Le Rhinolophe (2009) **18** : 17-24

Vocalisations of the Seychelles sheath-tailed bat *Coleura seychellensis*

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Abstract. The vocalisations of the Critically Endangered Seychelles sheath-tailed bat *Coleura seychellensis* are described. Four call types are identified : complex social calls, orientation calls within the roost, open habitat orientation calls and foraging calls. The open habitat orientation calls and foraging calls are quasi-CF, the latter having alternating frequencies. The function of the alternating calls is discussed and it is concluded that in this species the lower frequency tone is used for navigation (being identical to the open habitat orientation calls) and the higher frequency tone for prey detection in cluttered environments.

Key words : *Coleura,* echolocation, Emballonuridae, foraging, orientation.

INTRODUCTION

Auditory communication is used by a wide range of animals, from insects to vertebrates. In most species this is used for communication between individuals ; in the case of bats vocalisations provide information both to other individuals and to the calling individual in the form of sonar. This mechanism and use of such communication in bats is relatively well understood and it is known that echolocation call structure is associated with physiological adaptations and foraging behaviour (NEUWEILER, 1989, 1990 ; SCHNITZLER & KALKO, 1998 ; PAVEY *et al.,* 2001, BOGDANOWICZ *et al*., 1999 ; GANNON *et al*., 2001 ; PAVEY *et al.,* 2001 ; MOSS & SURLYKKE, 2001 ; HUIHUA *et al*., 2003).

A large proportion of bat species have not been studied in detail and their use of different calls remains unknown. The Seychelles sheath-tailed bat *Coleura seychellensis* Peters, 1868 is typical of these bats, having been the subject of only a small number of research projects which have recorded the frequency of bat calls but without any further details (NICOLL & SUTTIE, 1982 ; BURGESS & LEE, 2004 ; JOUBERT, 2004 ; GERLACH, 2004). This species is categorized as Critically Endangered (MICKLEBURGH *et al*., 2004) and is known from only a small number of roosts on the islands of Mahé and Silhouette, where it has been located foraging in lowland woodland (GERLACH, 2004 ; JOUBERT, 2004). There are some data on feeding, movement and social interactions but the details of vocalisations are unknown. In recent research vocalisations were recorded, these are described below.

METHODS

Two sets of recordings were analysed from Silhouette and Mahé islands. On Silhouette an automated recording system comprising the Anabat II bat detector and ZCAIM storage system was used for recording bat calls at La Passe in July 2005. The bat detector was left in place overnight (18:00-07:00 hours) in the roost and in foraging areas. The recordings were analysed with Analook 4.9j. On Mahé island recordings were made by Philippe Favre at Port Launay in 2002 using a Pettersson D980 bat detector coupled with a Minidisc recorder. These calls were analysed by Frédéric Leblanc using Batsound 3.1.0.

RESULTS

Four main categories of call were recorded (Table 1 ; Fig. 1, 2) :

1. Social calls - complex calls covering a wide frequency range (typically 12-40 kHz), with a significant audible component (at around 5 kHz). Social calls were defined as vocalisations made by a bat and directed at another bat (observed during recording), with no clear regular pulse repetition. These calls were identified in the roost on Silhouette.
2. Orientation calls in complex habitat - broadband frequency modulated (FM) calls (16.6-41.0 kHz) with a characteristic upsweep followed by a downsweep, produced by bats flying in a confined space (usually within the roost). Complex habitat orientation calls were restricted to within the roost and adjacent tunnels on Silhouette.

Table 1 : Properties of *Coleura seychellensis* vocalisations on Silhouette.

Type		Duration	Bandwidth	Characteristic frequency	Interpulse interval	Pulse repetition rate	N
		(ms)	(kHz)	(kHz)	(ms)	(Hz)	
Silhouette							
Social		2.3±0.05	0.71±0.14	34.25±0.05	49.5±3.85	13.47±2.34	131
Orientation (confined)	navigating	2.4±0.25	17.69±3.55	23.50±0.22	4.5±0.05	12.67±1.02	140
Orientation (cruising)		4.4±1.55	0.52±0.13	39.17±0.03	199.5±40.85	10.00±0.47	29
Foraging		1.4±0.27	0.94±0.16	41.05±0.07	105.6±5.13	9.61±1.33	141
Foraging components	low	1.5±0.25	0.02±0.01	38.98±0.01	121.2±6.35	9.80±1.44	109
	high	1.4±0.30	0.94±0.17	44.47±0.15	117.1±1.45	4.82±1.25	32

