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Descriptions of the vocalisations of the Chestnut-backed Button-quail *Turnix castanotus*

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Abstract. Button-quail (Turnicidae) are a greatly understudied family of birds; their cryptic habits make studying them in the wild challenging. They are known to be quite vocal which could assist with detectability, and so it follows that survey results will be more reliable as knowledge about button-quail vocal repertoire increases. Until recently, there were no published vocal recordings of the Chestnut-backed Button-quail *Turnix castanotus*, and descriptions and accounts of this species' vocalisations were limited. We recorded vocalisations of Chestnut-backed Button-quail at six locations across the Northern Territory and Western Australia. Three broad vocalisation types were identified: advertising *ooms*, *drumming*, and contact calls. We present descriptions and visual representations of these vocalisations, and draw comparisons with previously published accounts of this species, and other Australian button-quail.

Introduction

Despite a growing number of records from birdwatchers and natural historians, the Chestnut-backed Button-quail *Turnix castanotus* appears to be the most poorly documented of Australia's seven species of button-quail. This family of birds is notoriously understudied (Yarwood *et al.* 2019) and, to our knowledge, the Chestnut-backed Button-quail has never been the target of ecological research. Aside from accounts in reference texts such as field guides and the *Handbook of Australian, New Zealand & Antarctic Birds* (Marchant & Higgins 1993), there is only one focused, peer-reviewed publication on this species, which documented juvenile plumage based on an opportunistic sighting (Ward & Young 2014). Although this species appears relatively well represented in museum collections, largely a result of early naturalists, there is a limited number of historical accounts, none of which alludes to the vocalisations of this species (Le Souëf 1902; Hartert 1905; Barnard 1914; White 1917). A very scant understanding of this species can be inferred from the historical accounts that are available. In contrast, there are more historical accounts and even some recent research on its closest relative, the apparently much rarer, and endangered Buff-breasted Button-quail *T. olivii* (McLennan 1922; White 1922a,b; Macdonald 1971; Squire 1990; Nielsen 2000; Mathieson & Smith 2017; Smith & Mathieson 2019).

Chestnut-backed Button-quail are widely distributed across the tropical savannas of northern Australia, from the Dampier Peninsula in Western Australia to Borroloola in the Northern Territory (Menkhorst *et al.* 2019; Debus & Kirwan 2020) and have recently been recorded in Queensland (Webster & Stoetzel 2021). They are most frequently reported from woodlands associated with ridges or stony rises of sandstone or lateritic substrates (Marchant & Higgins 1993). Based on collected specimens, their diet comprises a diversity of small invertebrates and seeds (Marchant & Higgins 1993). As with other button-quail species where females are the larger and more brightly coloured sex, the Chestnut-backed Button-quail is thought to be polyandrous (Marchant & Higgins 1993). The breeding biology of this species and environmental cues that trigger breeding are unknown, although it is likely to breed in the wet season like other tropical button-quail (McLennan 1922).

Fundamental to research or survey of button-quail is the ability to detect them. Some species can be detected by the presence of foraging scrapes known as platelets left in the substrate after foraging (McConnell & Hobson 1995; Smyth & Pavey 2001). However, for many species we know little about reliablilty of scrapes as a detection tool, given that they are expected to vary according to factors such as seasonality, weather and substrate. Also, considerable training is required to find and identify scrapes with any confidence. By comparison, detecting and analysing vocalisations promise a more reliable detection method that can be applied with comparatively less training. The better-studied species are known to give a wide range of calls and females of all species are known to give a loud, deep advertising *oom* call (Debus 1996). However, before acoustic-based surveys can be conducted with any degree of confidence, a detailed understanding of a species' repertoire is needed. The vocalisations of Chestnut-backed Button-quail are largely undescribed and had apparently not been recorded until 17 February 2018 by Hoffman *et al.* (2018). Apart from soft clucks and an ambiguous *oom* call (MacDonald *et al.* 1973; Andrew 1992; Menkhorst *et al.* 2019), no other calls have been described. In this paper we present novel descriptions of three distinct Chestnut-backed Button-quail vocalisations.

