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Source: Zoological Science, 12(4) : 503-505

Published By: Zoological Society of Japan

URL: https://doi.org/10.2108/zsj.12.503

ZOOLOGICAL SCIENCE 12: 503–505 (1995)

[RAPID COMMUNICATION]

Regular Pulse Emission in Some Megachiropteran Bats

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ABSTRACT—We recorded vocalizations of megachiropteran bats, *Cynopterus brachyotis, C. horsfieldi, Megaerops ecaudatus* and *Macroglossus sobrinus* as they were held in our hands, in a hanging position or moved up and down, simulating flight. All four species produced regular audible tone pulses with a frequency spectrum of less than 9 kHz (peak at 4–6 kHz). The duration of a single pulse varied from 14.9 to 23.6 msec on average among these species. The interpulse interval was between 108.3 and 127.7 msec. In *M. ecaudatus* and *M. sobrinus*, double pulses were occasionally emitted, with interpulse intervals averaging 39 msec and 31 msec, respectively. The regular pulse emission may indicate that the bats studied use sounds to probe space.

INTRODUCTION

In the Megachiroptera, only one genus, *Rousettus*, is known to echolocate [4, 6, 8, 10, 12]. They often roost in dark caves, and their sonar clicks are produced by the tongue. As yet, there have been no reports of echolocation in the other genera of Megachiroptera. Some of the megachiropteran bats use the dark understory of the rain forest as a flyway or feeding site. They possibly depend not only on vision but also on hearing for their orientation in flight. We suspected that some of the Old World fruit bats, in addition to *Rousettus*, might use click-like sounds for echolocation. The purpose of this paper is to present an evidence for sound emission which is possibly used for echolocation by the megachiropteran fruit bats *Cynopterus brachyotis, C. horsfieldi, Megaerops ecaudatus* and *Macroglossus sobrinus*, whose echolocation calls were previously undescribed.

MATERIALS AND METHODS

In August 1993 and March 1994, we caught four species of megachiropteran bats, *Cynopterus brachyotis, C. horsfieldi, Megaerops ecaudatus* and *Macroglossus sobrinus*, in mist nets at the Field Study Center, University of Malaya, Ulu Gombak, Selangor, Malaysia. They emitted audible tone pulses when they were in a hanging position or were moved up and down gently while held in our hands, simulating flight. These were useful and reliable methods to elicit echolocation signals in echolocating bats. We recorded their calls with a microphone and bat detector (Ultra Sound Advice SM2 and S-25), then registered them using an Aiwa HS-F160 cassette recorder. The temporal structure and frequency spectrum of the recorded sounds were analyzed with an IBM-PC computer using the "RTS" and "Signal" programs (Engineering Design Inc.). For purpose of comparison with such signals, we also recorded distress calls. It was easy to obtain the calls as a bat was being held tightly.

Accepted April 25, 1995
Received November 7, 1994

RESULTS AND DISCUSSION

The regular pulse emission was originally recorded in the four species of Megachiroptera. Sonagrams of these pulses are given in Figure 1. In all species, the audible pulses had spectrums of less than 9 kHz (peak 4–6 kHz). The duration of calls varied from 14.9 to 23.6 msec on average among the four species (Table 1). The average interpulse interval was between 108.3 and 127.7 msec, corresponding to repetition rates of 4–12 successive calls per sec. In echolocation calls of *Aerodramus vanikorensis*, interpulse interval averaged 116 msec with repetition rates being 3–20 calls per sec [5]. In addition, double pulses were occasionally emitted by *M. ecaudatus* and *M. sobrinus*, and their interpulse intervals averaged 39 msec (range 33–44, N=6) and 31 msec (range 28–35, N=5), respectively. The presence of double pulses (double clicks) have also been reported in echolocation calls in *Rousettus amplexicaudatus* and *R. aegyptiacus* [6, 12] and in five species of *Aerodramus* [11]; the interpulse interval of the former two was about 30 msec [6, 12] and 20 msec [12], respectively.

In stressful situations causing fear or disturbance, the bats produced distress calls which were harsh broadband signals (Fig. 2). In all species, the call was composed of a train of large numbers of clicks which produced the broadband appearance. The duration of the call was more than 100 msec. The similar click components are also found in the screams of anger or frustration of other megachiropteran bats, *Macroglossus lagochilus* and *Syconycteris crassa* [6]. It is interesting to note that the click components in the screams