3. Orientation calls in open habitat (cruising) - regular pulses of very shallow quasi-CF calls (37.9-40.4 kHz) and with no change in frequency or amplitude. These calls were used in open habitat on both Mahé and Silhouette.
4. Foraging calls - these resemble the calls defined as orientation calls in open habitat but comprise two alternating CF pulses (38.5-40.9 and 43.6-46.1 kHz) with numerous harmonics. These calls varied in frequency in association with feeding buzzes. Foraging calls were recorded in gaps in woodland on both Mahé and Silhouette. On Mahé the characteristic frequency of the low frequency first signal was 37.5-38.4 kHz (38.7-39.4 kHz on Silhouette) and the second (higher frequency) signal is 42.5-42.9 kHz (42.2-45.2 kHz on Silhouette), with a duration of 3.8-6.39 ms (1.03-4.32 ms on Silhouette) and an interpulse interval of 127-291 ms (100-121 ms on Silhouette). These differences appear to indicate the use of slightly lower frequencies on Mahé than on Silhouette, but this may reflect differences in recording and analysis techniques rather than real biological differences.

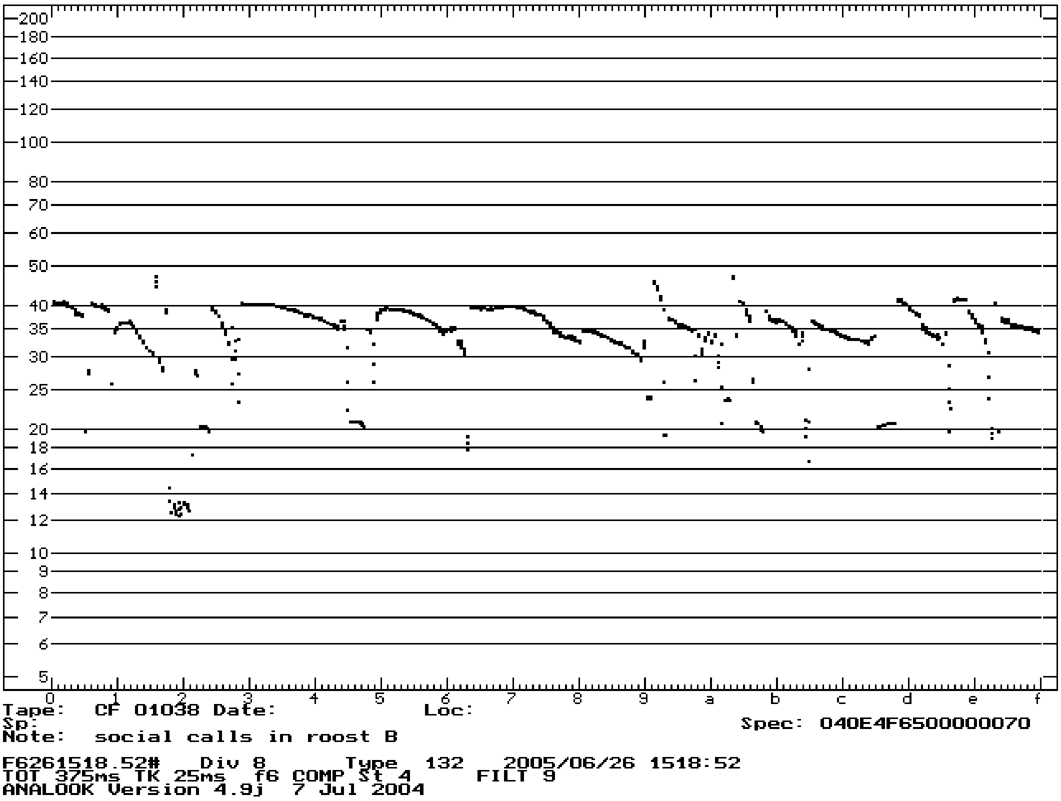
DISCUSSION

The four call types identified in *Coleura seychellensis* appear to reflect the characteristics of the different calling situations. Social calls are highly complex and presumably convey relatively complex information between individuals. Typically they were recorded when a roosting bat directed calls towards a flying bat, the intensity of such calls increased with increasing levels of within-colony agitation. Social calls were also detected between roosting bats. Further analysis of calls, combined with simultaneous recording of interactions is required before any subdivisions of social calls can be identified.