Study areas and methods

The vocalisations described in this paper were recorded at six locations: the Dampier Peninsula, Wunaamin Miliwundi

Ranges (previously known as King Leopold Ranges), and Kununurra in the Kimberley region of Western Australia; and Timber Creek, Katherine, and Pine Creek in the Top End region of the Northern Territory (Figure 1). These locations cover most of the known range of the species. All observations and sound recordings were in habitat broadly defined as monsoonal tropical savanna. Vocalisations from the three Northern Territory locations were recorded from 25 February to 1 March 2020, and in Western Australia from the Dampier Peninsula on 4 December 2019 and 8 March 2020, the Wunaamin Miliwundi Ranges from 13 to 15 June 2020, and Kununurra on 21 February 2018. These dates largely coincided with northern Australia's wet season, although conditions were still dry on the Dampier Peninsula in December 2019, and recordings from the Wunaamin Miliwundi Ranges occurred following an early dry-season rainfall event. The veracity of each recording was confirmed by visually identifying the species at the time of each recording, except for the Wunaamin Miliwundi Ranges where the vocalisations were recorded remotely and later identified as belonging to this species. A Sennheiser ME66 shotgun microphone (Sennheiser electronic GmbH & Co. KG, Wedemark, Germany) with Tascam DR-40 recorder (TEAC Corporation, Montebello, USA) was used to record vocalisations in the Northern Territory. A Sennheiser ME66 shotgun microphone and Olympus LS-12 (Olympus Corporation, Tokyo, Japan) recorder was used to record vocalisations on the Dampier Peninsula; a Song Meter 4 (Wildlife Acoustics, Massachusetts, USA) recorded vocalisations in the Wunaamin Miliwundi Ranges; and an Apple iPhone 5s (Apple Inc., California, USA) was used on the Dampier Peninsula and at Kununurra.

Audio recordings were recorded as, or converted to, 'wav' files before being imported to Audacity (Audacity 2.2.2: Audacity Team 2018) for processing and analysis. Spectrograms were produced in *R* (R Core Team 2020) using the package warbleR (Araya-Salas & Smith-Vidaurre 2017). Measurements were taken from spectrograms. Where applicable, all descriptive statistics give the mean ± standard deviation.

Results

Three broad vocalisation types were identified, and classified as: advertising *ooms*, *drumming*, and contact calls. Advertising *ooms* and *drumming* were recorded in both Western Australia and the Northern Territory, and although no statistical analysis was performed to investigate variability in vocalisations between localities or between individuals, qualitatively they are not noticeably different. Contact calls were heard at all sites except the Wunaamin Miliwundi Ranges, but were recorded only at the Northern Territory sites. Each of these calls is described below.

Advertising oom

The advertising *oom* call was a series of deep, tremulous, booming notes (*oom* notes), with each note being composed of a series of rapidly repeated elements. The *oom* notes began soft and low, then rose in pitch and volume but shortened in duration, with a distinct and consistent pause of 0.49 ± 0.10 seconds (n = 27) between

