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Calls and vocal behaviour of the Black Falcon *Falco subniger*

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Some calls of the Black Falcon *Falco subniger* (adult female cackle calls and begging whines, adult male creaking call) are described and illustrated, together with quantification of calling rates of both sexes at four active nests near Tamworth, NSW. Females were more vocal than males at all stages of the breeding cycle. Black Falcon cackle calls are similar to those of the Peregrine Falcon *F. peregrinus*, although more guttural owing to a lower fundamental frequency of ~1 kHz in females, compared with ~2 kHz in female Peregrine Falcons. The Black Falcon is less vocal than the Peregrine, and breeding males use the whining call much less frequently than do Peregrine males.

INTRODUCTION

The vocalisations of the Black Falcon *Falco subniger* (BF) were described in general terms, with sound spectrograms, by Marchant and Higgins (1993) and Jurisevic (1998), although it was difficult to align and categorise them according to standard terminology of the cackle, creaking call and wailing call of large falcons (e.g. as defined by Carlier 1995 and Leonardi *et al.* 2013). Subsequent studies on the BF tried to match observed call types with the aforementioned literature on that species (Debus *et al.* 2005; Debus and Olsen 2011; Debus and Tsang 2011; Debus and Zuccon 2013). However, it is apparent that some confusion remained, until Charley *et al.* (2014) and Whelan *et al.* (2016) provided somewhat more accurate interpretations. Baylis *et al.* (2015) noted that spectrographic metrics of the calls of Australian falcons require further study and comparison of specific call types (e.g. cackle, creaking call, wail) in specific contexts among species, and that a spectrographic study on the BF is needed. Such an investigation would extend the prior (incomplete) work on this species, and be potentially useful in determining falcon systematics and in interpreting behavioural studies.

In 2015–2016, we studied the breeding biology and behaviour of four pairs of BFs (Debus *et al.* 2017), partly modelling our approach (e.g. quantification of calling rates) on studies of the Lanner Falcon *F. biarmicus* (Leonardi *et al.* 2013) and Red-headed Falcon *F. chicquera* (Naoroji 2011). In the process, we obtained sound-recordings of some typical calls. A comparable study has been conducted on the Grey Falcon *F. hypoleucos* (Ley and Tynan 2016), with spectrograms of its cackle and whining calls provided by Baylis *et al.* (2015). The Lanner and Black Falcons are heirofalcons ('great' or 'desert' falcons), the Grey Falcon is sister to the heirofalcon/Peregrine Falcon *F. peregrinus* split, and the Red-headed Falcon is sister to that divergence (Fuchs *et al.* 2015). Thus, all these species are related to some degree. As the form of falcon vocalisations is evidently innate (Cade 1982; Jurisevic 1998), and there is no suggestion of individual or regional variation in the calls of the BF (Marchant and Higgins 1993), the results presented here may be applicable continent-wide, although further study in other regions would be valuable.

METHODS

The study area was the Tamworth district of northern inland New South Wales, and the subject breeding pairs are here numbered 1 to 4, corresponding with pairs described in the breeding biology study (see Debus *et al.* 2017). Adult vocalisation types were categorised according to previous studies on hierofalcons (including the BF) and the Peregrine, i.e. the cackle, creaking call (or *ee-chip*) and food-begging wail or whine ('whine' being considered more apt than 'wail') (e.g. Marchant and Higgins 1993; Leonardi *et al.* 2013; Charley *et al.* 2014; Baylis *et al.* 2015; Ley and Tynan 2016). Vocalisations were quantified as the number of separate calling events (bouts) rather than individual syllables (which were highly variable within a calling bout), a 'bout' being a sequence that was separated from others by a distinct pause at least the duration of a syllable of that call type.

The principles for interpreting sound spectrograms, as described by Baylis *et al.* (2015), were followed here. That is, spectrograms are graphical representations of the structure, pitch and tempo of bird calls, the vertical axis showing frequency (pitch) and the horizontal axis showing time elapsed. The fundamental frequency is the lowest value (trace) in the spectrogram, and the dominant frequency is the frequency band that contains the greatest acoustic energy.