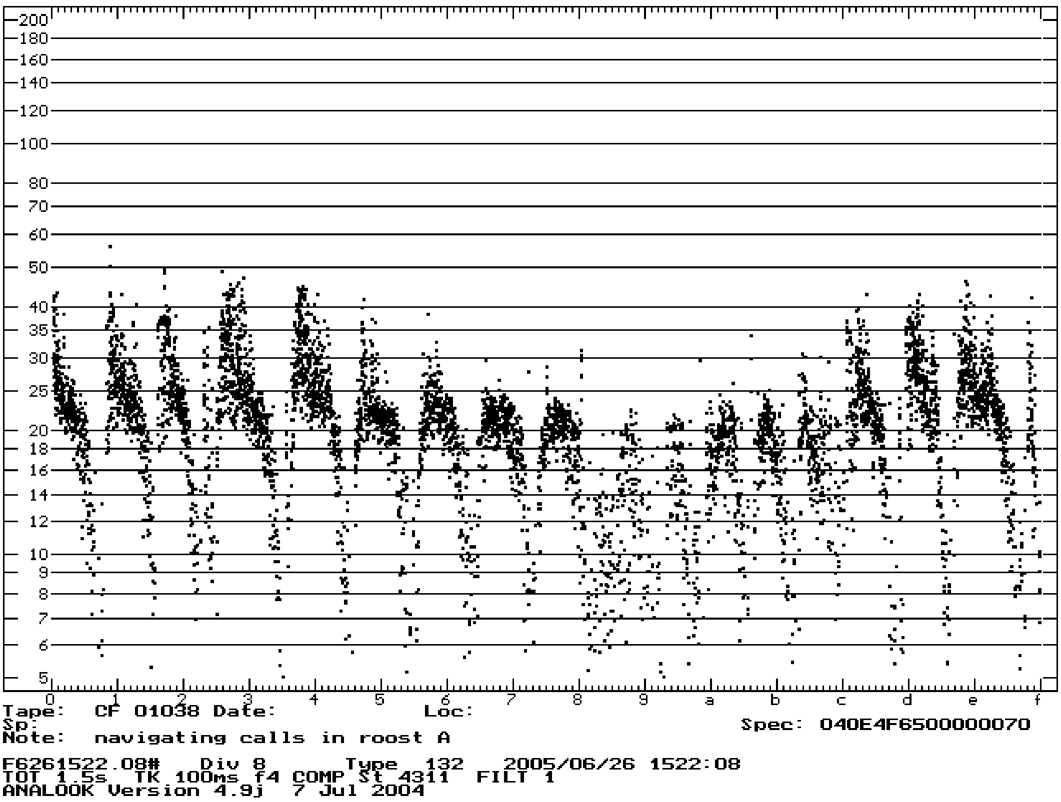
Orientation calls within the roost are notably different from those recorded in open habitat. Differences would be expected due to the acoustic characteristics of enclosed and open spaces but the differences recorded here appear to reflect real call differences and not simple recording artefacts. Identical complex habitat orientation calls were recorded in two different situations : bats flying within the roost, circling in front of the recorder, and those flying directly towards, and over the recorder in the straight tunnel. These differ only in the Doppler shift ; in the circling bats a cyclical shift is detectable whereas a linear shift occurs in the linear tunnel. There was considerable noise on the recordings and an exact pulse could not be extracted from the circling calls, the tunnel recording included some calls with less noise and a more distinct pulse has been identified. No other differences are apparent despite the circling bats flying in an area of $10m^2$ and the linear flights occurring in a tunnel 75 cm wide. The broad bandwidth of these calls is in accordance with other calls from confined spaces (Kalko & Schnitzler, 1993).

The open habitat orientation calls are shallow calls with only slight modulation. They can be described as quasi-CF. This energetically economical call is believed to provide spatial information at long distances, but with low resolution (Fenton, 1985 ; Barataud, 1996) and is thus useful for navigantional purposes. The foraging calls differing only in being steeper and having alternating frequencies. The alternating foraging calls recorded in the present study are typical of many woodland foraging bats. A system of using two alternating quasi-FC pulses in foraging has been recorded in several emballonurids, including *Cormura brevirostris* (with three alternating frequencies), *Peropteryx macrotis*, *Saccopteryx bilineata* and *S. leptura* (Biscardi *et al*., 2004 ; Kalko, 1995). There are several suggestions for the function of this alternation, including a social or anti-jamming function (Habersetzer, 1981 ; Kossl *et al*., 1999), in increasing