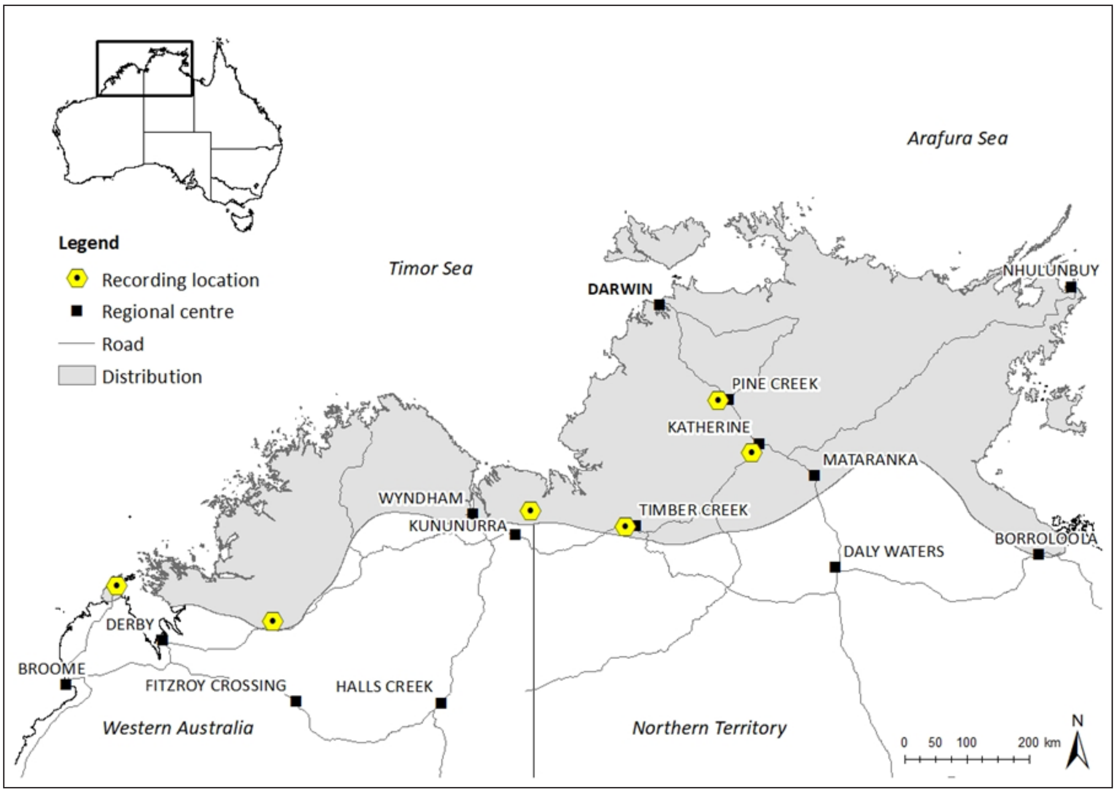

Figure 1. Map showing localities where vocalisations of Chestnut-backed Button-quail were recorded, from east to west: Katherine, Pine Creek, Timber Creek, Kununurra, Wunnaamin Miliwundi Ranges and Dampier Peninsula. The distribution of Chestnut-backed Button-quail is based on Hill (1913), Barnard (1914) and Marchant & Higgins (1993).

oom notes (Figure 2a, Western Australia recording and Figure 2b, Northern Territory recording). Peak frequency of the initial and final *oom* notes was 253 ± 40.3 Hz (*n* = 43) and 325 ± 27 Hz (*n* = 47), respectively. The duration of the *oom* notes decreased throughout the call; initial and final *oom* notes were 0.95 ± 0.19 seconds (*n* = 32) and 0.75 ± 0.13 seconds (*n* = 48), respectively. Each *oom* note was comprised of 1–15 (typically 4–8) rapidly repeated elements, which decreased in number throughout the duration of the call. The initial *oom* notes within an advertising *oom* call had the greatest number of elements, up to 15, delivered at ~12 elements per second. The succeeding *oom*s decreased in the number of elements, with the final *oom* notes within an advertising *oom* call typically having 4 elements delivered at ~5.40 elements per second. Some short advertising *oom* calls of fewer than 13 *oom* notes might have had a final *oom* note with up to 13 elements. Of the 50 advertising *oom* calls analysed, only three had a final *oom* note that was composed of a single element. Some variability was noted in the parameters analysed between advertising *oom* calls (Table 1), but there was no discernible difference between localities.

Although no measures of amplitude were taken, the advertising *oom* call was comparatively soft, and only audible to the human ear to a distance of <150 m. Advertising *oom* calls were often given repeatedly, with a break of 1–4 minutes between calls. The bird might have moved around within a presumed territory between vocalisations. This call was also often heard on occasions after a flushed individual landed. Vocalisations were most often heard in the cooler hours of the morning and afternoon although, if conditions were overcast and cooler, they were heard throughout the day. This vocalisation type

