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SHORT NOTE

The presence of ultrasonic harmonics in the calls of the rifleman (*Acanthisitta chloris*)

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Ultrasonic vocalisations (frequencies ≥20 kHz) have been extensively studied in the context of echolocation by bats and other mammals (Sales & Pye 1974; Wilson & Hare 2004). Ultrasonic calls have also been recorded from birds, including the blue-throated hummingbird (*Lampornis clemenciae*) (Pytte *et al.* 2004), where it was first thought that individuals made use of high pitch calls to avoid masking by background noise in a visually obscured environment. Similarly, city-dwelling great tits (*Parus major*) use song with a higher minimum frequency (although not ultrasonic) compared to woodland birds to communicate with conspecifics to avoid the predominantly low-frequency background noise in the city (Slabbekorn & Peet 2003). The theory that birds use ultrasound to avoid noise masking was discarded when it was discovered that there was no corresponding auditory brainstem response (i.e. sensory perception) to the ultrasonic calls in the hummingbirds producing those calls.

An alternative adaptive hypothesis for the production of ultrasound is that insectivores use their calls to flush ultrasound-hearing insects (Hoy & Robert 1996) from crevices, for ease of sighting and capture. Ultrasonic calls may also trigger predator-avoidance movements in insects, such as erratic flight patterns and the 'stop and drop' response mid-flight (Olesen & Miller 1979; Yager *et al.* 1990). These insects may again be easier for birds to catch, especially for those insectivorous birds which are relatively poor flyers and spend most of their time near the forest floor (Hunt & McLean 1993; Pytte *et al*. 2004). The endemic New Zealand rifleman (*Acanthisitta chloris;* titipounamou) is one such poor-flying and substrate-foraging species. In addition, ultrasonic hearing is known to occur in 5 insect orders: Orthoptera, Neuroptera, Dictyoptera, Coleoptera and Lepidoptera (Michelsen & Larsen 1985; Yager & Hoy 1986; Spangler 1988) and the rifleman is noted to feed most frequently on species from 3 of these orders: beetles (Coleoptera), weta (Orthoptera), and moths (Lepidoptera) (Moeed & Fitzgerald 1982).

Preliminary observations using equipment for recording ultrasonic bat calls (S. Parsons, *unpubl. data*) indicated that the rifleman is able to produce ultrasonic signals. As the rifleman is a forest dwelling, social insectivore (Hunt & McLean 1993), both the communication and the prey flushing hypotheses for ultrasound production in birds (Pytte *et al*. 2004) may be applicable. The foraging hypothesis is also supported by other aspects of rifleman behaviour, which includes the rapid flushing of wings that has been associated with insectivory in other species of birds in New Zealand and beyond (Mumme 2002).

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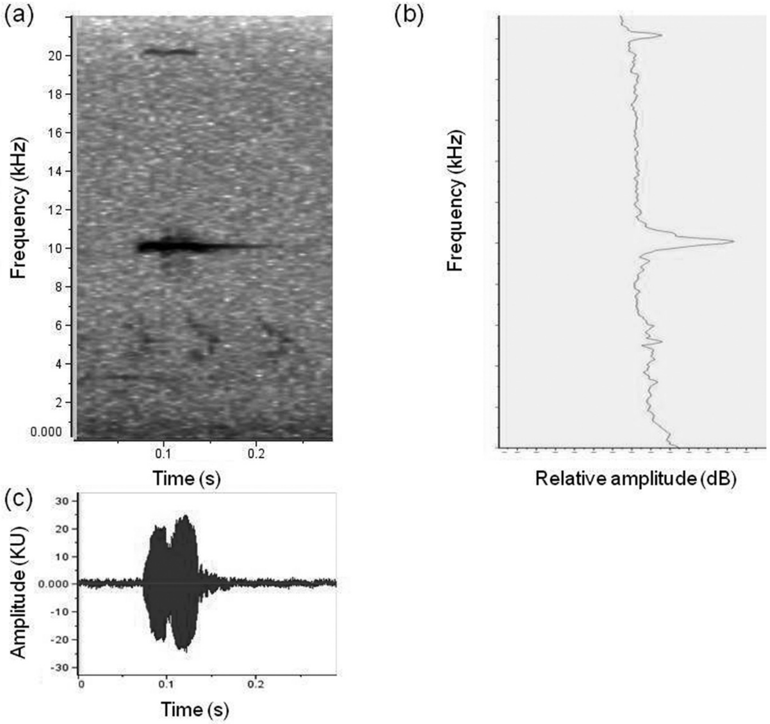

Fig. 1. Spectrogram (a), power spectrum (b), and waveform (c) of the Kaikoura rifleman contact call. The spectrogram and power spectrum were created using 512-point FFTs, 50% overlap and 124 Hz resolution.