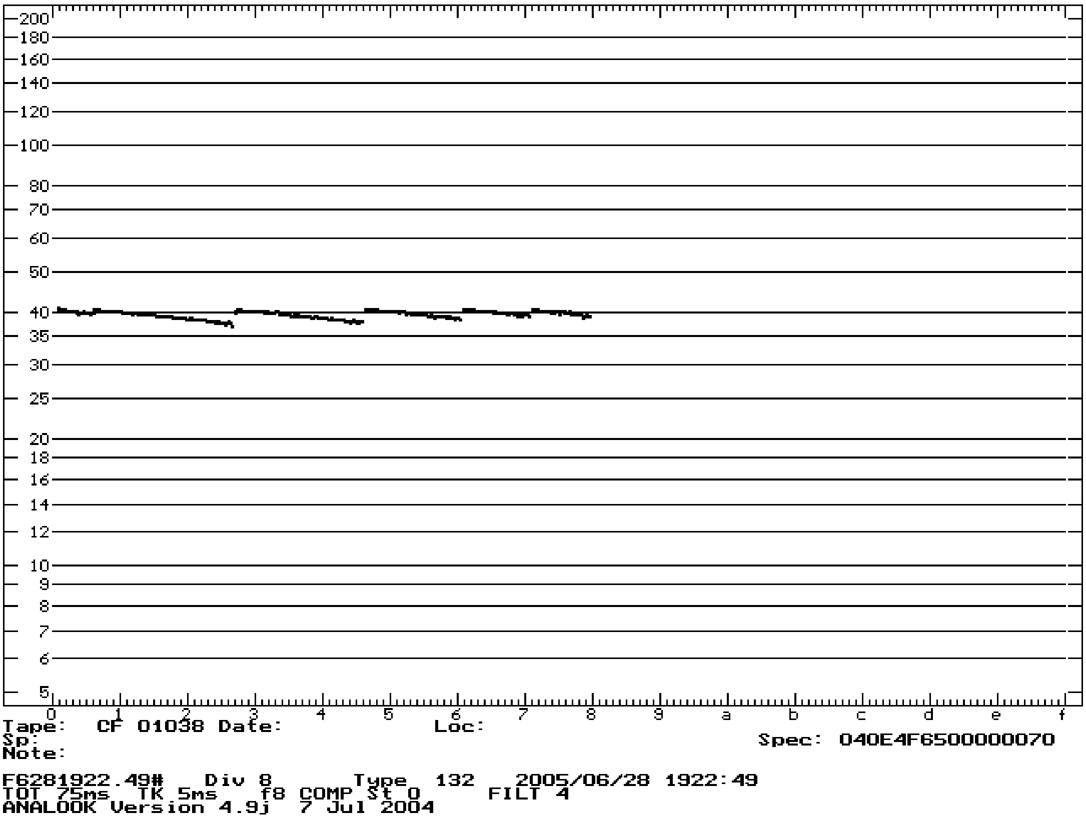
Fig. 1: Seychelles sheath-tailed bat calls recorded on Silhouette island.