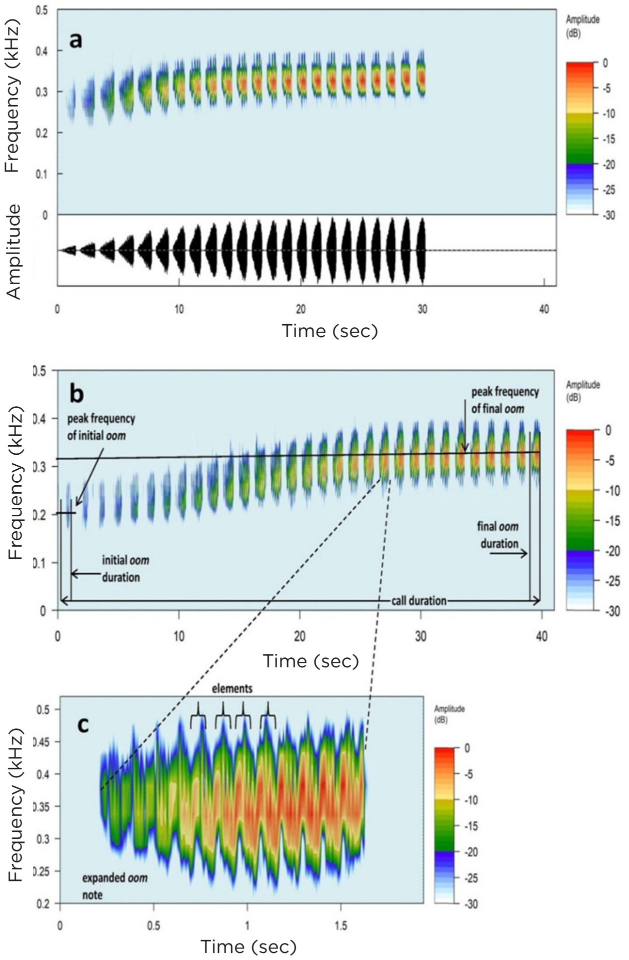

Figure 2. Spectrograms of typical advertising *oom* call of Chestnut-backed Button-quail showing some variability between vocalisations. (a) Spectrogram (upper) and waveform (lower) of advertising *oom* call recorded at Dampier Peninsula, Western Australia, March 2020, Australian National Wildlife Collection reference (ANWC): X49192. Note the increasing pitch (spectrogram) and amplitude (waveform) and decrease in *oom* note duration. Note that this advertising *oom* call starts at a higher frequency than that of Figure 2b. (b) Advertising *oom* call with expanded *oom* note (c) showing the rapidly repeated elements, recorded at Timber Creek, Northern Territory, March 2020, ANWC: X49191. Annotations on (b) and (c) refer to the parameters described in Table 1, adapted from Smith & Mathieson (2019).

Table 1. Summary of vocalisation parameters of advertising *oom* calls of Chestnut-backed Button-quail. Values are displayed as mean ± standard deviation and range (in parentheses); *n* = number of recordings analysed.

Call duration (sec.)	*No. notes/ call*	*Pause between notes (sec.)*	*No. notes/ sec.*	*Duration (sec.)*		*Peak frequency (Hz)*		*No. elements*	
				Initial note	*Final note*	*Initial note*	*Final note*	*Initial note*	*Final note*
28.16 ± 7.81	20.91 ± 6.55	0.49 ± 0.0.10	0.73 ± 0.07	0.95 ± 0.19	0.75 ± 0.13	253 ± 40	325 ± 27	9.5 ± 2.66	4.27 ± 1.80
(14.07–43.66)	(9.0–33.0)	(0.32–0.85)	(0.55–0.97)	(0.56–1.47)	(0.49–1.19)	(169–371)	(243–353)	(5–15)	(1–10)
n = 47	*n* = 47	*n* = 27	*n* = 47	*n* = 3	*n* = 48	*n* = 43	*n* = 47	*n* = 30	*n* = 45

has been recorded between December and June, which coincides with rain during the wet season, or continuing good conditions following the wet season. It was not determined if this vocalisation type is sex-specific, but it is assumed to be made by the female as in other members of the genus (Debus 1996).

Drum

The *drum* call was a short, deep rattle, composed of rapidly repeated elements delivered at a rate of 15.81 ± 3.10 elements/sec (*n* = 25). The initial elements were low and slightly softer, with succeeding elements rising in volume and pitch to a point where the amplitude decreased and pitch remained constant or decreased (Figure 3). The *drum* call lasted 3.44 ± 1.49 seconds (*n* = 25) and had a peak frequency of 309 ± 27.26 Hz (*n* = 25). Some variability was noted in the parameters analysed between vocalisations (Table 2), but there was no discernible difference between localities.