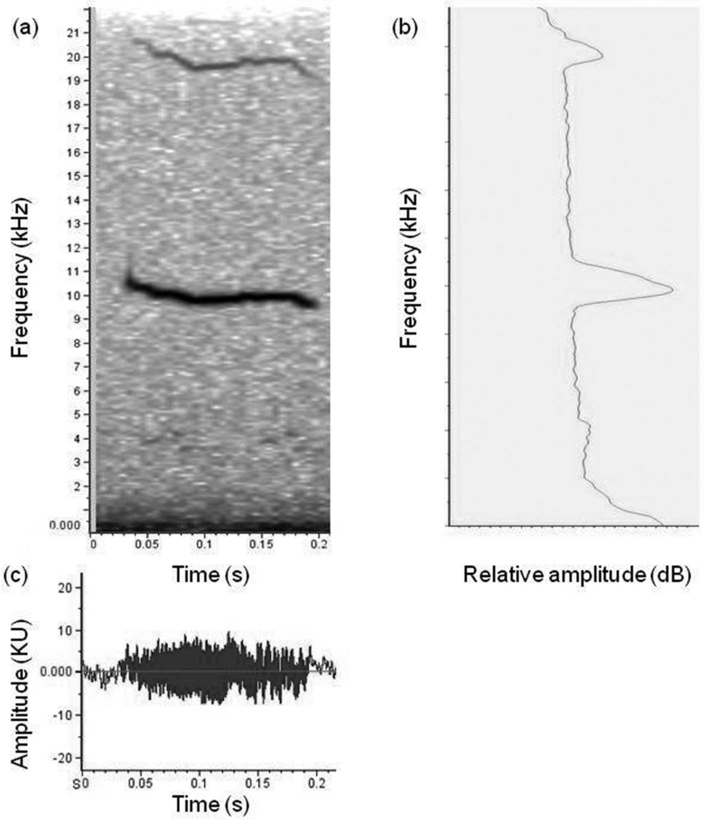

Fig. 2. Spectrogram (a), waveform (b), and power spectrum (c) of the Kaikoura rifleman begging call. The spectrogram and power spectrum were created using 512-point FFTs, 50% overlap and 124 Hz resolution.

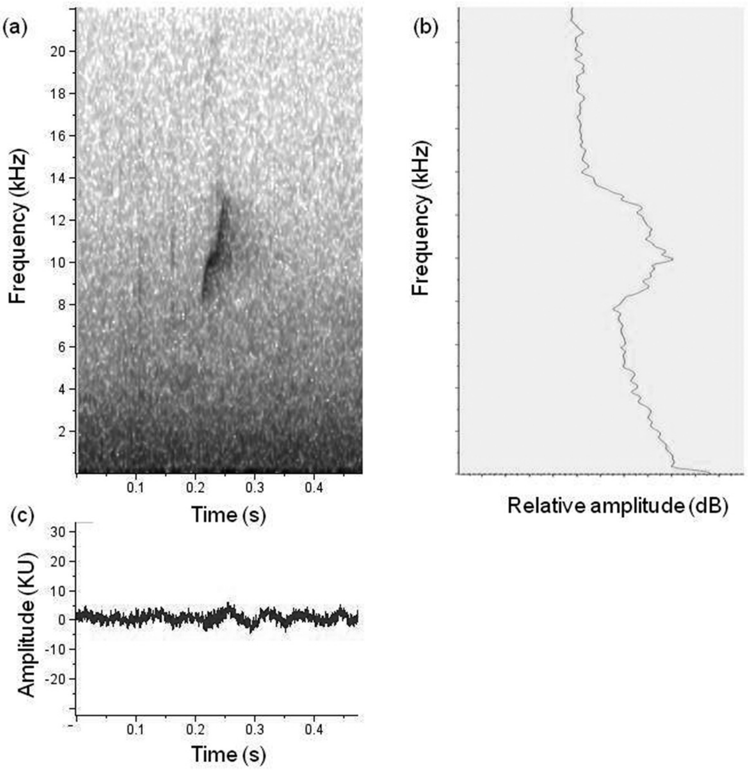

Fig. 3. Spectrogram (a), power spectrum (b), and waveform (c) of the Taranaki rifleman contact call. The low signal to noise ratio in this recording was due to close proximity to a stream. The spectrogram and power spectrum were created using 512-point FFTs, 50% overlap and 124 Hz resolution.

