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SHORT COMMUNICATION

The vocal repertoire and the daily calling activity of the Yellow-breasted Barbet (*Trachyphonus margaritatus*)

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Abstract

The Yellow-breasted Barbet (*Trachyphonus margaritatus*) is a group-living and chorusing bird species. However, its vocal repertoire remains poorly described. In this study, we measured the acoustic features of four distinct vocalisations as well as the daily calling activity of barbets at 11 roosting cavity sites. We found that bird's peak of calling activity is early in the morning and at the end of the day. The cohesion calls and group vocal displays were the most common vocalisations. Moreover, cohesion calls were often used before the start of a group vocal displays which suggests a function in the intra-group cohesiveness.

Keywords Non-oscine · Vocal repertoire · Duetting and chorusing species · *Lybiidae*

Zusammenfassung

Das stimmliche Repertoire und die tägliche Rufaktivität des Perlenbartvogels (Trachyphonus margaritatus)

Der Perlenbartvogel ist eine in Gruppen lebende und im Chor singende Vogelart. Sein Gesangsrepertoire ist jedoch nur unzureichend beschrieben. In dieser Studie haben wir die akustischen Merkmale von vier verschiedenen Vokalisationen sowie die tägliche Rufaktivität von Perlenbartvögeln an 11 Schlafplätzen gemessen. Wir fanden heraus, dass die Vögel ihre Rufaktivität am frühen Morgen und am Ende des Tages am stärksten entfalten. Kohäsionsrufe und Gruppenrufe waren die häufigsten Vokalisationen. Darüber hinaus werden Kohäsionsrufe häufig vor dem Beginn von Gruppengesangsdarbietungen eingesetzt, was auf eine Funktion für den Gruppenzusammenhalt schließen lässt.

Introduction

The vocal behaviour of duetting and chorusing bird species has been subject to growing interest over the last decades (Hall 2009; Dahlin and Benedict 2013). The studies have focused on understanding the functions of duet and chorus displays (Mennill and Vehrencamp 2008; Baker 2004; Wu 2013), as well as the way birds learn to coordinate their song with a partner (Rivera-Cáceres et al. 2018; Rivera-Cáceres and Templeton 2019) and the mechanisms of song coordination (Hoffmann et al. 2019; Ręk and Magrath 2020). But most of the work has been done on oscine duetting bird species and non-oscine species have received less attention. Moreover, the research tends to focus mainly on conspicuous duetting and chorusing behaviour, with sometimes little information about the other vocalisations that birds might produce in their daily life. In the case of group living species that perform coordinated choruses, assessing the vocal repertoire would provide a better understanding of the social structure and inter-intra-group interactions (Hale 2006; Radford 2004), which in return could help to understand the functions of the group vocal displays. Here we analyze the acoustic features of different long and short-range vocalisations emitted by the Yellow-breasted Barbet (*Trachyphonus margaritatus somalicus*) and discuss the context of the emission and potential functions of the alarm and cohesion calls. These vocalisations are not considered part of the duet or

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chorus song of the species. We also provide details about the calling activity per hour during the day, around the barbet's roosting cavities.

Methods

Study species and data collection

The Yellow-breasted Barbet is a group-living bird species (Soma and Brumm 2020). Like several other African barbets (*Lybiide* family), it emits loud and conspicuous duets and choruses throughout the year to defend its territory (Short and Horne 1983). A territory encompasses a roosting cavities site dug along a sandy riverbank or found in rocky cliffs, where birds spend each night and serve as nesting site during the breeding season. We conducted a passive acoustic monitoring (PAM) to record the daily vocal activity of 11 well-identified groups of barbets (marked with colour rings) around their cavities site, from January to March 2022, in the Djalelo valley in Djibouti (N 11 21.266 E 042 47.842). We put one SongMeter Micro from Wildlife Acoustics within each territory, near the cavities site (Supporting Information S1), to record birds for several days from 5:30 a.m. to 7:30 p.m. (16 bits, sampling rate: 24,000 Hz, gain: + 18 dB, internal clock set using a smartphone Samsung A5 2016, mean sunrise 06:27 a.m., mean sunset 06:15 p.m.). The barbets entered their roosting cavity from 6 p.m. to 6:30 p.m. and flew out of it around 6 a.m.