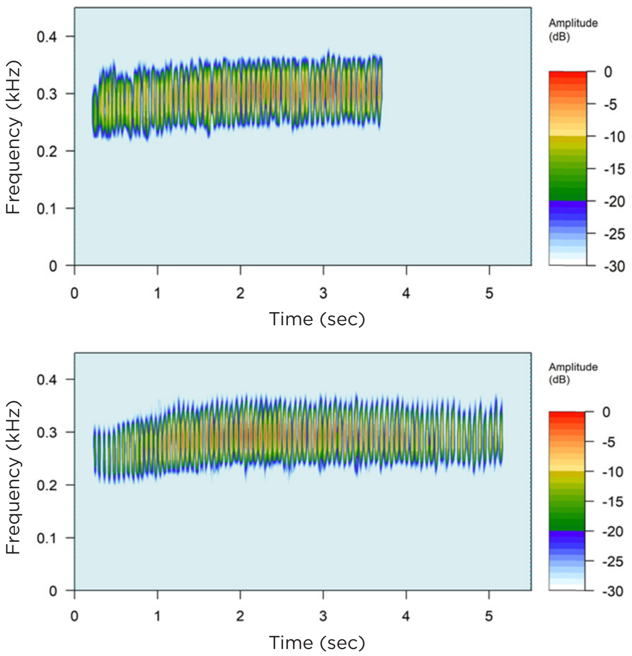

Figure 3. Typical *drum* calls of Chestnut-backed Button-quail showing a slight rise in pitch at the start of the call and the rapidly repeated elements. These two spectrograms demonstrate variation in the duration of this call type. The top call was recorded at the Dampier Peninsula, Western Australia, March 2020, ANWC: X49194 and the bottom vocalisation from Timber Creek, Northern Territory, February 2020, ANWC: X49195.

This vocalisation was given in response to the advertising *oom* call or another *drum* call. In comparison with the advertising *oom*, the *drum* was very soft and was audible to the human ear only in calm conditions at <10 m. When initiating the *drum*, the bird assumed a similar position to when it gave an advertising *oom* (Debus 1996), by craning its neck and opening its bill (potentially to inhale), before inflating the dorsal part of the neck. During the vocalisation, the bird remained standing in one position, with bill held closed. Both wings were very slightly drooped, and pulsated with every element of the *drum* (Figure 4).

Contact calls

Contact calls consisted of a variety of short, soft trills, whistles and clucks given in quick succession. The *drum* call was often interspersed amongst the contact calls with the *whip* vocalisation typically preceding a *drum*. Contact calls then recommenced following a *drum* call. Seven types of vocalisations were identified as contact calls (Figure 5, Table 3). It is important to note that these vocalisations were not given singly; rather, they constituted a continuous series of vocalisations that may last for several minutes. A sequence of a contact calls is shown in Figure 6.

Discussion

This research demonstrates that the Chestnut-backed Button-quail shares a similar repertoire of vocalisations with other members of the genus *Turnix* (Hughes &

Figure 4. The body position of a female Chestnut-backed Button-quail during a *drum* vocalisation. Photo: P. Webster

Table 2. Summary of vocalisation parameters of *drum* calls of Chestnut-backed Button-quail. Values are displayed as mean ± standard deviation and range (in parentheses); *n* = number of recordings analysed.

Duration (sec.)		*No. elements*		*Peak frequency (Hz)*		
Call	*Element*	*Per drum*	*Per sec.*	*Call*	*Initial element*	*Final element*
3.44 ± 1.49	0.05 ± 0.01	54.72 ± 26.14	15.81 ± 3.10	309 ± 27.26	286 ± 31.19	333 ± 27.39
(1.21–5.94)	(0.04–0.06)	(18–114)	(7.00–22.65)	(268–361)	(240–329)	(284–374)
n = 25	*n* = 25	*n* = 25	*n* = 25	*n* = 25	*n* = 23	*n* = 20

