Notes on the *Zoothera* thrushes in the Tweed Range of north-eastern New South Wales

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Abstract. The *Zoothera* thrush complex is represented on the Australian mainland by the Bassian Thrush *Z. lunulata* and the Russet-tailed Thrush *Z. heinei*. These species are sympatric at several locations on the eastern coast. Often, these populations occupy different elevations, with the Bassian Thrush preferring higher elevations, though reasons for this are poorly understood. I present data from automated acoustic recordings made of these species in the Border Ranges and Mebbin National Parks of north-eastern New South Wales between ~300 m and 1100 m above sea-level over a 1-year period from June 2015 to May 2016. Bassian Thrushes were recorded most frequently in October, typically at or above 900 m. Russet-tailed Thrushes were recorded most frequently in August, at or below 700 m. Differences in elevational preference between the species may be driven by several factors including adaptation to cold, avoidance of interspecific competition and avoidance of hybridisation.

Introduction

The Bassian Thrush *Zoothera lunulata* and Russet-tailed Thrush *Z. heinei* are two secretive occupants of forest habitats along the eastern coast of Australia. They are the only native representatives of the worldwide thrush family, Turdidae, that breed on the Australian mainland (Cooper 1959; Higgins *et al.* 2006). Both species were previously included in the widespread Scaly Thrush *Z. dauma* complex until Ford (1983) proposed that they were distinct species, based on differences in plumage, song and morphological characters (Higgins *et al.* 2006). This classification was supported by Christidis & Boles (1994), and has now been accepted by numerous authorities (Christidis & Boles 2008). The two species are sympatric in several regions of Australia (Barrett *et al.* 2003). In south-eastern Queensland and north-eastern New South Wales (NSW), they are sympatric in subtropical rainforest, where the Bassian Thrush (hereafter BT) usually occupies higher elevations than the Russet-tailed Thrush (hereafter RT) (Ford 1983; Gosper & Holmes 2002; Higgins *et al.* 2006). The ecological processes responsible for the elevational preferences of the species remain poorly understood. In this paper, I present data on both *Zoothera* species along an elevational gradient in the Border Ranges and Mebbin National Parks of north-eastern NSW generated using automated acoustic recorders.

Methods

Sites

Data were collected during a 12-month period from 10 June 2015 to 31 May 2016 in two national parks (NP) in north-eastern NSW: Border Ranges NP (28°23′S, 153°3′E) and Mebbin NP (28°27′S, 153°10′E). Sampling occurred along an elevational gradient with a design like that used by Leach *et al.* (2016). A total of 20 sites was used: four sites in each of five elevational bands, ~300, 500, 700, 900 and 1100 m above sea-level. Sites within each band were separated by at least 400 m, with some sites being up to 16 km distant because of their location on different sides of the Tweed Range.

Recordings

Bioacoustic Audio Recorders (BARs) (see http://www.frontierlabs.com.au) were used to make automated acoustic recordings of the soundscape at these sites as part of an ongoing study in the region. A BAR was deployed at one site per elevational band in each month of sampling. Five BARs were used so that recordings were collected simultaneously at the five different elevations. Each month, the sites were visited to collect data and to move each BAR to a new site within its elevational band. BARs were set to record for five 2-minute periods each day. The first 2-minute recording began 10 minutes before sunrise. Each subsequent recording was then made after a 10-minute delay, such that the last recording each day took place 30 minutes after sunrise.

Analysis

After collecting the data from the BARs, I listened to each 2-minute recording and noted all bird species heard. I then extracted 2-minute recordings in which I detected *Zoothera* song for further analysis. Recordings that were compromised by high levels of ambient noise (e.g. from heavy rain or strong wind) were not processed; in total, from all elevations, 795 such recordings were excluded. *Zoothera* contact calls (see Figure 1a) were noted but not included in the dataset, as distinguishing the two species based only on contact call is difficult, if not impossible. The recording period (June 2015–May 2016) encompasses the probable breeding and non-breeding seasons of both *Zoothera* species in the region (BT breeds July–September; RT breeds September–January) (Cooper 1959; Higgins *et al.* 2006).

