homing in on insect calls or the buzzing sounds of the insect's wingbeats. These sounds often are largely ultrasonic, so bats cannot simply filter out background noises to avoid interference. In many situations, ultrasonic insect calls are a significant source of intense ultrasound that can interfere with echo reception. Hearing also is used for acoustic communication and for listening to the echolocation sounds of other bats. Several bats of the same species commonly will forage for insects together in the same area, within hearing range of each other. Moreover, large numbers of bats sometimes swarm over water to drink or hunt for insects. Because the sonar sounds of different bats in the same species are very similar, mutual interference is a real problem. Although their sounds all are wideband, covering the same frequencies, individual bats introduce a small frequency shift of a few kilohertz at the low-frequency end of the sweeps. Although this shift is only a few percent of the total band and thus seems insufficient for each bat to segregate the broadcasts and echoes of other bats, psychophysical tests reveal that bats can suppress spurious 'echoes' in their images when these shifts are present. In the most extreme situations of bats involved in dogfight pursuits through vegetation, several strategies of coping with environmental sounds are combined to render this seemingly impossible scenario quite easy.