Variations in Vocalizations Produced by the Giant South American Toad, Bufo blombergi

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ABSTRACT: The vocalizations of two male *Bufo blombergi* Myers and Funkhouser, which were recorded in the laboratory, show greater diversity than the mating calls of any of the species of *Bufo* which have been previously recorded. The calls of *B. blombergi* were of three distinct types: untrilled; slow-trilled; and fast-trilled. The two trilled types show no overlap in trill rates, with the mean of the fast-trill type being more than three times faster than the mean of the slow-trilled type. Slow-trilled calls show considerable variation in dominant frequency, duration and the proportion trilled, whereas untrilled and fast-trilled types exhibit less variation. Various combination and intermediate calls were also produced by the two animals. The behavioral significance of the different call types is not understood.

INTRODUCTION

Compared to the highly developed vocal communication systems that are characteristic of many of the higher vertebrates, the mating calls produced by toads of the genus *Bufo* seem remarkably simple. Although there is considerable interspecific variation in the known *Bufo* mating calls (Blair, 1956a, 1956b, 1957a, 1957b; Blair and Pettus, 1954; Bogert, 1960, 1962; Bogert and Senanayake, 1966; Karlstrom, 1962; Porter, 1964, 1965, 1966; Schiøtz, 1964; Schneider, 1966; Zweifel, 1965), there is a notable lack of intraspecific diversity. The vocalizations of the giant toad *Bufo blombergi* which are analyzed in this paper show a unique degree of variation when compared to the known *Bufo* mating calls. Virtually nothing has been reported on the behavior and ecology of *B. blombergi* since it was described (Myers and Funkhouser, 1951) from a remote tropical area in the Province of Nariño, Colombia.

METHODS AND MATERIALS

The calls of two large mature males, purchased from an animal dealer, were recorded in the laboratory at 7½ ips using a Stancil-Hoffman Minitape, Model M9 portable tape recorder with an Altec, 633A microphone. A total of 137 calls (56 calls of individual no. 1; 81 calls of individual no. 2) were analyzed by means of a Sona-Graph Sound Spectrograph, manufactured by the Kay Electric Company (see Blair and Pettus, 1954). Narrow-band analysis was utilized when determining call durations, dominant frequencies, slow-trill rates and time intervals between calls; wide-band analysis was used in the determination of fast-trill rates. In determining trill rates, only those calls that contained five or more notes were analyzed.

The animals were housed in different pens 36″ long × 22½″ wide × 15½″ high. Male no. 1 was kept in a pen with another mature male of the same species; a large mature female *B. blombergi* occupied

the same pen in which male no. 2 was housed. The two toads appeared healthy and seemed well adjusted to captivity at the time of recording. They both called while out of water in a temperature-controlled room at 26 C. Male no. 1 was recorded on 13 October 1965, and male no. 2 on 28 May 1965. The animals were not handled or artificially stimulated to vocalize during the recording periods (none of the calls recorded were release calls).

RESULTS

Three distinct types of calls were produced: untrilled calls; slow-trilled calls; and fast-trilled calls. A summary of the call characteristics of each type is presented in Table 1. Table 2 indicates the number of analyzed calls of the different types emitted by each toad.

Untrilled Calls.—A sonagram of a representative untrilled call is shown in Fig. 1-A. This was the second most frequent call of in-

TABLE 1.—Summary of some of the call characteristics for two male *Bufo blombergi*. Categories with asterisks include data from some combination and unclassified calls

Individual	Call type	Mean	Number	Range	Standard deviation
Dominant frequency (CPS)					
#2	Untrilled				
	initial	630	27	563-688	34.4
	terminal	799	27	688-875	67.8
#1	Slow-trilled				
	initial	639	53	500-813	70.0
#2	Slow-trilled				
	initial	767	33	625-1063	74.3
	terminal	746	32	313-875	108.7
#2	Fast-trilled				
	initial	674	9	625-813	60.9
	terminal	792	9	688-875	62.4
Trill rate (notes/sec)					
#1	Slow-trilled	17.5	32	16.4-18.8	0.588
#2	Slow-trilled	19.0	20	15.9-20.8	1.488
#2	Fast-trilled*	63.8	19	56.6-70.0	3.850
Call duration (sec)					
#2	Untrilled	0.47	27	0.30-0.65	0.074
#1	Slow-trilled	0.79	53	0.40-1.50	0.282
#2	Slow-trilled	0.67	33	0.30-1.30	0.213
#2	Fast-trilled	0.47	9	0.35-0.55	0.066
Call intervals (sec)					
#2	Untrilled	0.41	20	0.25-0.50	0.064
#1	Slow-trilled	0.52	33	0.35-0.95	0.108
#2	Slow-trilled	0.30	24	0.20-0.45	0.063
#2	Fast-trilled	0.45	3	0.40-0.50	.....
Notes before call					
#2	Untrilled and fast-trilled*	1.39	46	1-3	0.538

dividual no. 2. Individual no. 1 produced only one untrilled call (Fig. 1-B). The dominant frequencies of the initial portion of the calls of male no. 2 are lower than the terminal portion ($P<.001$). One, two, or rarely three notes precede the untrilled segments. The initial portions of the untrilled calls of male no. 2 are relatively uniform in structure, duration, and dominant frequency. The single untrilled call of male no. 1 differs slightly from the untrilled calls of male no. 2 in that no terminal portion of a higher frequency is present. The single preceding note is also greatly reduced.