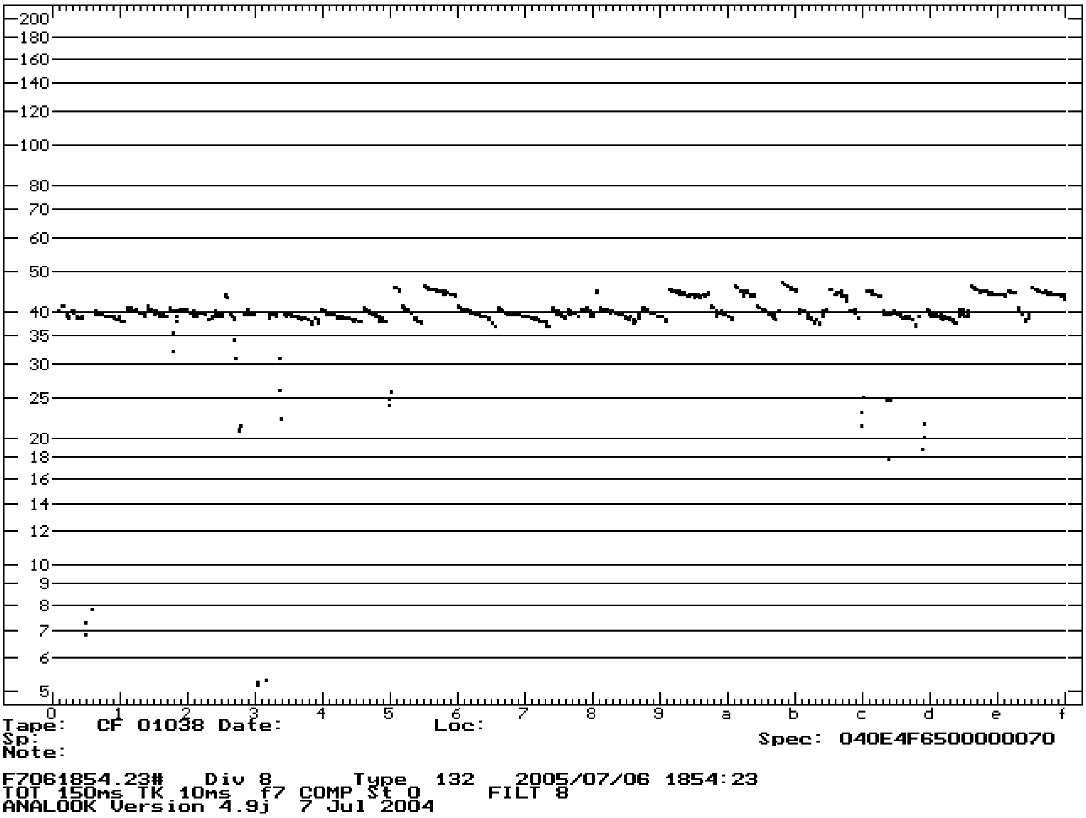
a) social calls



b) orientation calls in caves

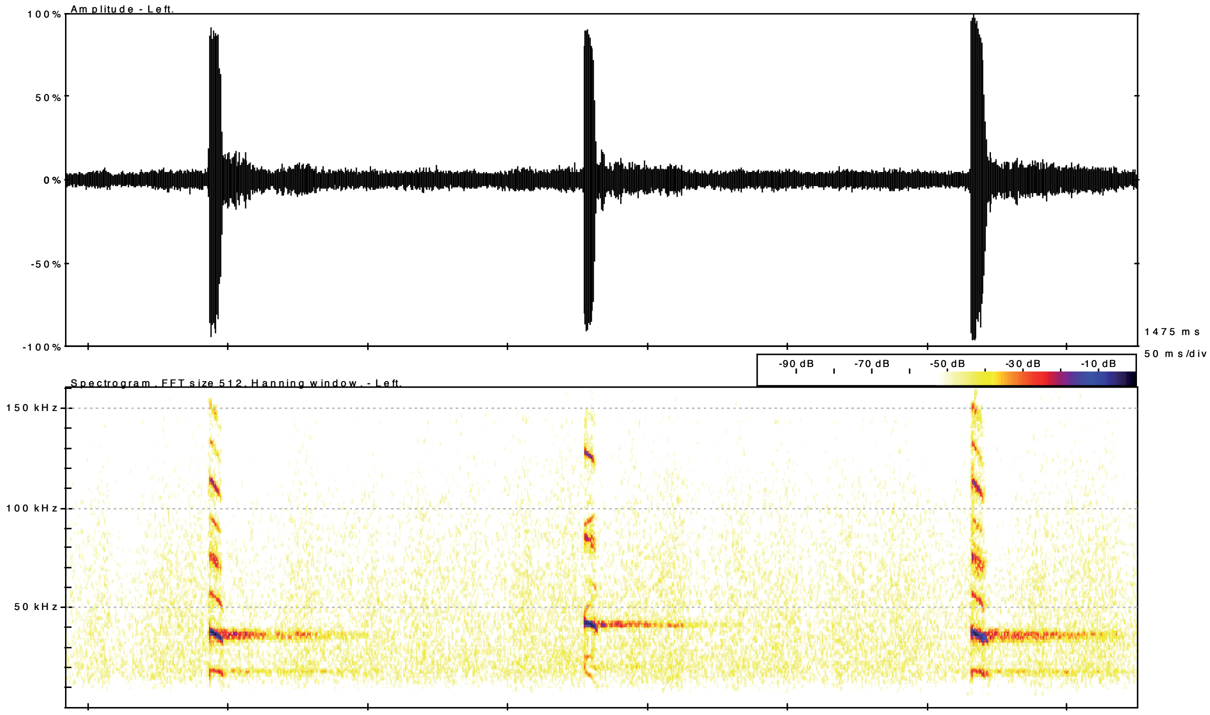


c) orientation calls in the open

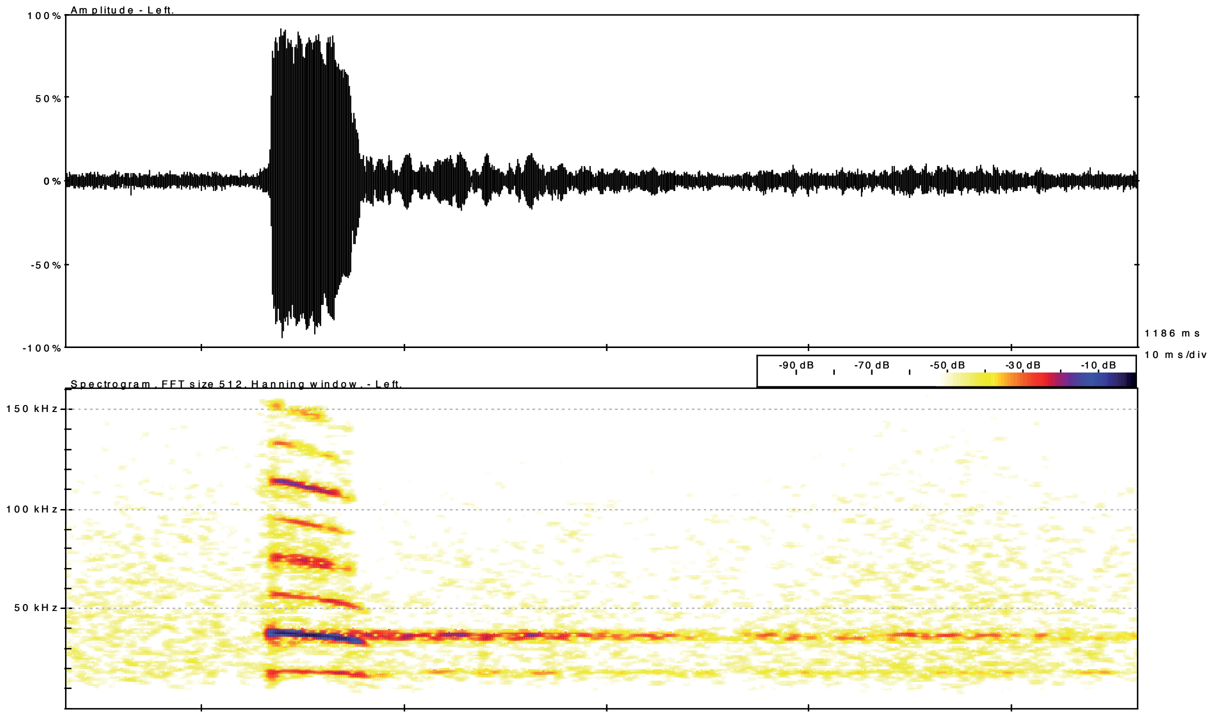