Results

In total, 5825 2-minute recordings were processed. Songs of *Zoothera* species were detected in 472 2-minute recordings between June 2015 and May 2016. BT songs were detected 239 times and RT songs 248 times. In general, the number of thrush detections increased with
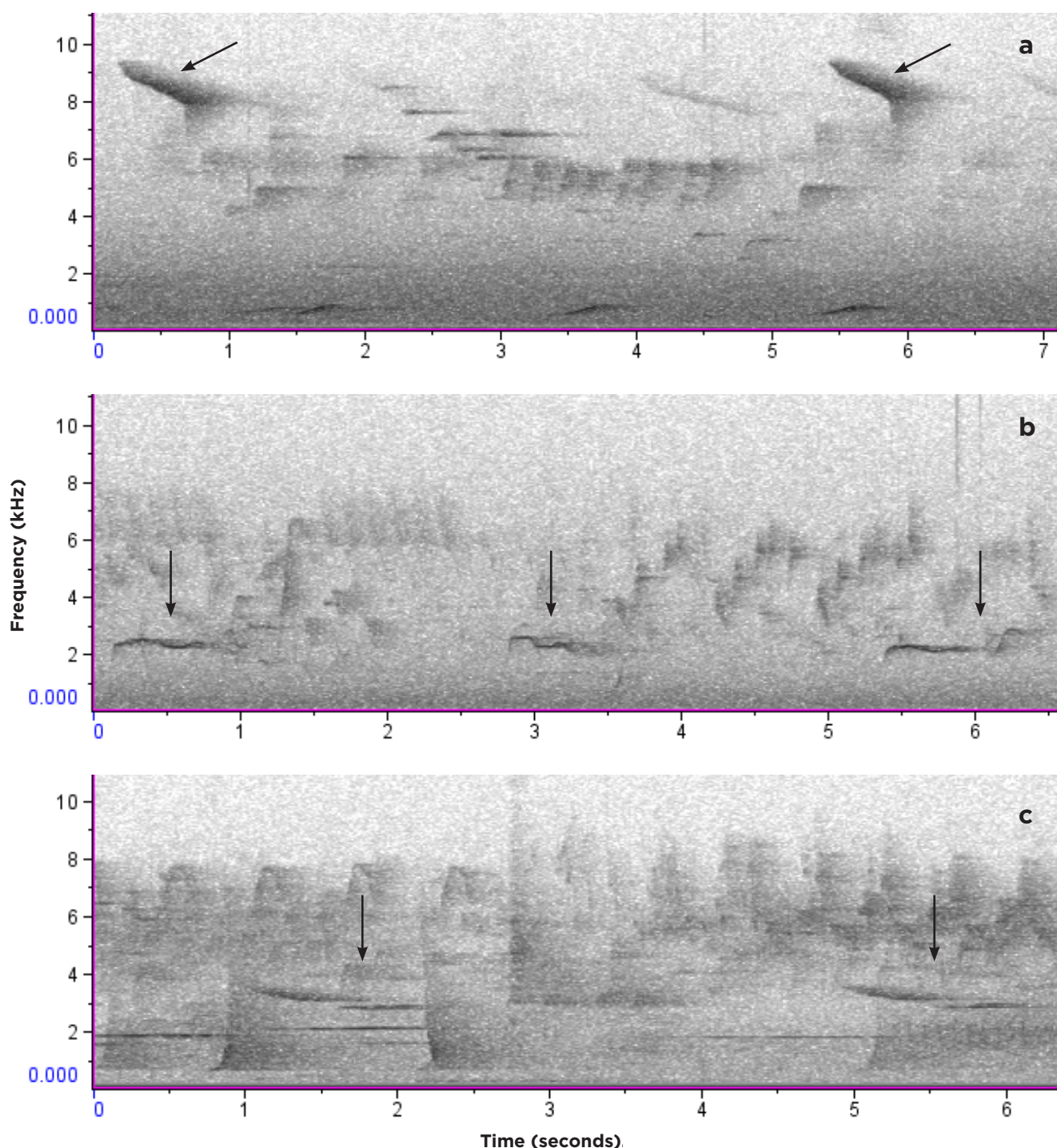
Figure 1. Sonograms of recordings made in June 2015–May 2016 from the study area in the Border Ranges and Mebbin National Parks, New South Wales, containing thrush *Zoothera* spp. calls and songs. Arrows indicate the midpoints of the calls and songs described as follows: (a) two contact calls of a thrush *Zoothera* sp. from 0 to 1 second and again from *c.* 5.5 to 6 seconds, in the 6.5–10-kHz frequency band (contact calls of the species discussed here are virtually identical); (b) three examples of Bassian Thrush (BT) song, from 0 to 1 second, from 2.75 to 3.5 seconds and from *c.* 5.5 to 6.5 seconds (the latter being an example of the *pilop-whee-er* call) in the 2–3-kHz frequency band; (c) two examples of Russet-tailed Thrush (RT) song, from 1 to 2.25 seconds and from *c.* 5 to 6 seconds in the 3–4-kHz frequency band.