Acoustic analysis

Each recording was filtered with a bandpass filter above 800 Hz and resampled to 22,050 Hz. We used acoustic and behavioural data gathered in January–February 2019 and 2020 to identify the different vocalisation types (Mahamoud Issa et al. 2023). A same experienced person manually selected each vocalisation in our recordings from the PAM in 2022, using RavenPro software (version 1.6). The acoustic analyses were conducted under R software using the *Seewave* R package (FFT lenght = 512, overlap = 90%). We measured 19 temporal and frequency parameters of four different vocalisation types (Supporting Information S2).

Statistical analysis

We assessed the daily vocal activity using the mean percentage of emission of alarm calls series ($N = 107$), cohesion calls series ($N = 1116$) and group vocal displays (a duet or chorus, $N = 375$) emitted per day (N days = 10.9 ± 1.74, min = 2, max = 19) and recorded site (11 sites). To identify the hours with the highest calling activity, we fitted an independent generalized mixed models (GLMMs, *glmmTMB* R package) with a negative binomial distribution for the cohesion calls and group vocal displays. We counted the number of vocalisations detected per hour in each day for each site as the response variable and the recording hour as a predictor (12 levels). The sites (11 levels) and recording day (27 levels) were used as random effects to control the inter-sites and day variation. We removed the potential double counting of acoustic events recorded simultaneously by two recording devices, by inspecting the recordings manually each time the delay of two acoustic events between recorders was shorter than 30 s. Finally, we selected 138 duets and choruses emitted close to our SongMeters during the hours with a significant peak of vocal activity and calculated the conditional probability that cohesion calls could be emitted within 2 min before a group vocal display. All statistical analyses were performed in R 4.2.0. The level of significance was $\alpha < 0.05$, and the results are expressed as the mean ± SEM.

Results

We identified four different call types emitted by the Yellow-breasted Barbet (Fig. 1, Table 1). We observed a peak of group vocal displays between 6 a.m. to 8 a.m. and a peak of cohesion calls between 7 a.m. to 8 a.m. Alarm calls were given mainly between 6 a.m. to 7 a.m. but several small peaks occurred during the day (Fig. 2). Our negative binomial GLMMs revealed that birds were significantly more active around their cavities in the morning between 6 a.m. to 9 a.m. and late in the afternoon (Supporting Information S3). We found that the probability of a group vocal display being preceded by the emission of cohesion calls was 44.9% while the probability of cohesion calls being followed by a group vocal display was only 12,2% ($N = 138$ group vocal displays, 62 were preceded by cohesion calls and 505 cohesion calls series detected).

Discussion

In this study, we provided more details regarding the acoustic features of different vocalisations emitted by the Yellow-breasted Barbet throughout the day. Birds left their roosting cavity between 5:50 a.m. to 6:20 a.m. in January–March. It coincided with a peak in the emission of alarm calls. Similarly, the amount of alarm calls increased at the end of the day, when birds returned to their cavity. Birds are more vulnerable to a predator when entering or leaving their cavity which increases their vigilance. The regular small peaks of alarm calls emitted between 8 a.m. to 5 p.m. could coincide with the foraging periods or the time when birds came to monitor their roosting cavities. We observed barbets emitting alarm calls during catching events, between-group

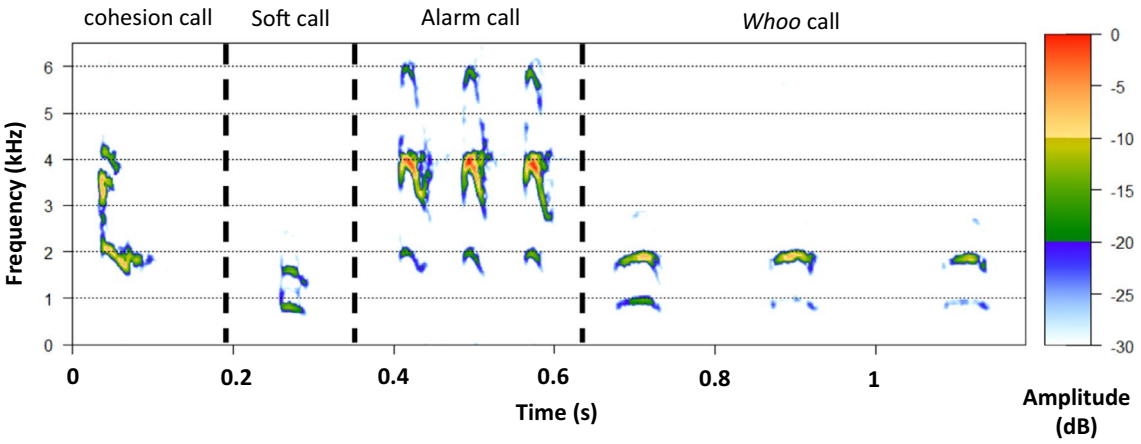

Fig. 1 Spectrogram of four different call types identified. From left to right: cohesion call, soft call, alarm call and *whoo* call (FFT = 512, ovlp = 90, f = 44,100). Details of the acoustic features of each types in Table 1