Recordings of BF calls were made at two active nests on 31 July–1 August (Pair 2) and 23–24 September 2016 (Pair 4), using three open Sennheiser K6 modular ME66 microphones and a parabolic dish (50-cm diameter fitted with an ME64 microphone) connected to a digital Sound Devices 702 recorder and two Tascam DR44WL recorders at each site (set up ~130 m from each nest). The recordings were made using a sampling rate of 96 kHz at 24 bits as WAV files (Waveform Audio File

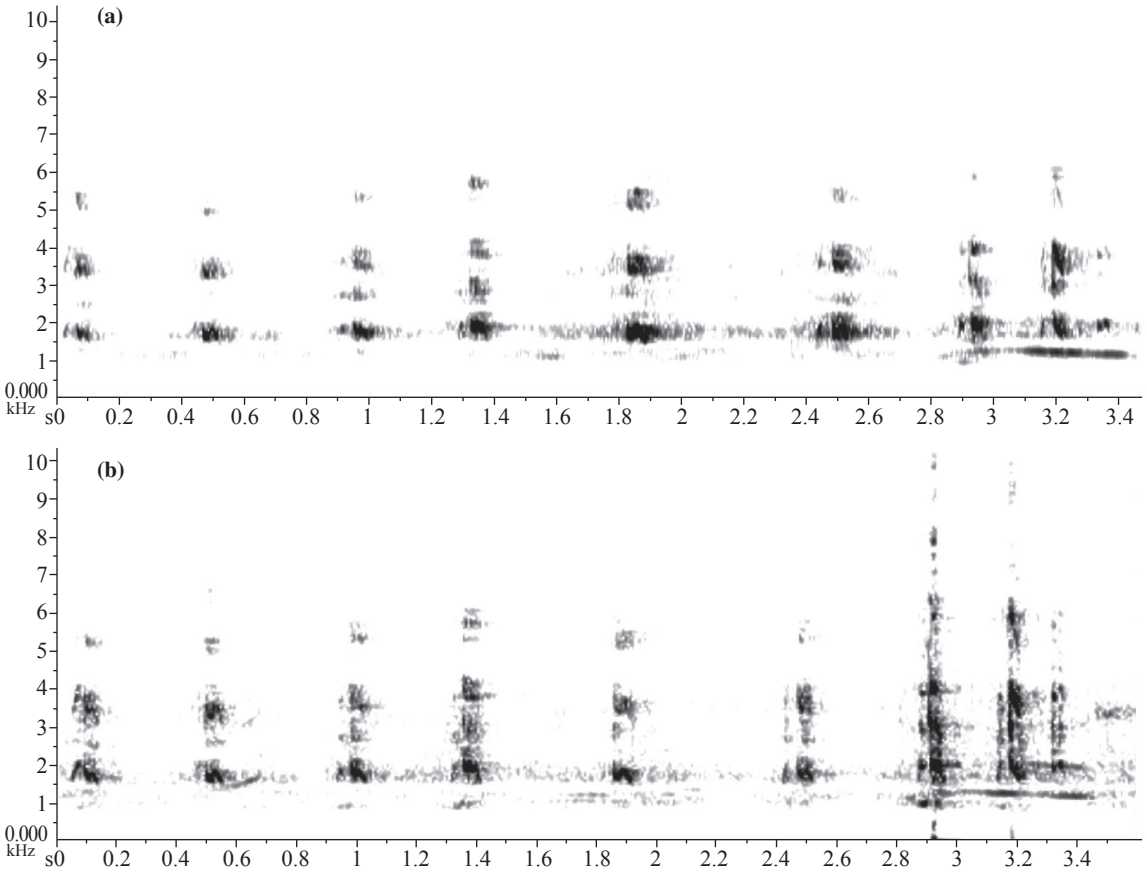

Figure 1. *Spectrograms of creaking calls of adult male Black Falcon (a) at the nest, and (b) when approaching the nest with prey, Pair 2 (female incubating). Tamworth (NSW), July–August 2016.*