elevation, a pattern driven by the increased frequency of BT detections at 900 m and 1100 m sites (see Table 1).

Bassian Thrush (BT)

BT song was quite variable, though typically consisted of two or three melodic whistles, which have been previously described as *pilop whee-er* (Higgins *et al.* 2006) (see Figure 1b). BT songs were detected in all elevational bands except 300 m: four times at 500 m, 12 times at 700 m, 92 times at 900 m and 131 times at 1100 m (Table 1). BT songs were detected most frequently from October to the end of December (see Figure 2). The low number of songs recorded in November was probably because recordings from the higher elevational bands in that month were often affected by rain, reducing the number of 'good days' available for processing; ~40% of records from 900 m and 1100 m sites in November were affected. BT songs were not detected in February or March.

Table 1. Two-minute sound recordings taken at different elevations in the Border Ranges and Mebbin National Parks, New South Wales: total number of recordings processed and numbers in which Bassian Thrushes (BT) and Russet-tailed Thrushes (RT) were detected.

Elevation (m)	Total no. of recordings	No. in which BT detected	No. in which RT detected
300	1165	0	84
500	1215	4	75
700	1240	12	77
900	1155	92	9
1100	1050	131	3

Russet-tailed Thrush (RT)

RT song was typically two whistles: *pee-eer hoo*, with the first phrase descending in tone and the second remaining steady (see Figure 1c). RT songs were detected in all elevational bands: 84 times at 300 m, 75 times at 500 m, 77 times at 700 m, nine times at 900 m and three times at 1100 m (Table 1). RT songs were detected most often in August (Figure 2). RT song was detected only once in December (at 700 m), and not at all in March.

Discussion

From this study, there is evidence that in north-eastern NSW BT and RT appear to be largely confined to high (900–1100 m) and low–mid (300–700 m) elevations, respectively. Gosper & Holmes (2002) also conducted fieldwork in the region and found BT to be resident at 550–1100 m and RT to be partially nomadic between 250 and 750 m, though the methodology and locations used differed from those in the present study. Regardless, both studies found that BT prefer high elevations and RT low–mid elevations. This may simply be a consequence of BT being better adapted to cold than RT (which can be seen in the wider distributions of the two species: see Higgins *et al.* 2006). Reduction of interspecific competition for resources or avoidance of interspecific pair formation are two other plausible explanations for the observed pattern (Hinde 1959; Slabbekoorn & Smith 2002; Irwin *et al.* 2008).