Slow-trilled Calls.—Slow-trilled calls (Fig. 1-C, D, E, F) were the most frequent call of both individuals. The "least developed" slow-trilled calls begin with a single trill note and then continue without further trilling (Fig. 1-C). In most cases, calls are only partially trilled and end with a portion that is not trilled (Fig. 1-D, E). However, some of the longer calls are completely trilled (Fig. 1-F). Both individuals produced an entire spectrum of calls from the "least developed" to the completely trilled. No regular sequence of changes in degree of trilling is apparent. In general, the longer the call, the greater the proportion of it that is trilled. There is little difference in dominant frequency of the initial and terminal portions of these calls. Slow-trilled calls show considerable variation in dominant frequency and duration (Table 1). Many additional calls produced by each toad were recorded but not analyzed on the sonagraph. These calls all sound like the slow-trilled type.

Fast-trilled Calls.—Fast-trilled calls (Fig. 2-A) were the third most frequently produced type of call of individual no. 2. Individual no. 1 did not produce any fast-trilled calls. Note durations and intervals between notes are shorter in fast-trilled calls than in slow-trilled calls. One or two isolated notes were often produced before the trill was started. The initial portions of fast-trilled calls have lower dominant

TABLE 2.—Enumeration of the different types of calls produced by two male *Bufo blombergi*

Individual	Number of calls	Type of call
#1	1	Untrilled
#1	53	Slow-trilled
#1	2	Intermediate untrilled/slow-trilled
	Total—56	
#2	27	Untrilled
#2	33	Slow-trilled
#2	9	Fast-trilled
#2	6	Fast-trilled that change into untrilled
#2	3	Slow-trilled that change into fast-trilled
#2	1	Slow-trilled that changes into untrilled
#2	2	Unclassified
	Total—81	

frequencies than the terminal non-trilled portions ($P<.001$). As was the case for the untrilled calls, there is a relative uniformity in structure, duration, and dominant frequency among the fast-trilled calls.

Atypical Calls.—A few calls, all emitted by individual no. 2, show a combination of call types while not being intermediate. Six calls (Fig. 2-B) begin as fast-trilled and then change abruptly to an untrilled portion without an intervening time gap or intermediacy of structure. Three calls (Fig. 2-C) show a similar abrupt change from

