



Original investigation

## Individual vs. non-individual acoustic signalling in African woodland dormice (*Graphiurus murinus*)

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## ABSTRACT

Animals that live in cohesive groups often use social calls for long-distance communication, particularly in low-visibility habitats, whereas other call types are only used to communicate over short distances. According to the “distance-communication hypothesis” only the former should encode individual information while the latter should not because individuals are in visual or olfactory contact when calls are broadcast. We used the African woodland dormouse *Graphiurus murinus*, a social rodent whose vocal repertoire is still poorly known, as a model species to test the hypothesis that long-range but not short-range calls will structurally differ across individuals. By conducting controlled video- and audio recordings in captivity, we associated calls to non-vocal behaviours in *G. murinus* and selected two call types (contact and aggressive calls) that clearly served long- and short-range communication respectively. In agreement with the distance-communication hypothesis, only contact but not aggressive calls differed significantly among subjects. Although we did not test the actual function of such variation, the latter provides a structural basis for the transmission of individual information. This is the first time this hypothesis is tested in a small non-volant mammal. Our study also provides the first description of acoustic behaviour in *G. murinus*.

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## Introduction

Acoustic signalling represents an important communication channel among animals (Wiley and Richards, 1978): conveying information about individual identity by acoustic communication is a fundamental feature for species that need to maintain social contact among group members, particularly those inhabiting low-visibility habitats (Bouchet et al., 2012). Encoding individual identity within acoustic signals allows animals to communicate such information from a distance, without the need of establishing visual contact between emitter and recipient, which would be difficult in structurally complex habitats such as forests (Maynard Smith and Harper, 2003). Individuality has been often recorded as ‘signatures’ found in social calls, widely used especially by birds and mammals to communicate with conspecifics (Matrosova et al., 2011; Kremers et al., 2012; Janik and Sayigh, 2013; Cornec et al.,

2014). Among mammals, individual signatures are most common in species with complex and stable social structures; comparative studies on rodents, for example, indicate that vocal complexity relates to that of the species’ social structure (Freeberg et al., 2012; Pollard and Blumstein, 2012; Bouchet et al., 2013).

The ‘distance communication hypothesis’ (Bouchet et al., 2012) predicts that, within the vocal repertoire of a species, signals used for short- or long-distance communication may be subject to different selective pressures. In close contact, animals provide non-vocal (visual or olfactory) individual cues, whereas long-distance communication, taking place in absence of direct contact, is more likely to encode individual identity, status or quality. This hypothesis has received support mainly from studies on primates (Macedonia, 1986; Mitani et al., 1996; Bouchet et al., 2012) as well as on the social giant otter (Mumm et al., 2014), but whether it also holds valid for small mammals is yet to be proven.

Dormice (Gliridae) are highly vocal rodents and many species produce a variety of acoustic signals, audible to humans as well as ultrasonic (Boratynski et al., 1999; Hutterer and Peter, 2001; Madiakiza, 2010; Ancillotto et al., 2014). The secretive, nocturnal habits of most dormice species (Webb and Skinner, 1994) make their social systems and communication signals difficult to unveil:

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**Table 1**  
Ethogram of captive *Graphiurus murinus*. Role of vocalizing subject: A = actor, R = receiver.

Behavioural class	Behaviour	Associated vocalization type	Role of vocalizing subject	Description
Sexual	Courting	h	A	Male (actor) subject chases and moves around a female (receiver).
	Mating	–	–	Male subject mounts a female for copulation.
Aggressive	Chasing	–	–	Subject actively chases another.
	Aggressive contact	d	R	Subject (actor) bites or scratches another (receiver).
	Tail waving	–	–	Subject conspicuously wags its tail.
Prosocial	Generic physical contact	a	A	Subject (actor) touches another (receiver) with its body
	Allogrooming	–	–	Subject (actor) actively grooms (licking, scratching) another (receiver).
	Nest retrieval	g	R	Subject (actor) carries an infant/juvenile (receiver) into the nest

observations on the African woodland dormouse *Graphiurus murinus*, the species dealt with in the present study, and the hazel dormouse *Muscardinus avellanarius* (Juškaitis, 2008; Madikiza et al., 2010) suggest that their social systems involve non-random association among individuals, with fission-fusion dynamics across small groups (Madikiza et al., 2011).

In this work we test the distance communication hypothesis on the vocal repertoire of the social rodent *G. murinus* predicting that long-range vocalizations will show a higher degree of individual variability than vocalizations broadcast by individuals close to each other. We assume that such variation provides the structural basis for conveying individual information.