Table 1 Acoustic features of the cohesion calls ($N = 265$), soft calls ($N = 93$), alarm calls ($N = 78$) and *whoo* calls ($N = 26$). 19 acoustic parameters were measured (mean ± SEM)

Call type	Duration (ms)	Mean fundamental frequency (Hz)	Max fundamental frequency (Hz)	Min fundamental frequency (Hz)	Difference between Max and Min fundamental frequency (Hz)	Mean frequency 1st harmonic (Hz)	Max frequency 1st harmonic (Hz)	Min frequency 1st harmonic (Hz)	Start fundamental frequency (Hz)
Cohesion call	75.6 ± 0.8	1834 ± 11	2200 ± 13	1513 ± 15	687 ± 16	–	–	–	2190 ± 14
Soft call	58.8 ± 1.0	1445 ± 30	1590 ± 33	1255 ± 32	335 ± 27	–	–	–	1469 ± 36
Alarm call	47.3 ± 0.8	2203 ± 21	2308 ± 22	1948 ± 31	359 ± 29	4443 ± 47	4713 ± 59	3962 ± 68	2223 ± 41
Whoo call	62.8 ± 2.2	989 ± 25	1045 ± 29	868 ± 32	232 ± 54	1954 ± 27	2090 ± 54	1859 ± 22	2001 ± 54

End fundamental frequency (Hz)	Peak frequency (Hz)	Slope (intercept)	Time stationary point (ms)	Frequency stationary point (Hz)	Q25 (Hz)	Q75 (Hz)	IQR (Hz)	Number of calls per series	Inter-call intervals within call series (s)
1595 ± 17	1988 ± 20	− 7.9 ± 0.2	–	–	1810 ± 10	2485 ± 28	675 ± 26	7.13 ± 0.85	1.00 ± 0.04
1377 ± 30	1465 ± 33	− 2.4 ± 0.5	–	–	1602 ± 24	2189 ± 25	587 ± 26	–	–
1992 ± 33	3941 ± 16	− 5.0 ± 0.5	18.1 ± 1.2	2299 ± 21	2571 ± 68	4326 ± 32	1754 ± 58	14.4 ± 3.09	0.11 ± 0.01
1919 ± 31	1800 ± 69	− 0.8 ± 0.4	49.0 ± 6.1	1030 ± 27	1355.4 ± 57	2051 ± 42	696 ± 72	2.79 ± 0.29	0.27 ± 0.01

interactions, against a Barbary Falcon (*Falco peregrinus pelegrinoides*) and a Common Kestrel (*Falco tinnunculus*), and when a pack of baboons or local shepherds were passing close by a barbet's roosting cavity.

From 6 a.m. to 8 a.m. the birds emitted a lot of cohesion calls. It could serve as a recruitment signal toward group members to start a group vocal display. When one bird emitted such cohesion calls, other birds in the vicinity replied with cohesion calls as well or just approached the emitter. The amount of cohesion calls also increased at the end of the day simply because birds gathered at their roosting site and often reunited to participate in a communal sand bath before entering their cavity (Supporting information S4). The cohesion calls seem to serve in intra-group communication to maintain group cohesiveness during joined actions such as foraging, taking a communal sand bath or heading back to the roosting cavity at dusk.

The Yellow-breasted Barbet like some other duetting and chorusing African barbet species is known to introduce its duet and chorus with a specific display described as a greeting ceremony (Short and Horne 1983), which consists of the emission of *chewp* notes (Short and Horne 2001). A recent study provided more details about this behaviour for the species. It was revealed that the birds