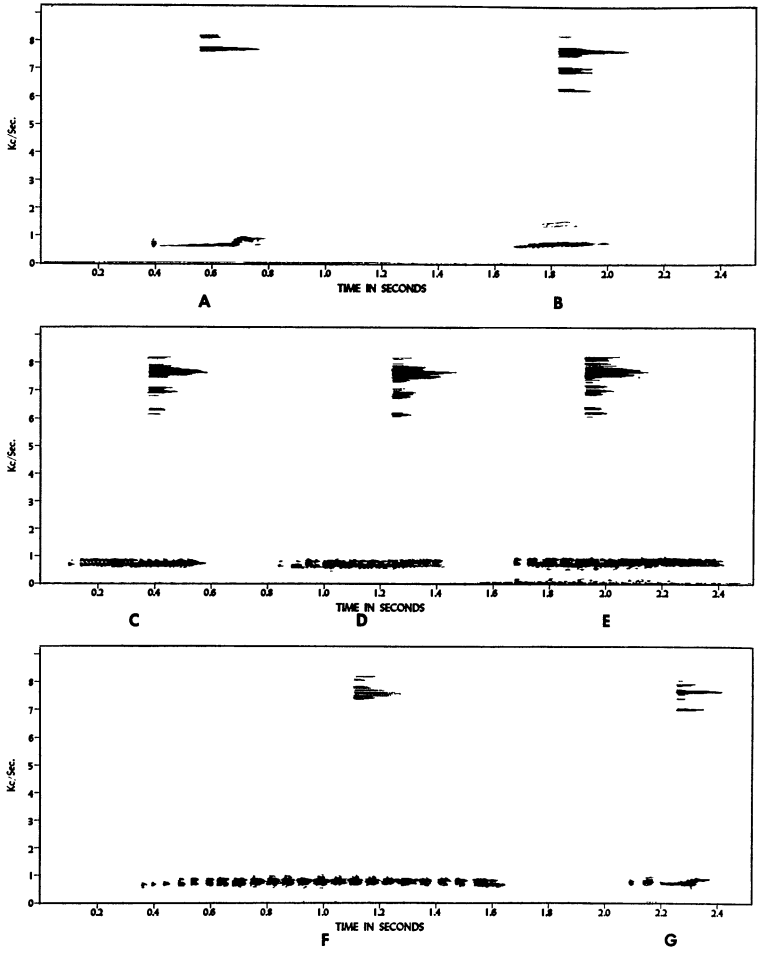

Fig. 1.—Narrow-band sonagrams of calls of two male *Bufo blombergi*. Frequency in Kc/Sec is expressed along the vertical axis; time in seconds is denoted along the horizontal axis. Inverted sections are shown above the calls. For further explanation see text.

a slow-trilled portion to a fast-trilled portion. The slow-trill notes of the latter calls are made up of two of the shorter, fast-trill notes. Trill notes of a number of the other slow-trilled calls are also composed of the shorter, fast-trill notes. One call changes from slow-trilled to untrilled type (Fig. 1-G). Two calls that were not classified were also produced by individual no. 2 (Fig. 2-G). Two calls that may be intermediate between untrilled and slow-trilled types (Fig. 2-E, F) were produced by individual no. 1.

Each of the two trilled call types is quite distinct from the other in pulse rate. The mean fast-trill rate is more than three times faster than the means of the slow-trilled rates and there is no overlap in range of variation. The durations of the untrilled calls are shorter than the slow-trilled calls ($P<.001$—for individual no. 2). Fast-trilled calls are similar in duration to the untrilled calls.

When male no. 2 first began to call, it produced untrilled calls. Fast-trilled calls, combination calls and unclassified calls were then

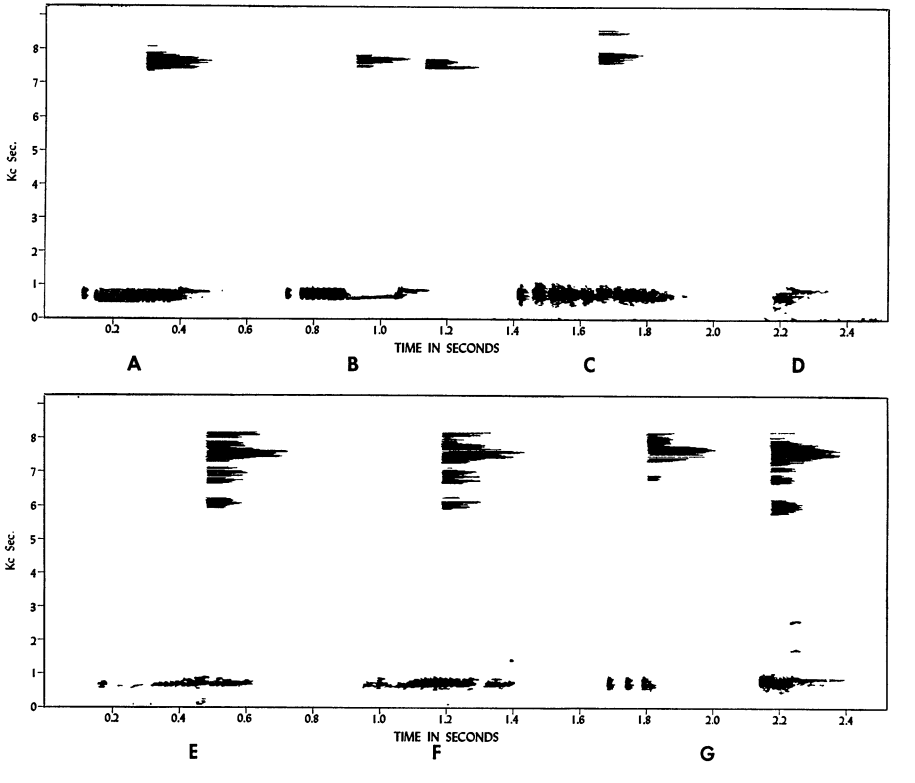

Fig. 2.—Narrow-band sonagrams of calls of two male *Bufo blombergi*. For further explanation see Fig. 1 and the text.

interspersed with the untrilled calls. Finally, a long sequence of slow-trilled calls was produced without interruption. Irregular notes (Fig. 2-D) were often produced between slow-trilled calls, especially in the latter part of this calling sequence. The calls of individual no. 1 were recorded after he had been vocalizing for some period of time.

All of the different types of calls were of a low volume, unlike the loud trills of most North American species of *Bufo*. The vocal sacs of the *B. blombergi* appeared fully inflated during the periods of calling but were proportionally smaller than those of many species of North American *Bufo*.

