Middle ear adaptations for seismic detection in the golden mole

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Abstract

Golden moles are nocturnal, surface-foraging mammals with rudimentary vision. Several species possess massively hypertrophied mallei that presumably confer low-frequency, substrate-vibration sensitivity through inertial bone conduction. When foraging, *Eremitalpa granti namibensis* typically moves between sand mounds topped with dune grass that contain most of the living biomass in the Namib Desert. We have observed that foraging trails are punctuated with characteristic sand disturbances in which the animal "head dips" under the sand, presumably to obtain a seismic "fix" on the next mound to be visited. Seismic playback experiments suggest that in the absence of olfactory cues, golden moles are able to locate food sources solely using vibrations generated by the wind blowing the dune grass on the mounds. Based on middle ear anatomy, the ossicular mass distribution and the anchorage points, we have hypothesized that there are several degrees of freedom of the middle ear apparatus of *Chrysochloris asiatica*, a closely-related golden mole. A horizontal vibration, which drives the head sideways will excite the rotational mode ωy, whereas a vertical vibration excites mode ωz. We suggest that these two modes play the main role in inertial bone conduction in response to seismic stimuli, since they depend on both the increased mallear mass and the displacement of its center of mass from the rotational axis. In addition to these two modes, we postulate that there is a third vibrational mode, namely the rotation of the ossicular chain about the long axis of the malleus (ωx) in response to airborne stimuli. The transition between modes occurs between 200-300 Hz. Laser Doppler vibrometric measurements of the malleus head in response to seismic stimuli in *Chrysochloris* reveals peak sensitivity to frequencies below 300 Hz. Functionally, they appear to be low-frequency specialists, and it is likely that golden moles detect prey principally through substrate conduction.

Bibliography

Dr. Narins has been carrying out pioneering work for more than 30 years on the selective pressures sculpting and mechanisms underlying the evolution of sound and vibration communication in amphibians and mammals. He grounds his research in a unique combination of rigorous experimental field studies and quantitative physiological measurements. He provided the first example, in the Puerto Rican coqui treefrog, of sexual dimorphism in a vertebrate sensory system. He discovered the mechanism that prevents the sensitive inner ear of this frog from being overstimulated when the male produces its extremely high intensity calls. More recently, his comparative research approach led to the discoveries of ultrasonic communication in the concave-eared torrent frog (China), the first species of songbird demonstrated to produce ultrasound (China), the first amphibian capable of modulating his call to produce purely ultrasonic calls (Malaysia), and a novel system of seismic communication in a remarkable sand-dwelling mammal, the Namibian golden mole (Namibia). He has led or participated in 47 overseas scientific research expeditions to six continents plus Madagascar, and is in great demand as a plenary lecturer on the evolution of communication systems both in English worldwide and in Spanish to universities throughout Latin America and Spain. He is an editor of the Journal of Comparative Physiology, and has served as Treasurer of the International Society of Neuroethology. He has received the Senior U.S. Scientist Award of the Alexander von Humboldt Foundation and a Fulbright Award (Montevideo, Uruguay). He was elected Fellow of the Guggenheim Foundation, Acoustical Society of America, Animal Behavioral Society, and AAAS. He is an Honorary Member of the Cuban Zoological Society and Professor Ad Honorem at the University of the Republic, Montevideo, Uruguay.