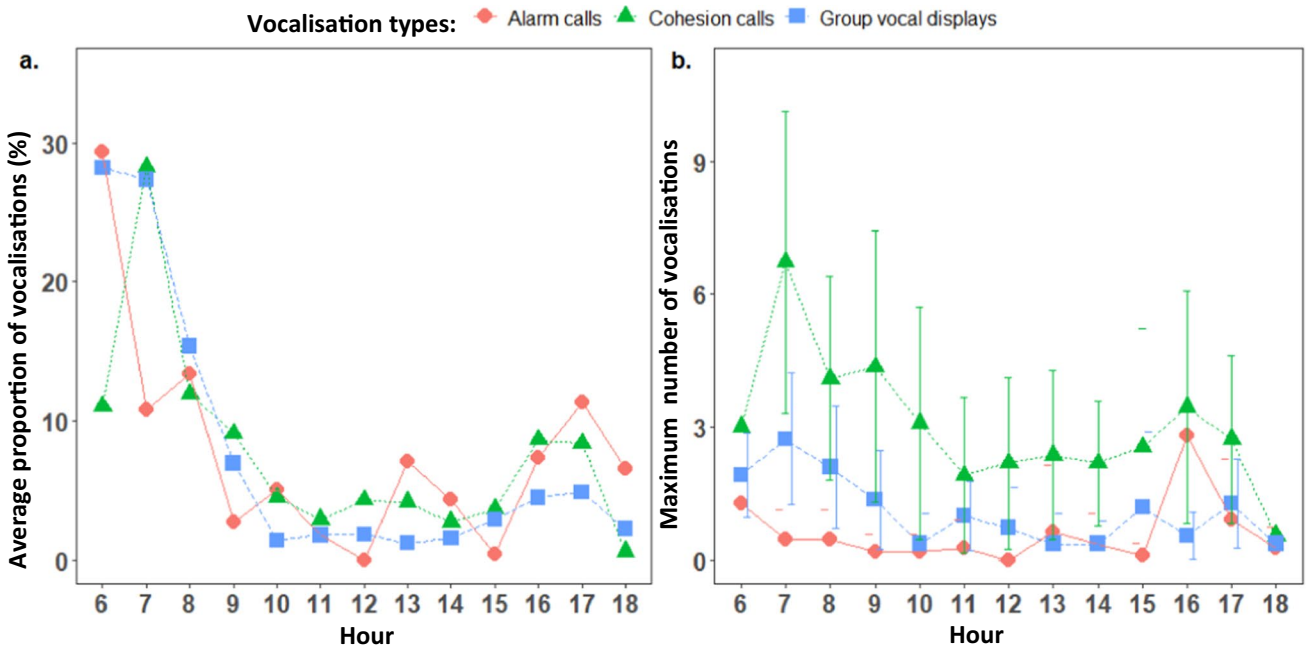

Fig. 2 Daily vocal activity of the Yellow-breasted Barbet per hour. One point represents a full hour ($x=6$ is the time between 6 a.m. to 7 a.m.). **a** Each point is the average proportion of vocalisations per site (11 sites) and day (10.9 ± 1.74 days). **b** The maximum number of vocalisations recorded per site for each hour of the day when the birds were vocally active. The blue squares represent the group vocal displays (duet or chorus), green triangles the cohesion calls series and the red diamonds the alarm calls series

use two variations of such *chewp* notes: *high chewp* and *low chewp* (Mahamoud-Issa et al. 2023). Moreover, the individual that initiated a group vocal display, considered as the leading individual emits more *high chewp* notes than the individuals that join, considered as followers. Finally, the leading individual sometimes combined the emission of *chewp* notes with a specific visual tail display. In this present study, we showed that cohesion calls are often used even before the start of a group vocal display, probably to recruit group members in the vicinity. It would be interesting to determine whether the bird that gives cohesion calls is the same individual who is leading the following group vocal display. Acoustic identity encoded in cohesion calls could thus allow other group members to recognize the different birds vocalising in their surroundings and decide whether or not to join.

Soft calls and *whoo* calls were the most difficult vocalisations to listen to in the field because of their low amplitude nature, not heard above a few meters from the birds. According to the few *whoo* calls recorded during the PAM, it seems that birds emitted these calls after a group vocal display. But we did not have enough data to suggest what function such calls might have. Regarding soft calls, birds did not open their bills when vocalising. Birds emitted such calls when they were close to each other. We observed one male using such calls just after leaving its cavity. He stayed on a branch in front of the entrance while the two females were still inside the cavity. Soft calls could serve during close-range interactions between group members.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10336-023-02112-5.

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Data availability The sound records are available at https://doi.org/10.7479/v3en-0567.

Declarations

Conflict of interest The authors have no competing interests to declare that are relevant to the content of this article.

Ethical statement The study on *Trachyphonus margaritatus somalicus* was conducted with an official agreement of the Decan Wildlife Association (https://www.decandjibouti.org/) which is responsible for the management of the protected area of and Djalelo in Djibouti where the study took place.

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