d) foraging calls

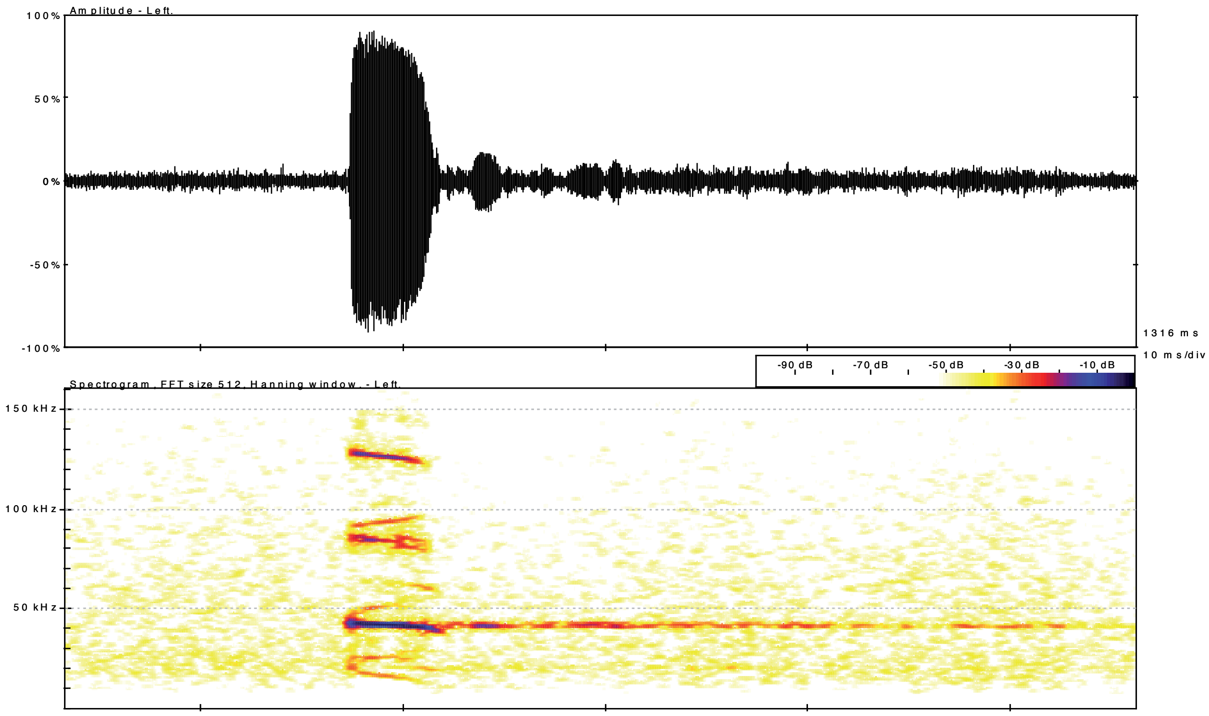
Fig. 2: Seychelles sheath-tailed bat calls recorded on Mahé (analysis provided by Frédéric Leblanc), top - oscillogramme, bottom - spectrogramme