DISCUSSION

The vocalizations of *B. blombergi* reported in this paper show a much wider degree of diversification than any of the calls of the other species of *Bufo* that have been previously analyzed. Unfortunately, the lack of ecological and behavioral information on *B. blombergi* precludes reaching any conclusions as to what adaptive function the different call types have. As the *B. blombergi* calls were recorded in the laboratory, consideration of the possible effects of captivity on the behavior of the toads is important in attempting to interpret the biological significance of the different call types. Many species of toads have been observed while calling in the University of Texas laboratories (where the *B. blombergi* were recorded) and no abnormal calls have ever been noticed. The short call intervals (Table 1) and the large number of calls produced indicate that the two *B. blombergi* were not inhibited from vocalizing. As previously noted, these animals appeared healthy and well adjusted to captivity at the time of recording. There thus appears to be little reason to invoke the laboratory conditions as a cause of the call variations.

The calling sequence from untrilled type to slow-trilled type and the presence of possible intermediate and combination types may indicate that the untrilled type represents an abnormality due to difficulty in initiating calling. An alternate interpretation is that the untrilled type might be a preliminary warm-up call. Bogert (1960) and Brown and Pierce (1965) have observed probable warm-up calling in *Bufo punctatus* as has Jameson (1954) in *Eleutherodactylus latrans*.

Because of the magnitude of the difference between the trill rates of the fast-trilled and slow-trilled types, and because there were no intermediate types (although there were combination calls) between fast-trilled calls and the other two types, it might seem that different purposes are being served (*i.e.*, mating call, territorial call, etc.). During the period in which male no. 2 was kept in captivity, he showed mating behavior, often going into amplexus with a large mature female of the same species which was kept in the cage with him. This female later laid eggs. As male no. 2 was the only male housed with a female and was the only male to give the fast-trilled type, it could be interpreted that this is a mating call. Male no. 1 did not call in an erect position as do most North American *Bufo* when

giving their mating calls. He instead called from under a low wooden shelter placed in his pen. Male no. 2 called in a semi-erect position. As male no. 1 was housed with another male of the same species and he did not emit any fast-trilled calls, it could be assumed that the slow-trilled type is a territorial call. However, the slow-trilled type was by far the predominant call of both males (considering the analyzed calls and the unanalyzed calls which were listened to) and thus, neither of the types can be designated with certainty as either a mating or territorial call. Bogert (1960) has pointed out in his summary of the territorial calls of anurans, that there is no evidence for their occurrence in the genus *Bufo*.

Seasonal variation may account for individual no. 1's failure to give any fast-trilled calls and giving only one untrilled call. Individual no. 1 was recorded in October whereas no. 2 was recorded in May. The data as to exact localities where these toads were collected are unavailable, and geographical variation may thus account for the calling differences between these two toads.

Martin (1967) has grouped bufonid vocalizations into three categories based upon the nature of their amplitude modulation. Structural differences in the laryngeal apparatus and other mechanisms involved in sound production determine the type of amplitude modulation. His "call type I" is characterized by a passive amplitude modulation and is confined to primarily African species. "Call type II" (active and passive modulation) and "call type III" (active modulation) are produced chiefly by New World and Eurasian species. Through oscilloscopic analysis of my *B. blombergi* recordings, Martin has concluded that the slow-pulsed calls correspond to his "call type II" and the fast-pulsed calls correspond to his "call type I." He has further pointed out possible phylogenetic implications: ". . . the presence of both mechanisms in *B. blombergi* suggests a transition point between call type I and II."

Blair (1956a) has suggested that the large sizes of *Bufo alvarius* and *Bufo marinus* are sufficient alone to prevent amplexus with other smaller species of *Bufo*. It would likewise be expected that this would be true for *B. blombergi*. Probably the only other toad sympatric with *B. blombergi* that approaches it in size is *B. marinus*. However, *B. marinus* is apparently quite small where the two species are sympatric on the western side of the Andes. *Bufo blombergi* has been reported only from the western side of the Andes. Copping (1957) has noted that *B. marinus* is much smaller than *B. blomergi* in northern Ecuador, presently the only known area of sympatry. A small race of *B. marinus* extends on the western side of the Andes from Olmos, Peru, to Ecuador (Vellard, 1959). The maximum recorded snout-vent length is 120 mm, but most individuals reach only 80-90 mm (Vellard, 1959). *Bufo blombergi* attains a snout-vent length of over 200 mm (Myers and Funkhouser, 1951). The *B. marinus* that Stebbins and Hendrickson (1959) report from Colombia were small (four males averaged 87.9 mm; nine females averaged 104.2 mm). The very large

size of *B. blombergi* is thus probably a factor of considerable importance in the isolating mechanism complex of this species. One would therefore suspect that the mating calls of male *B. blombergi* probably function more as a sex attractant, than in an isolating capacity.

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