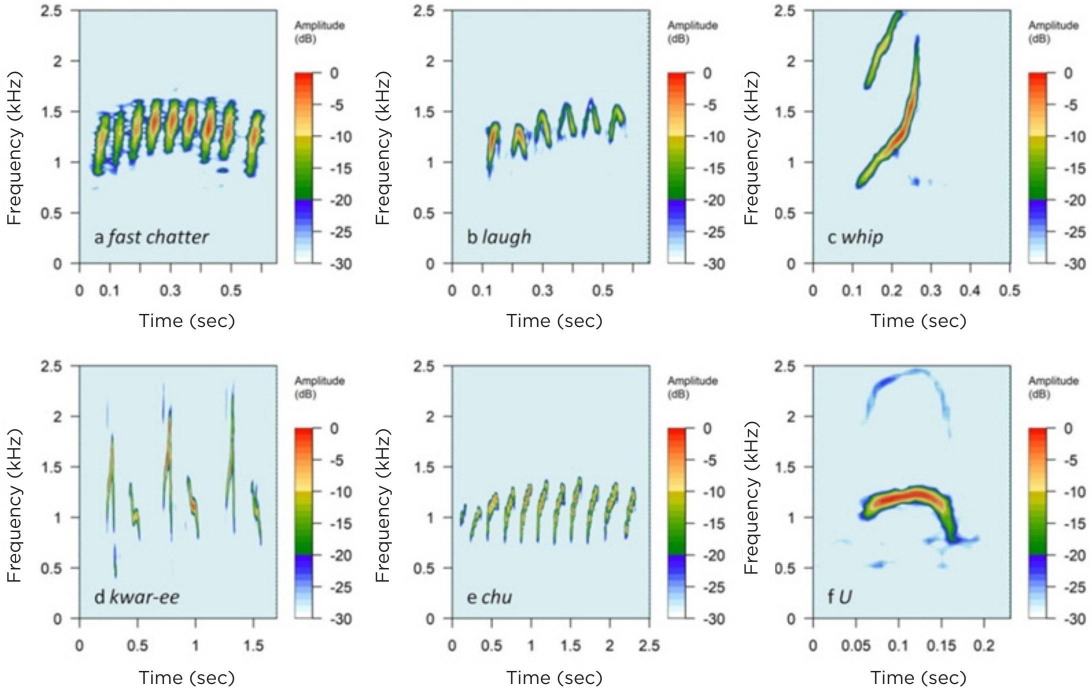

Figure 5. Vocalisations identified as contact calls of Chestnut-backed Button-quail recorded in the Northern Territory, 2020, ANWC: X49193, as described in Table 3.

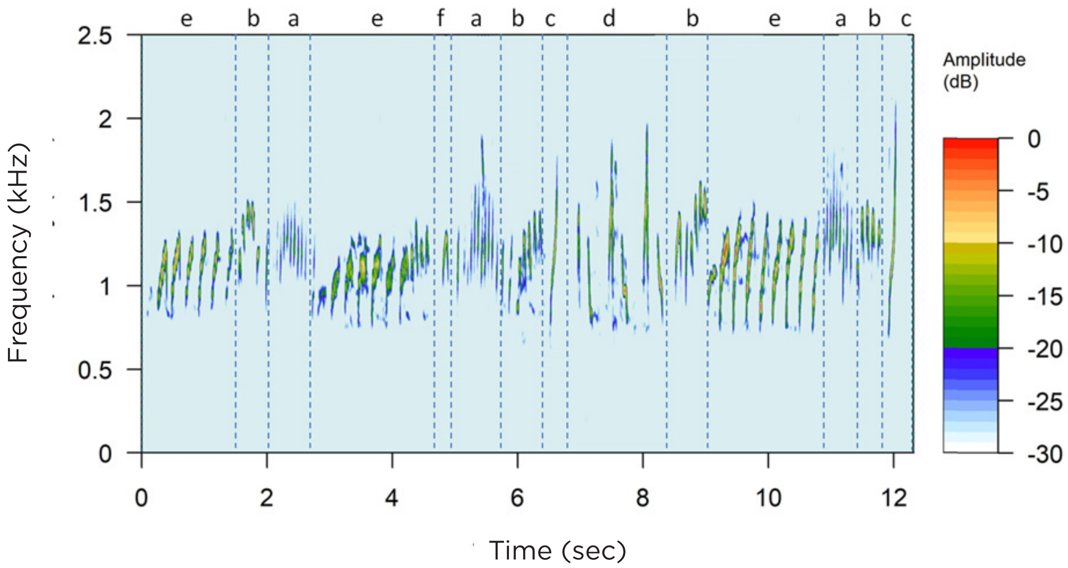

Figure 6. Example series of contact calls of Chestnut-backed Button-quail recorded at Pine Creek, March 2020, ANWC: X49193. The letter above each vocalisation type refers to Table 3 and Figure 5. Note these vocalisations are at a higher pitch than both the advertising *oom* and *drum* calls, and have greater variability.

Hughes 1991; Debus 1996). The three vocalisation types identified appear analogous to descriptions for other species of button-quail; however, the advertising *oom* of the Chestnut-backed Button-quail displays considerable differences from that of most other species, notably in its tremulous quality, which is shared only with the Black-breasted Button-quail *T. melanogaster* (Hughes & Hughes 1991). Our results suggest that qualitatively there is little geographic variation in vocalisations, as vocalisation types and quality were consistent across the study area. The advertising *oom* call of button-quail appears diagnostic for each species, and that is the case here. This vocalisation is the one most likely to be heard by the human observer and therefore of most use in identification and detection.