Format, being uncompressed audio files). To generate the spectrograms, the recordings were edited and down-sampled to 44.1 kHz at 16 bits (i.e. CD quality) for use with Raven Lite 1.0. The fast Fourier transform (FFT) was set at 512; otherwise settings were Raven Lite 1.0 default settings (e.g. window type is Hann, setting unstated for dB depth). The recordings will be made available to *bona fide* researchers, but not publicly (e.g. through Sound Cloud), to reduce the risk of over-use and misuse of call-playback.

In processing the sound-recordings for presentation of spectrograms here (Figures 1–3) at the same scale (standardised to 3.5 sec. in length), all spectrograms were made using Raven Pro 1.4, FFT 1024, Hann window, overlap 50% and then converted to greyscale in Photoshop for publication. No low-cut filter was used on the sound-recordings, but for producing the spectrograms a filter was used to delete the very loud and low frequencies (60–70 Hz) made by aircraft noise and wind (i.e. environmental noise). The BF spectrograms are from typical samples of multiple recordings of multiple individuals (see above), which we regard as representative of the respective call types of that species (based on SD's experience of Black Falcon calls interstate, e.g. Queensland and Victoria, and of a further two breeding pairs not sampled by FVG in this study). Therefore, the recorded calls are likely to be within the range of individual variation.

RESULTS

Vocalisation types

Breeding adult BFs of both sexes uttered the three main call types (Table 1), examples being the male's creaking call (Figure 1), the female's whining call (Figure 2) and the female's cackling call (Figure 3). All are broad-band calls with most acoustic energy in the 2–3.5 kHz range. Creaking calls by the male were usually an abrupt 'chip' or 'chik' sound repeated, sometimes disyllabic (fundamental frequency ~800 Hz, dominant frequencies ~1.7–3.8 kHz; Figure 1); those of the female were deeper and more guttural, occasionally disyllabic ('ee-chip' type). Female whining calls were long, slightly rising notes (~0.5–1 sec duration and pulse rate, fundamental frequency ~ 1.9 kHz, dominant frequencies 2–3.5 kHz; Figure 2). The whining call of one female during the incubation period (Figure 2a) was at times more rapid and intense than that of another during the nestling period (Figure 2b). Either sex occasionally uttered a single low moan, deeper in pitch than the whine, when approaching the nest tree. Female cackle calls were a series of slow, hoarse cackles with a guttural quality, the notes being somewhat clipped, uttered at a slightly faster rate than the whining call (cackle fundamental frequency ~ 1 kHz, dominant frequencies ~1.9–2.7 kHz; Figure 3), and more guttural than the male's cackle. Male cackle calls sounded somewhat more

