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SHORT NOTE

Categorisation of common syllable types in the complex vocalisations of tui (*Prosthemadera novaeseelandiae*)

SAMUEL D. HILL*
WEIHONG JI
Human-Wildlife Interactions Research Group, Institute of Natural and Mathematical Sciences, Massey University, North Shore Mail Centre, Private Bag 102904, Auckland, 1131, New Zealand

Vocal repertoires in songbirds vary greatly across species. Some species such as the Oregon junco (*Junco hyemalis oreganus*) have just a single sound unit (syllable) within their repertoire (Konishi 1964), whereas other species such as the tropical mockingbird (*Mimus gilvus*) have highly complex repertoires consisting of over 100 different syllable types (Botero *et al.* 2008). In birds with complex repertoires, syllables can be grouped into types in order to simplify comparative song analysis.

The complex vocalisations of tui (*Prosthemadera novaeseelandiae*) were studied at Tawharanui Regional Park, 90 km north of Auckland, New Zealand (36° 22′S, 174° 50′E). The tui is a relatively large honeyeater (females range from 72-134 g and males range from 82-170 g; Sarah Wells, *pers.comm.*) endemic to New Zealand (Family Meliphagidae). The high diversity of syllables in tui songs presents a challenge to group syllables into categories. An analysis of 50 songs from 10 individual tui (5 males and 5 females: 5 songs each) was conducted. All song recordings were made during the tui breeding season between October 2010 and January 2011 between the hours of 0800 and 1500. Recordings were made using a Sennheiser ME67 shotgun directional long-range microphone and a Marantz PMD620 digital recorder, at a sampling rate of 44.1 Kilohertz (kHz). Songs were digitised and analysed using Raven Pro 1.4 Beta Version software (Cornell Lab of Ornithology, Ithaca, NY, USA) (discrete fourier transform (DFT) = 256, Hann window, 2.9 milliseconds, 50% frame overlap, bandwidth = 3dB).

The analysis revealed 6 main types of syllables within the Tawharanui tui population (Fig. 1). These were: (1) harmonic, defined as a number of integer multiples of the fundamental frequency (Qin *et al.* 2005), and the most common syllable type (Fig. 2); (2) rapid multiple note repetition (RMNR); (3) harsh, throaty syllables; (4) rapid frequency modulation or trill syllables; (5) high-frequency syllables (with a fundamental frequency of 5 kHz or above); and (6) low-frequency (syllables below 2kHz). These 6

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*Correspondence: *S.Hill@massey.ac.nz*

syllable types comprised 63% of the entire number of syllables (360) detected within the dataset. The remainder of syllables (37%; termed: 'other') could not be categorised into common syllable types due to lack of common characteristics between them (see Fig. 3 for examples).

The mean number of syllables per song was seen to vary between male and female tui. Males produced a mean of 23 syllables in total per song (and 12 *different* syllables per song), whereas females produced a mean of 8 syllables in total per song (and 5 *different* syllables per song).

Syllable diversity, or vocal complexity, varies across the Meliphagidae. The repertoires of noisy miners (*Manorina melanocephala*) and New Holland honeyeaters (*Phylidonyris novaehollandiae*) for example consist of simple single note whistles (Jurisevic & Sanderson 1994). Red wattlebirds (*Anthochaera carunculata*) and little wattlebirds (*A. chrysoptera*) sing relatively simple songs, generally consisting of a small number of different harsh syllables covering several frequencies (Jurisevic & Sanderson 1994). Tui, on the other hand, sing highly complex vocalisations consisting of many different syllables and songs, akin more to the tropical mockingbird than the Oregon junco. This shows that phylogenetic relatedness does not necessarily correlate with similar degrees of vocal complexity (*i.e.*, phylogenetic signal; see Price *et al*. 2007).

The advancement of syllable recognition software should pave the way for further grouping of syllables within the tui vocal repertoire and indeed other species with complex vocalisations, leading to the eventual phasing out of the traditional method of audial and visual syllable classification. Advanced syllable classification software will also enable large datasets from complex repertoires to be analysed and will permit large-scale studies (Ranjard & Ross 2008). Specifically, software advances could help us to answer questions related to the highly complex nature of tui songs and the reasons why the repertoires of some species have evolved to become so complex. This could be due to evolutionary factors such as female sexual selection for high levels of vocal complexity or due to strong degrees of territoriality in some species. Evidence suggests that complex vocalisations can play a critical role in conspecific male to male competition in Oscines (Mountjoy & Lemon 1991; Briefer *et al*. 2008; Hall & Peters 2008).