Advertising *oom* calls in other button-quail species are often regarded as territorial or breeding calls, used either to attract a male partner or to define territory boundaries (Debus 1996). Observations of captive populations of Black-breasted Button-quail have shown associations with breeding activities and the advertising *oom* call of the female (Phipps 1976; Mills 1985; Roulston 1992). Hughes & Hughes (1991) noted that wild Black-breasted

Table 3. Descriptions and parameters of each type of vocalisation identified as a contact call of the Chestnut-backed Button-quail. Values are displayed as mean ± standard deviation and range (in parentheses); *n* = no of recordings analysed.

Vocalisation	*Description*	*Duration (sec.)*	*Peak frequency (Hz)*	*No. elements*	*Comments*
Fast chatter (Figure 5a)	Short rattle of rapidly repeated elements, delivered at rate of 16–19 elements/sec.	0.53 ± 0.14 (0.37–0.94) *n* = 30	1284 ± 162 (963–1727) *n* = 30	9 ± 2 (6–14) *n* = 30	1st element often lower-pitched than succeeding elements.
Laugh (Figure 5b)	Short trill, similar to fast chatter but slower, individual elements slightly longer and higher-pitched. Individual elements rise and fall in pitch.	0.44 ± 0.09 (0.30–0.70) *n* = 53	1454 ± 187 (1028–2194) *n* = 53	6 ± 1 (8–4) *n* = 53	1st element often lower-pitched; succeeding elements rise in pitch but may fall in last elements.
Whip (Figure 5c)	A single element starting low (~600 Hz) and rising in pitch (~2000 Hz); amplitude appears to be consistent throughout frequency range.	0.16 ± 0.03 (0.10–0.21) *n* = 65	1187 ± 213 (777–1605) *n* = 65	1 ± 0 (1–1) *n* = 65	Always only a single element; precedes and follows a *fast chatter* or *kwar-ee* call. Could be interpreted as a rising *whip*.
Kwar-ee (Figure 5d)	Rapidly repeated phrase of 2 elements with distinct pause between, given in repetition. 1st element starts low (~1300 Hz) and rises sharply (~2200 Hz), before dropping but becoming soft. 2nd element starts at higher pitch (~1400 Hz) and decreases (~900 Hz).	1.75 ± 0.99 (0.61–3.81) *n* = 28	1106 ± 146 (942–1458) *n* = 28	4 ± 3 (2–11) *n* = 28	Upward element in 1st phrase is always lower-pitched than those in succeeding phrases. This call often follows a single *whip* and is followed by a single *whip*. Could be interpreted as *kwar-ee.*
Chu (Figure 5e)	Rising rattle starting at ~700 Hz and increasing rapidly to ~1500 Hz. 1st 2–3 elements often do not rise as high as succeeding ones. Usually reaches ~1100–1300 Hz, delivered at rate of 4.01–8.20 elements/sec.	1.71 ± 0.60 (0.73–3.31) *n* = 45	1170 ± 139 (899–1456) *n* = 45	9 ± 2 (5–16) *n* = 45	Could be interpreted as *chu-chu- chu- chu- chu-chu- chu- chu*. Most often following and followed by *laugh* but also *whip* and *fast chatter.*
U (Figure 5f)	Typically a single element starting low then rising in pitch before lowering again to initial frequency.	0.14 ± 0.03 (0.10–0.30) *n* = 27	1321 ± 122 (1031–1610) *n* = 27	1* *n* = 27	Spectrogram of vocalisation shaped like upside-down U. *Once, 2 *U* calls given.

Button-quail commenced the advertising *oom* after 100 mm of rainfall had fallen over several days in any month. During his expedition to Coen on Cape York Peninsula in 1921 and 1922, McLennan (1922) noted a similar relation between rainfall and the advertising *oom* call of the Buff-breasted Button-quail. The Buff-breasted Button-quail and Chestnut-backed Button-quail have previously been considered one species (Macdonald 1971), so similarities in their biology could be expected.

It has been suggested that significant rainfall events create an increase in abundance of invertebrates, which results in the female Black-breasted Button-quail establishing territories and hence initiating advertising (Hughes & Hughes 1991; Flower *et al.* 1995). Although this theory appears to be established for this more intensively studied species, it is likely that the Chestnut-backed Button-quail has similar environmental cues for breeding and hence vocalising, although its breeding biology is largely unknown. It is possible that an increase in ground-cover, especially grasses stimulated by the rainfall, may promote an environment suitable for Chestnut-backed Button-quail to breed. Qualitatively, we have noted that an increase in the number of advertising *oom*s of the Chestnut-backed Button-quail coincides with northern Australia's wet season (December–April), when the majority of the region's annual rainfall is delivered over a short period. Vocalisations recorded at the Wunaamin Miliwundi Ranges followed 55 mm of rainfall (Bureau of Meteorology 2020) in late May, suggesting that precipitation might have induced the advertising *oom* call in what would be considered the early dry season. Advertising *oom* calls have also been recorded at times throughout the dry season. We have noted that in the dry season advertising *oom* calls have been associated with prolonged wet conditions, dry-season rainfall events or a human disturbance to a covey of birds. Further research is required to strengthen the association of rainfall with breeding and advertising *oom* calls and to determine exactly what factors induce this type of vocalisation.