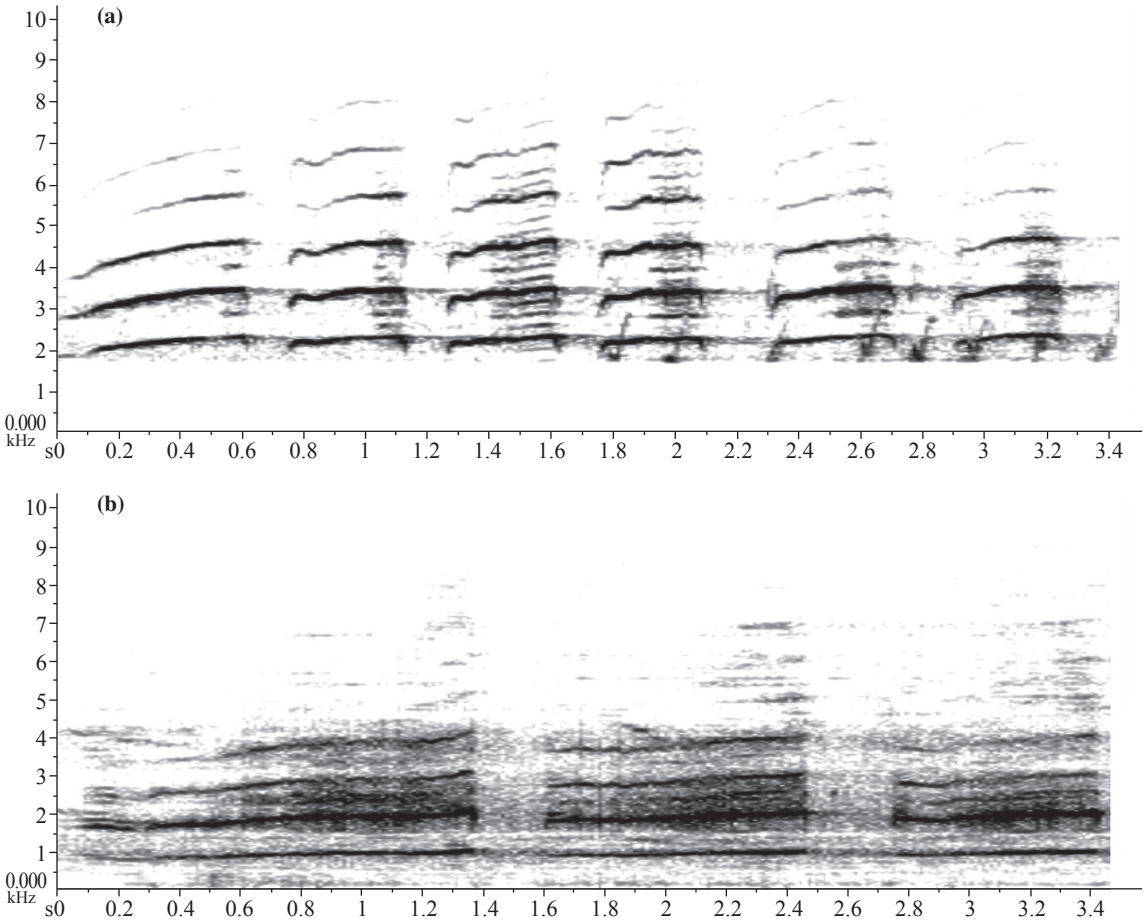

Figure 2. *Spectrograms of whining calls of adult female Black Falcon as the male was approaching the nest with prey: (a) incubation period, Pair 2, and (b) nestling period, Pair 4. Tamworth (NSW), August–September 2016.*

Table 1

Frequency of adult Black Falcon vocalisation types (calling bouts per hour of observation time) in stages of the breeding cycle: pre-laying period to laying/start of incubation (Pair 1, May–July 2015); incubation period (Pairs 2 and 3 pooled, July–September 2016); nestling period (Pairs 3 and 4 pooled, September–October 2016). Total hours of observation are given in parentheses for each stage.

	Creaking		Whining		Cackle	
	Male	Female	Male	Female	Male	Female
Pre-lay (94.5 h)	0.15	0.97	0.03	1.47	0	0.07
Incubation (134.75 h)	0.11	0.29	0.01	2.69	0.01	0.24
Nestling (50.83 h)	0.04	0	0	0.94	0.06	0.37

Peregrine-like than those of the female. A male fledgling, when captured, uttered a shrill, 'screaming' version of the cackle (whereas a captured female fledgling uttered a repeated, deep, resonant whining call: Debus *et al.* 2005).

Vocal behaviour

Female BFs were more vocal than males at all stages of the breeding cycle, and the frequency of the three main call types also changed through the cycle (Table 1). Creaking calls, used by the male as nest-advertisement (to the female in the courtship period) and food-delivery calls, by the female in social contexts (e.g. nest selection and defence, pre-copulatory posture) and by both sexes in intraspecific conflicts, were most frequent in the pre-laying (especially) and incubation periods. Whining calls were frequently used by females as food-begging calls throughout the cycle, but particularly in the incubation period. Cackle calls became frequent in the incubation and especially the nestling period, during interspecific nest defence (notably against Wedge-tailed Eagles *Aquila audax*) and especially by the female (the main defender of the nest and young, Debus *et al.* 2017) (Table 1). Creaking calls, particularly during intraspecific conflicts and especially given by the female, often became long rattling or 'chittering' series (e.g. up to at least 20 syllables).