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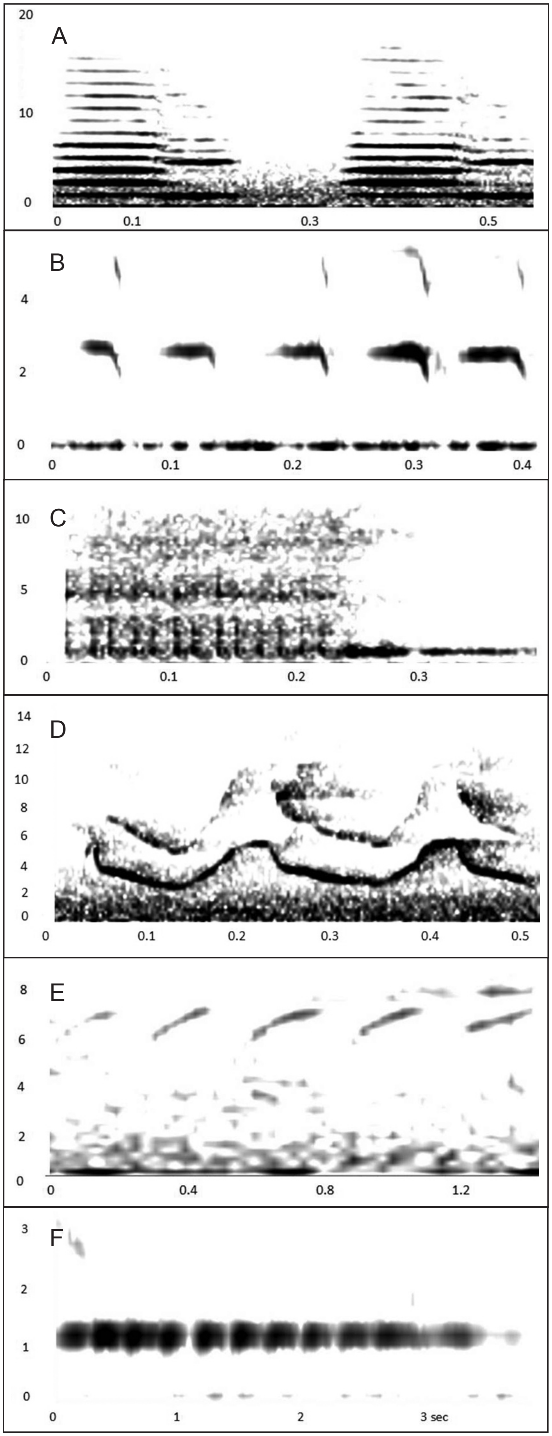

Fig. 1. The 6 main tui syllable types encountered within a repertoire of 10 individuals from 50 songs. Harmonic (a); RMNR (b); harsh (c); trill (d); high-frequency (e); and low-frequency (f).

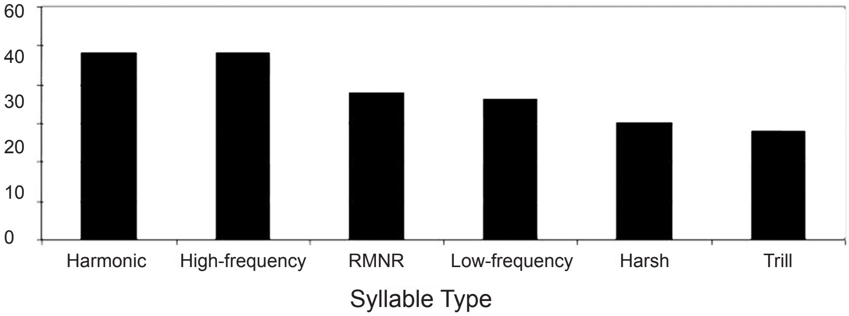

Fig. 2. Frequency distribution of the most common syllable types from 360 different syllables in the repertoire of 10 tui at Tawharanui Regional Park.

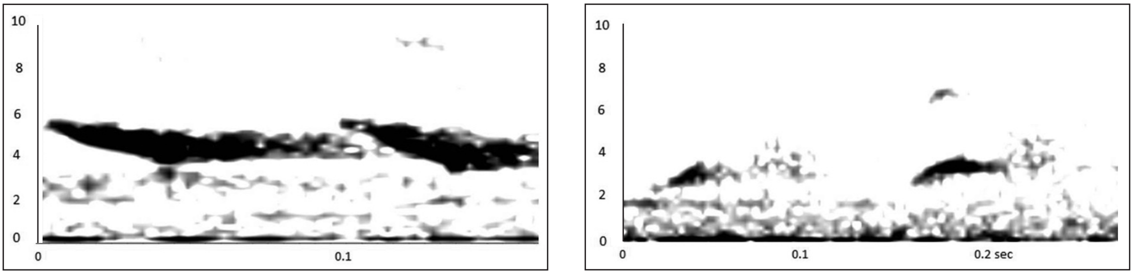

Fig. 3. Two examples of syllables placed into the 'other' category due to lack of common characteristics between them.

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