The vocal behaviour of *G. murinus* is poorly known, thus we first analyse the acoustic repertoire of the species and associate vocalization types with non-vocal behaviours; then, we test our hypothesis selecting two signal types that best contrast short vs. long-distance communication.

## Material and methods

### Model species, experimental individuals and housing conditions

*G. murinus* is an arboreal small-sized glirid (weight: 24–34 g; head-body length: 78–113 mm; tail length: 58–94 mm) common throughout central and southern Africa, where it inhabits woodlands, scrublands and suburban gardens (Madikiza, 2010). This species is also widespread as a pet in Europe and North America, where it is commercially known as ‘African pygmy dormouse’ (Suckow et al., 2012).

We considered 15 adult subjects originating from two groups kept at the ‘Charles Darwin’ Department of ‘La Sapienza’ University in Rome, descendants of a heterogeneous stock of captive-bred individuals; specific identification was confirmed by comparing preserved skulls of previously deceased individuals with those illustrated in Terryn et al. (2007). The two groups, kept separated from each other over 3 generations, were made of respectively 9 (3 males, 6 females) and 6 (2 males, 4 females) adults; juveniles ( $n = 5$ ) were also present in the smaller group when we performed our study.

Groups were kept in 70 × 55 × 100 cm wire-mesh cages, each enriched with branches, twigs, four wood nest boxes and pinewood shavings used as bedding material. Dormice were fed on a commercial mix for insectivorous birds, rodent seed-mix, fresh fruit and live mealworms; food and water were available *ad libitum*. Cages were housed in two identical rooms, kept at ca. 24 °C and subjected to natural light cycles through a window.

### Recording protocol

Continuous and synchronized automatic acoustic and infrared video recordings were undertaken during four sessions between April and May 2014, each lasting 3 nights (from 21.00 to 05.00). Audio recordings were made with Pettersson D500x bat detectors

(Pettersson Elektronik AB, Uppsala) whose frequency recording range (1–190 kHz) covered the frequency bandwidth known for the congeneric *G. parvus* (Hutterer and Peter, 2001). We used Sony Handycam SR501 camcorders with nightshot function for video recording.

Because *G. murinus* is a nocturnal rodent (Kastenmayer et al., 2010) we did not record during the day. Bat detectors were placed ca. 20 cm from the cage’s front mesh, 50 cm from the ground; camcorders were placed at the same height and fixed with tripods to both sides of the cages, in order to cover entirely their upper part. *G. murinus* are strictly arboreal (Madikiza, 2010), so they rarely used the lower part of the cage. The identity of video-recorded subjects was unambiguously assessed by the presence of distinct body features, e.g. white spots, missing tip of the tail, or small scars on ears.

### Sound analysis

We analysed audio files with BatSound release 4.11 (Pettersson Elektronik AB, Uppsala), using a sampling frequency of 384 samples/s, with a 512-point FFT Hanning window, and 98% window overlap.

We followed Holy and Guo (2005) for classification of single syllables, or ‘notes’, and their association in different independent calls. We manually measured call structural variables from spectrograms (number of harmonics, number of notes, start frequency SF, end frequency EF), power spectra (frequency of maximum energy FmaxE) and oscillograms (duration Dur, inter-pulse interval IPI); SF and EF were measured at –25 dB relative to the amplitude of the frequency of maximum energy from the corresponding power spectra.

### Vocal repertoire and behaviour

We first screened recordings visually based on spectrogram shape and frequency range and allocated calls to different categories accordingly, then such visual classification was assessed quantitatively by Kruskal-Wallis tests followed by *post-hoc* pairwise comparisons testing, for each parameter, whether significant structural differences occurred between categories.

To associate vocalizations to non-vocal behaviours, we adapted the ethogram (Table 1) used for another glirid (*M. avellanarius*) described by Ancillotto et al. (2014). Each vocalization was matched with the sex and age class of the emitter, as well as with the non-vocal behaviour performed by the same focal individual during or immediately before/after vocalizing. Such associations were tested with chi-squared tests on contingency tables followed by a *post-hoc* analysis of residuals. The approximate distance between vocally interacting dormice was also determined *a posteriori* from video recordings. We excluded from further analyses all calls whose emitters’ identities were ambiguous (e.g. when two or more subjects called simultaneously or calls were emitted by subjects not visible in the video).

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