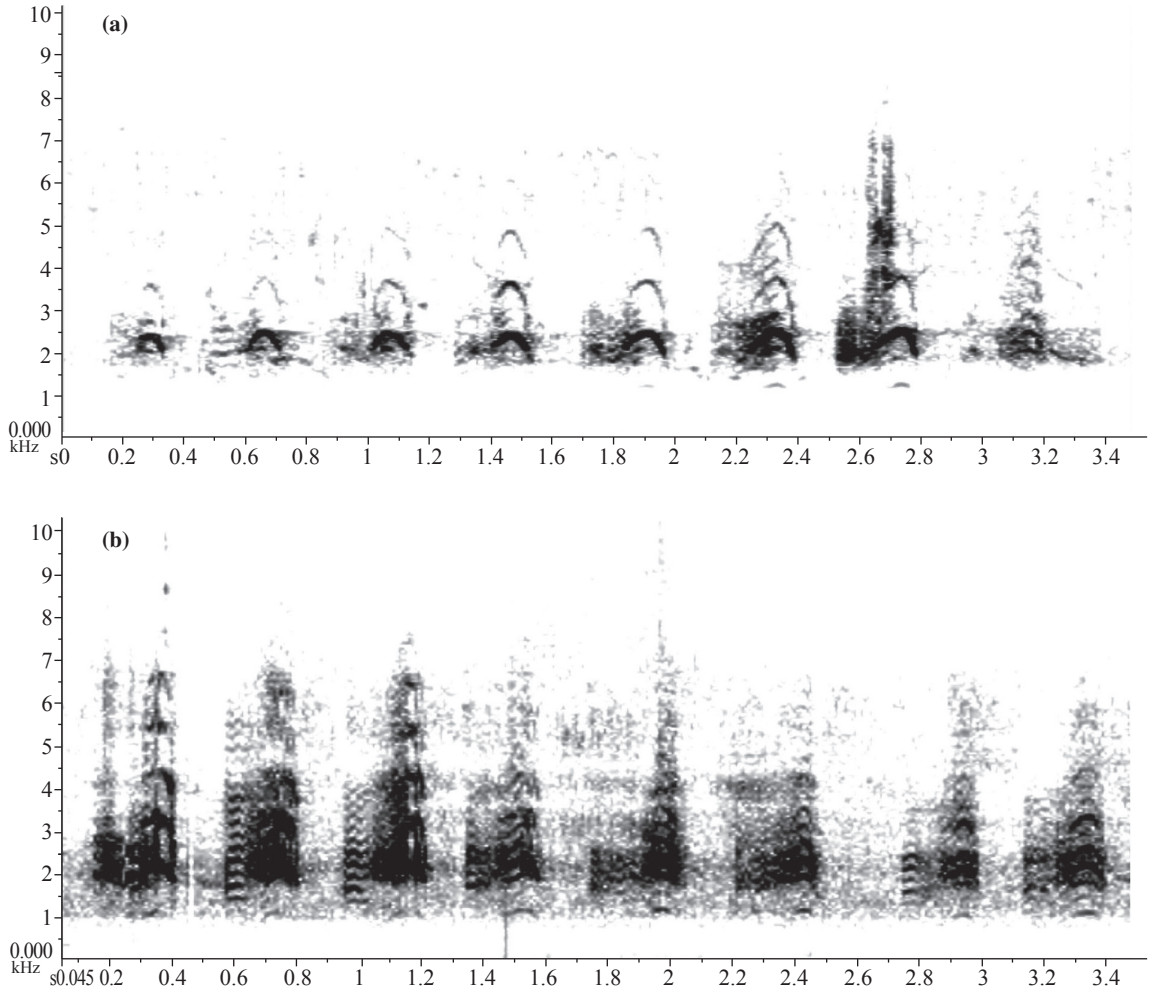

Figure 3. *Spectrograms of two examples of the cackling call of the adult female Black Falcon defending the nestling against a Wedge-tailed Eagle, Pair 4. Tamworth (NSW), September 2016.*