Several species of button-quail have been noted to make a variety of soft contact calls (Marchant & Higgins 1993; Debus 1996); however, descriptions are poor and the relationship of these calls with behaviours or activities are not conclusive. Previous descriptions include a variety of soft clucking, trilling and whistling vocalisations that are produced by both the male and the female (Debus 1996). They are very soft and are likely short-range communications between nearby conspecifics (Debus 1996). They may be produced by both male and female but it is not known if there is variation between male and female vocalisations. Further research is needed to improve our understanding of these vocalisations.

The vocalisations presented in this paper are generally comparable with those published for other button-quail (Debus 1996). However, the tremulous quality of the Chestnut-backed Button-quail advertising *oom* call is shared with only one other Australian button-quail, the Black-breasted Button-quail. It is important to note here that there are no verified recordings of the Chestnut-backed Button-quail's likely closest relative, the Buff-breasted Button-quail (Macdonald 1971), either in peer-reviewed literature or in online databases.

Hughes & Hughes (1991) referred to the advertising *oom* call of the Black-breasted Button-quail as a drum, which should not be confused with the *drum* described in the present paper. It can be assumed that those authors referred to the advertising *oom* as a drum, as each *oom* note is comprised of several (5–7) elements and has the audible quality of a *drum*. The most important feature to note of the advertising *oom* call of Black-breasted Button-quail is the tremulous quality of each *oom* note. Both species produce an advertising *oom* note that consists of a series of rapidly repeated elements, ~4–15 in Chestnut-backed and 5–7 in Black-breasted Button-quail (Hughes & Hughes 1991). The advertising *oom* of Black-breasted Button-quail is at a slightly higher frequency (400 Hz) and the individual *oom* notes of longer duration (Hughes & Hughes 1991). Similar to the Chestnut-backed Button-quail, the advertising *oom* of the Black-breasted Button-quail increases in amplitude as the call progresses.

The lack of research surrounding button-quail is partly because of their cryptic habits, which means that it is extremely difficult to observe natural behaviours in the wild (Debus 1996). Captive populations enable some behaviours to be observed and described (Phipps 1976; Mills 1985; Roulston 1992) but few button-quail species have been held in captivity, and captive environments are known to alter natural behaviours (Mellor *et al.* 2018). Continual advancements in the application and development of remote acoustic recording units as well as autonomous recognition and analysis may provide a detection method for the Chestnut-backed Button-quail and other button-quail species. A solid understanding of a species' vocal repertoire is critical for this application. The analysis provided here for the Chestnut-backed Button-quail and the methods described provide a foundation for this application and future work on other species of button-quail. The use of acoustic detection has proven effective for other highly cryptic but vocal species (Stiffler *et al.* 2018; Znidersic *et al.* 2020). The Chestnut-backed Button-quail, like others of the genus, appears highly vocal at certain periods of the year, which lends itself favourably to this application.

Until now, the vocalisations of the Chestnut-backed Button-quail had been undescribed. We have presented here a detailed description of several key vocalisations of the species, including the advertising *oom* call, which is likely to be critical for both detection and identification. There may be other vocalisations produced by this species yet to be recorded and which can be attributed to activities other than territoriality and breeding. The vocalisations of Australia's other button-quail have been described broadly in the literature yet there has been little done to analyse the parameters or variation of these vocalisations, or to compare them with other species. In this paper we have built on the initial work by Smith & Mathieson (2019) to describe button-quail vocalisations and, using vocalisations of the Chestnut-backed Button-quail, improved the method of visualising and describing button-quail vocalisations generally. We expect that this will assist future comparison of the vocalisations of button-quail. We suggest that the parameters described herein are adopted in future work on descriptions and comparisons of button-quail vocalisations. A solid and comparable understanding of button-quail vocalisations will assist automated recognition, particularly as detection methods are transitioning to remote audio recordings and automated analysis.

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