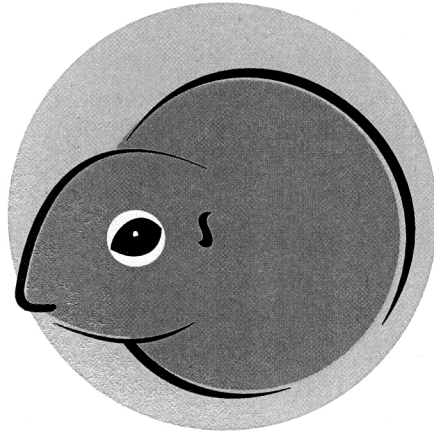


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ABSTRACTS
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Nonlinear phenomena as a reflection of degrees of arousal in screams and alarm calls of ground squirrels

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Emotional arousal modifies the acoustic structure of animal calls, and these changes, when adaptive, are supported by natural selection. Inclusion of nonlinear phenomena make calls more evocative and less predictable, thus preventing ignoring such calls by the listeners. In addition, loud dissonant calls can act as "an acoustic club" for predator discouragement, providing prey a chance to escape. Alarm calls are emitted for discouraging predators and warning kin by a relatively stationary caller with approximately equal inter-call intervals. The alarm calls are produced until the distance from a predator is still sufficient for dipping in a burrow. Thus, during the alarm calling, the level of arousal is moderate, as the caller controls the situation. Alternately, emission of screams is related to the grasping by a predator or to the immediate threat in a close vicinity of the predator. This is a howl of despair (distress call), as the caller does not control already the situation. We examined individually identified 50 speckled (*Spermophilus suslicus*), 18 European (*S. citellus*) and 59 yellow (*S. fulvus*) ground squirrels for variation in the acoustics and for the occurrence of nonlinear phenomena in their two most emotionally expressive calls types, the alarm call and the scream. Alarm calls were strictly species-specific in frequency modulation and temporal pattern of syllables, highly stereotyped in their acoustic structure within species. In all three species, the alarm calls were produced in prolonged series with regular intervals. Less than 1% of calls were complicated with nonlinear phenomena (subharmonics or biphonation). Additionally, alarm calls with ultrasonic components were found in 2 of 116 individual *S. suslicus*. Screams were not species-specific in the acoustic structure, representing in all three species the prolonged, penetrating notes, deeply modulated in frequency. Screams often contained the nonlinear phenomena, such as subharmonics (in 50% individual *S. fulvus*), frequency jumps (in 50% individual *S. fulvus* and 25% individual *S. citellus*), and sidebands (in 100% individual *S. citellus*). Also, screams were often complicated with a second-order saw-like frequency modulation. We conclude that nonlinear phenomena reflect degrees of emotional arousal in screams and alarm calls across species of ground squirrels.

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