Similarly, the female's whining calls when begging to the male, especially if he was present but had no prey, often became prolonged, insistent series (e.g. Figure 2a). Thus, the frequency of bouts of these call types by the female during the pre-laying to nestling periods does not fully reflect their intensity. For instance, when begging intently the female's whining could persist for up to four bouts per minute, each of up to 20 syllables, and continue for up to five minutes before pausing.

DISCUSSION

This study clarifies that the BF's three main loud calls are the cackle, the creaking call and the whining call, all often heard around the nest or (the cackle) when defending the area against eagles. The long series of creaking calls run together are what have been called 'chittering', rattling or chuckling calls elsewhere (e.g. Debus *et al.* 2005; Charley *et al.* 2014; Whelan *et al.* 2016). The 'greeting trill' described by Charley *et al.* (2014) was a soft, musical version of the extended creaking series, and the calls of interacting juveniles in Barnes and Debus (2012) were the cackle. The BF's calls, including softer 'ticking' or clucking variants of the creaking call given at the nest, are similar to equivalent calls of the Lanner Falcon (see Leonardi 2015). As in the Lanner Falcon and Grey Falcon (Leonardi *et al.* 2013; Ley and Tynan 2016), females are more vocal, and use the whining call much more frequently than males (Table 1).

The results of this study enable classification of the various descriptions and/or spectrograms in Marchant and Higgins (1993) and Jurisevic (1998) according to standard terminology for falcons. The adult BF call types as numbered by Marchant and Higgins (pp. 303–304) are: (1) first sentence = cackle, second sentence = creaking call; (2) = low moan; (3) = begging whine; (4) first sentence = maternal cluck, second sentence = single cackle note; (5) = male creaking call in aerial display ('falsetto' version, labelled Sonagram A); (7) first sentence = begging whine, final clause = creaking call; Sonagrams B and C are juvenile creaking call (B) and whine (C). Similarly, the BF spectrograms in Figure 2 of Jurisevic (1998) are: (a, b) male and female whining calls; (c, d) cackle calls; and (e) a distress 'chitter'. The adult Peregrine Falcon spectrograms in Figure 1 of Jurisevic (1998) appear to be: (a, b) cackle calls; (c, d) whining calls; (e) creaking calls; and (f) a single cackle note. It is apparent from the present study and those of Jurisevic (1998)

and Baylis *et al.* (2015) that the BF's creaking and cackle calls are somewhat deeper (slightly lower in pitch, i.e. in fundamental and dominant frequencies) than those of the Peregrine Falcon (~1 kHz vs ~2 kHz, respectively), and the cackle call is also uttered rather more slowly than typical Peregrine cackles.

The relative frequency of use of the creaking and whining calls by male and female BFs, and their change in relative frequency of use through the breeding cycle, are consistent with the pattern in other well-known hierofalcons (cf. Potapov and Sale 2005; Leonardi *et al.* 2013). These aspects contrast with the more vocal Peregrine Falcon, in which there is no difference between the sexes in the use of the creaking call in the pre-laying period, or in the whining call throughout the breeding cycle (Carlier 1995). However, only one of three BF nests at Tamworth succeeded, producing a single underweight male fledging (Debus *et al.* 2017), so vocal rates might differ at more successful nests under better weather and prey conditions (as suggested by Charley *et al.* 2014). These comparisons are still rather incomplete; it remains to obtain sound-recordings of the male BF's cackling call, the female's creaking call, and the long series of creaking calls given by either sex and subject them to similar analysis as used here.

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