For this report, riflemen were recorded at Kowhai Bush, Kaikoura (42° 23′ S, 173° 37′ E) in Oct 2006. Recordings were also made on the Kamahi and Mountain House track, Mt Taranaki (Egmont National Park; 39° 17′ 47″ N, 174° 3′ 53″ E) in May 2007. Four individuals were recorded in Kaikoura and a further 5 individuals at Mt Taranaki. All recordings of adult birds were made whilst the individuals were actively foraging. Additional details on the conspecific social behavioural context of call production were also noted when the birds were recorded. Recordings were made using a handheld Sennheiser microphone (model K6 ME 66, Sennheiser, Wedemark-Wennebostel, Germany), which has a frequency response of 40 – 20,000 Hz ± 2.5 dB (the microphone is sensitive beyond 20,000 Hz, but not with the stated sensitivity) and a maximum sound pressure level of 125 dB at 1000 Hz. A Marantz (Kanagawa, Japan) portable high-resolution digital audio recorder was used to store the recordings as 48-bit WAV files (44.1 kHz sampling rate, giving a recording bandwidth of 22.05 kHz). The recordings were analysed using Raven v1.2 (Cornell Lab of Ornithology, Ithaca). Spectrograms and power spectra were generated using a 512-point Fast Fourier Transform (giving a resolution of 124 Hz) and the highest frequency and lowest frequency of the fundamental and all harmonics of each call were noted.

By combining behavioural context and acoustic evidence from the Kaikoura recordings it was evident that there were 2 types of call present. While this may not represent a full sampling of the rifleman repertoire, both of these calls were recorded in a clear intraspecific communication context. The first was a contact call consisting of a regular ‘cheep’ and containing only 1 element (Fig. 1). This call was made whilst the individual was foraging in the proximity of 1 or more conspecifics. The dominant component of this call was always the fundamental frequency. The highest frequency recorded for the fundamental was 11.3 kHz and the lowest was 7 kHz. The lowest frequency recorded for the second harmonic was 20 kHz and the highest was 20.3 kHz.

The second call type from the Kaikoura birds was a begging call produced by an 18 day old chick in nest box (Anderson *et al*. 2009) (Fig. 2), which contained the fundamental and 1 harmonic. The fundamental was loudest and had a highest frequency of 11.8 kHz and lowest frequency of 9.4 kHz. The second harmonic was ultrasonic, with the highest frequency for this harmonic, 20.75 kHz, and the lowest, 19.3 kHz.

According to the above classification, the recordings from Mt Taranaki were all contact calls, although these recordings had too much background noise to allow clear determination of the fundamental frequency. However, the highest frequency of the dominant harmonic was 14.5 kHz and the lowest was 8.3 kHz (Fig. 3). Overall, our recordings show that the calls of rifleman contain ultrasonic components but we did not detect solely ultrasonic calls. These findings, nevertheless, pose questions about the rifleman's ability to hear these harmonics, and the developmental mode and the communication function of such sounds.

None of the vocalisations of the rifleman can be classified as purely ultrasonic. Therefore, the production of ultrasound may be an epiphenomenon, similar to the calls of the blue-throated hummingbird, and rifleman may solely communicate with conspecifics using the non-ultrasonic parts of their calls. Bird song has 2 primary functions: to repel other males from a defended space, and to attract females and stimulate their courtship (Nowicki & Searcy 2004). Narins *et al.* (2004) suggested that high-frequency harmonics of the rufous-faced warbler (*Abroscopus albogularis*) allowed the birds to avoid the masking of communication calls by a nearby stream, and that ultrasound is required as stream noise in this species' habitat extends to 20 kHz. Rifleman may be under similar selective pressure given its frequently wet and leafy forest habitat, sometimes near streams, and small size. However, such a suggestion presupposes that the birds are able to hear ultrasound and no evidence to support this exists (Narins *et al.* 2004). Alternatively, there may be a combined function of conspecific communication in the audible range with the prey-flushing or other insect-behaviour modifying functions of ultrasonic harmonics. We propose that it is more likely that the presence of ultrasonic harmonics in the rifleman is either targeted at prey species or represents merely an epiphenomenon and that rifleman cannot hear the ultrasonic harmonics of their calls; further research would be needed to confirm this proposition.

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