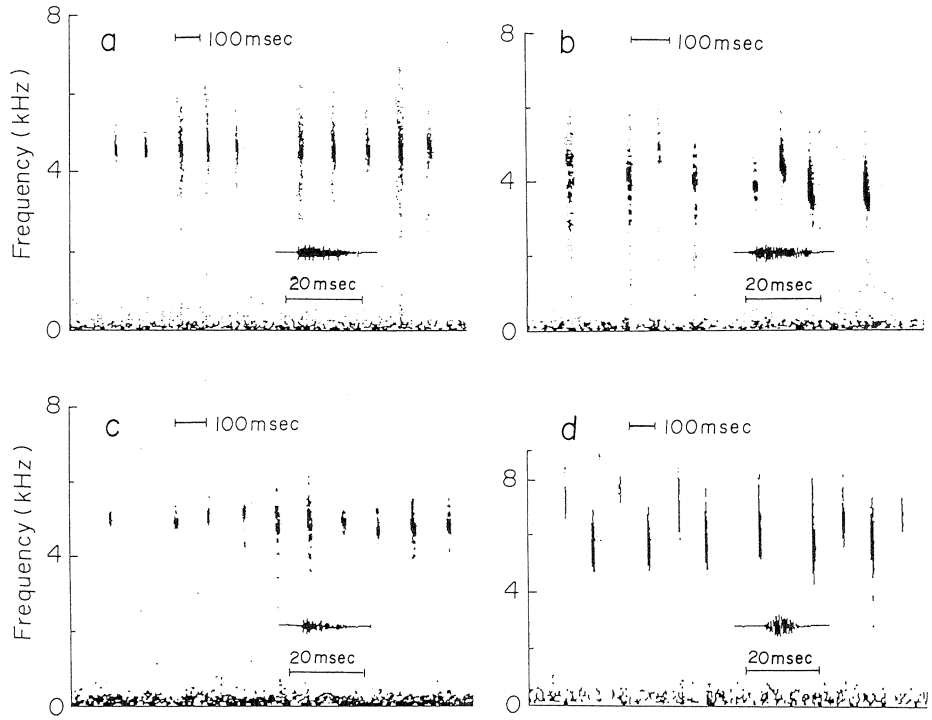

FIG. 1. Sonagrams and oscillograms of regular pulses emitted by *C. brachyotis* (a), *C. horsfieldi* (b), *M. ecaudatus* (c) and *M. sobrinus* (d).

TABLE 1. Duration of call and interpulse interval in four species

Species	Duration of call (msec)		Interpulse interval (msec)	
	N	M±S.E.	N	M±S.E.
C. brachyotis	42	23.6±1.08	44	120.2±5.97
C. horsfieldi	24	22.6±1.20	22	108.3±9.24
M. ecaudatus	23	23.0±0.81	21	117.2±6.51
M. sobrinus	24	14.9±0.87	21	127.7±9.25

of the two species, though not orientation sounds, do not differ greatly from the echolocation calls of *R. amplexicaudatus* [6].

The communication calls in African fruit bat, *Epomophorus wablbergi*, consist of several harmonics covering 2–8 kHz, and have a duration of 200–300 msec but contain a slight click at the beginning [13]. In Australian flying foxes, *Pteropus poliocephalus, P. gouldi and P. scapulatus*, the communication calls are composed of multiple-harmonics ranging 2 to 14 kHz, and the durations vary from 50 to 500 msec [9].

Therefore, the acoustic features of the regular pulse emitted by bats we studied show striking differences, not only from those of the distress calls, but also from those of the communication calls of other pteropodid bats. Although the frequency was very low, the regular pulses are similar to the echolocation calls of *R. amplexicaudatus* [6]. Such low

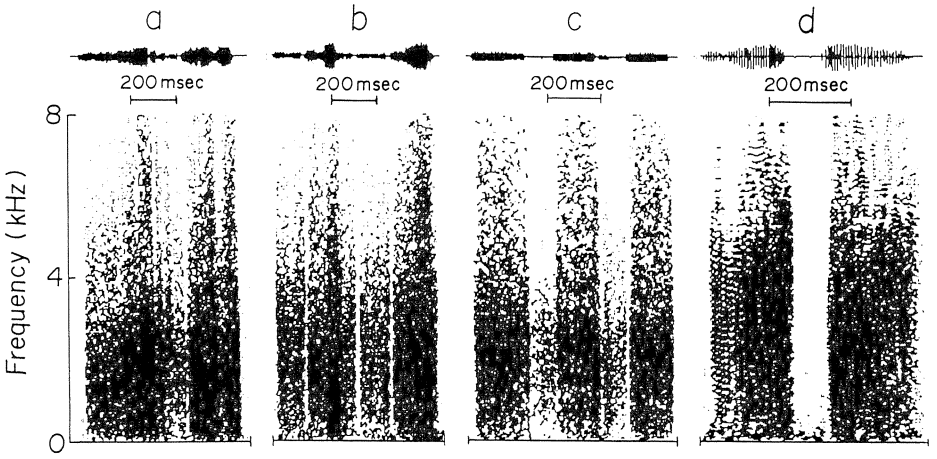

FIG. 2. Sonagrams and oscillograms of distress calls emitted by *C. brachyotis* (a), *C. horsfieldi* (b), *M. ecaudatus* (c) and *M. sobrinus* (d).

frequency sounds have been shown to occur in echolocating birds, such as cave swiftlets *Aerodramus fuciphagus, A. hirundinaceus, A. maximus, A. vanikorensis*, and oil birds *Steatornis caripensis* [2, 5, 7]. Audible echolocation pulses are also known to be emitted by shrews *Sorex palustris, S. vagrans, S. cinereus, Blarina brevicauda* [3] and Allegheny wood rats *Neotoma floridana* [1].

As mentioned above, the sounds emitted by bats studied are very similar to those of echolocating *Aerodramus*, both in frequency pattern and in interpulse interval. The results, therefore, may support the hypothesis that the bats studied have the ability to echolocate, and such an echolocation is probably widespread among small megachiropteran bats. In the future, we will provide further evidence for echolocation in these bats.

ACKNOWLEDGMENTS

We wish to thank Drs Y. Tubaki and H. Nagata of National Institute for Environmental Studies for encouragement and valuable advice, Dr H. I. Azarae of the University of Malaya for permission to use facilities, and Messrs S. Ripin and S. Dali for assistance in the field. We are also indebted to Mr T. Kirwan and other staff of the Field Study Center, University of Malaya for various help, and to Mrs. B. Andre for comments on the manuscript. This work was supported in part by grants from National Institute for Environmental Studies of Japan.

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