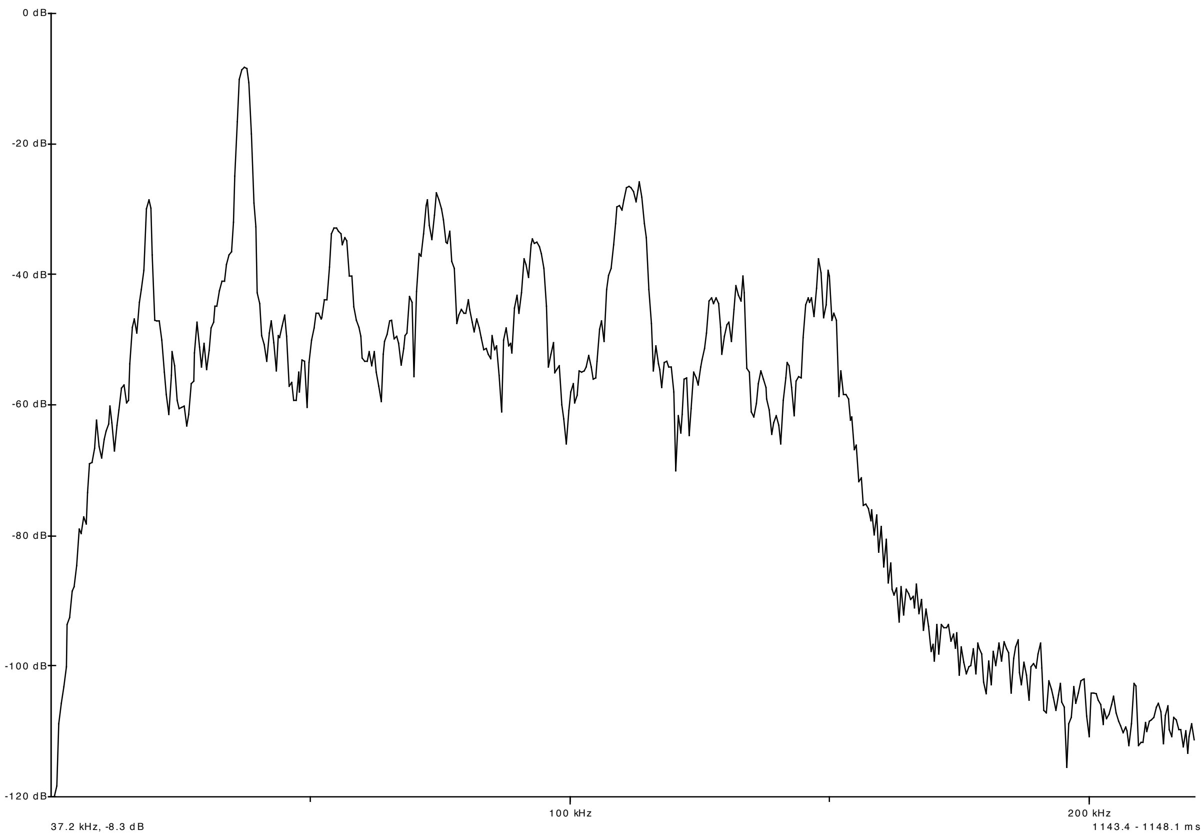
a) Foraging sequence



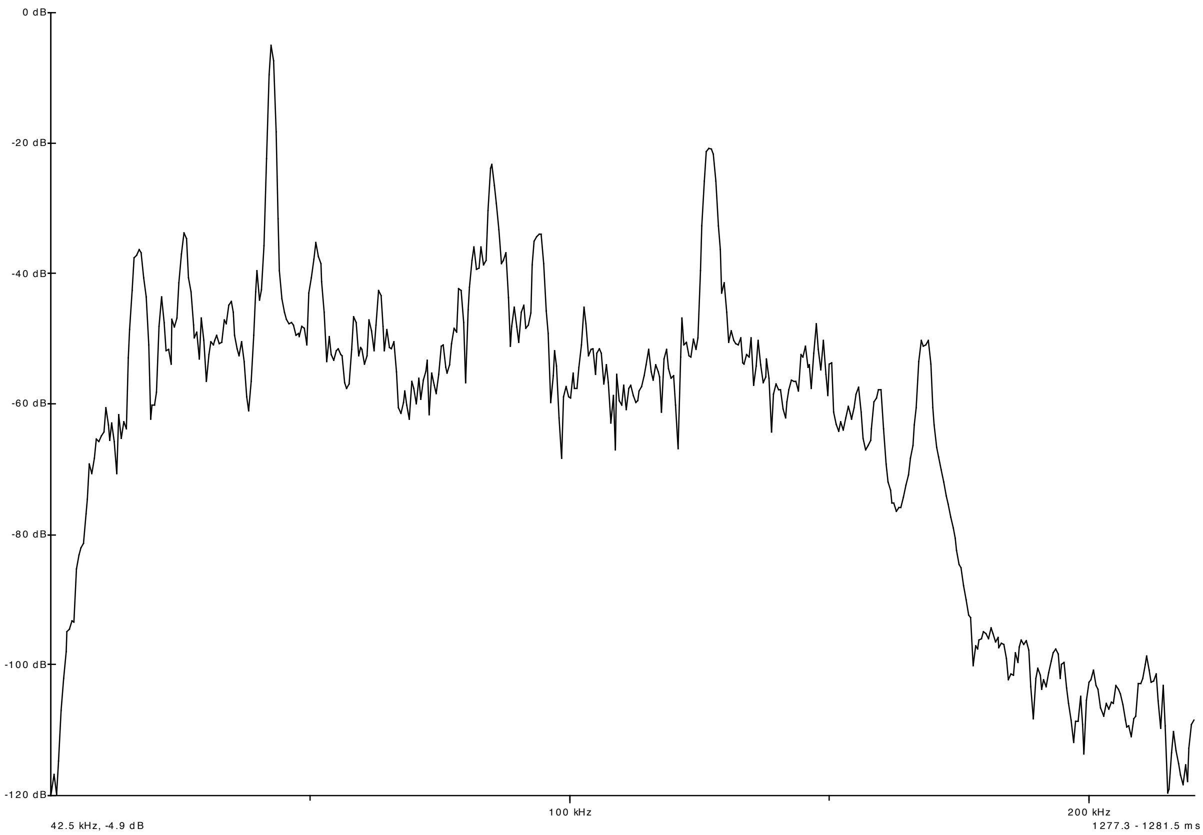
b) First signal of an alternating sequence



c) Second signal of an alternating sequence



d) Spectral density of the first alternating signal (zero crossing frequency 37.2 kHz)



e) Spectral density of the second alternating call (zero crossing frequency 42.5 kHz)

detection distance (FENTON *et al*., 1998; HELLER, 1989, 1995; WEID & VON HELVERSEN, 1987), detection of different sized prey (HELLER, 1989, 1995), increase bandwidth to facilitate identification (HELLER, 1995) or to combine prey detection and navigation (DENZINGER *et al*., 2001; HELLER, 1989; PARSONS *et al*., 2001; SCHNITZLER & KALKO, 1998; KINGSTON *et al*., 2003; BARCLAY, 1983; KALKO, 1995). In the latter hypothesis one tone would be used as a general navigational sonar, whilst the other is the hunting system, pre-compensated for the bat's flight speed. A similar two-tone call has been recorded for *Coleura afra*. Confined flying *C. afra* produce frequency modulated (FM) calls and a single frequency CF call in the roost foraging appears to use the basic CF frequency from the roost with the addition of a second harmonic (HALLS, undated). CF calls are thought to be effective in detecting moving objects in cluttered environments (PAVEY *et al*., 2001).

The calls described above are typical of those used by emballonurid bats (BARATAUD, 2004). Their comparatively simple facial, laryngeal and auditory morphology is associated with relatively basic echolocatory properties. Call alternation in emballonurids, including *C. seychellensis*, has been suggested to be a specialization to facilitate feeding on tympanate moths (BARATAUD, 2004). This does not appear to be a significant component of the behaviour in *Coleura seychellensis* as call alternation is used only within complex habitats and the diet contains only a small proportion of tympanate species (GERLACH, 2004).

ACKNOWLEDGEMENTS

In undertaking this research I am grateful for support from Conservation International. I am grateful to Frédéric Leblanc for allowing me to make use of his unpublished analysis of the *Coleura seychellensis* calls from Mahé, and to Michel Barataud and Philippe Favre for bringing them to my attention.

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