Interspecific communication (and possible avoidance) between BT and RT is presumably based on vocalisations. I found that BT and RT in north-eastern NSW have very different songs in terms of frequency and structure (though, interestingly, very similar contact calls) (Figure 1). Several factors may have contributed to the divergence in signalling between the species. The acoustic adaptation hypothesis proposes that differences in habitat structure may lead to signal divergence (Irwin *et al.* 2008), as different sonic frequencies can travel more efficiently in different environments (Boncoraglio & Saino 2007). Differences in morphology have implications for the ability to produce certain vocalisations; for example, body mass is negatively correlated with song frequency, and large bills are not well suited to the production of certain sounds (see Seddon 2005). The species recognition hypothesis suggests that difference in song structure (or other traits) is an evolutionary adaptation to reduce hybridisation between closely related species (Sætre *et al.* 1997; Seddon 2005). In the context of the present study, the differences in habitat structure between the low elevations of the Border Ranges (characterised by palm forest) and the high elevations

(characterised by cloud forest dominated by Antarctic Beech *Nothofagus moorei*) suggest that there may be some support for the acoustic adaptation hypothesis. However, it is necessary to test each hypothesis specifically before conclusions can be drawn.

The two species appear to have different calling 'seasons', with RT detected most frequently in August and BT detected most frequently in October. There were no records of either species in March (Figure 2). If vocalisation is related to breeding, the delayed peak in the detections of BT may be explained by the fact that conditions at low elevations become suitable for breeding earlier than those at higher elevations, though further work is needed to confirm this.

Generating a dataset on secretive or cryptic species such as that presented in this study can be difficult using traditional fieldwork techniques. Using automated acoustic recorders allows researchers to monitor such populations over long time periods relatively cheaply and easily. There are many other potential applications of such technology; for a broader discussion of the advantages and disadvantages associated with using automated acoustic recorders in ornithological contexts, see Leach *et al.* (2016). Further investigation of the vocalisations of the *Zoothera* thrushes in Australia would benefit from the use of automated acoustic recorders.

Conclusions

This study contributes to the general understanding of the ecology of both BT and RT, in particular by providing
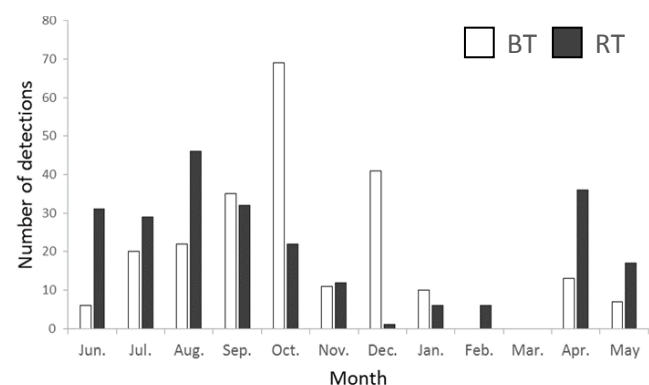
Figure 2. The number of 2-minute recordings per month in which Bassian Thrush (BT) and Russet-tailed Thrush (RT) songs were detected across the entire elevational gradient, 10 June 2015–31 May 2016, in the Border Ranges and Mebbin National Parks, New South Wales.

empirical evidence for the elevational preferences of the two species in north-eastern NSW. Data such as these are important for conservation purposes: as the climate continues to warm, the populations of many Australian birds (particularly montane species) are predicted to decline (Williams *et al.* 2003; Chambers *et al.* 2005; Garnett & Franklin 2014). The use of automated acoustic recorders to monitor cryptic species that are best detected by call (e.g. thrushes *Zoothera* spp., ground parrots *Pezoporus* spp.) is recommended in future studies. Fieldwork is continuing at the sites used in this study, and further work will focus on community-level patterns of elevational stratification in the avifauna.

Acknowledgements

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