

Distress Calls in Neotropical Frogs

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Abstract. Large neotropical hyloid and leptodactylid frogs frequently emit loud distress calls under hand held conditions. In spite of remarkable similarities in the production and structure (i.e. spectral energy distribution, short rise and fall times) of these calls, distinct differences between the screams of the ten species studied were found. The percentage of adult individuals producing distress calls is high in *Leptodactylus pentadactylus* (60%), *Hyla lanciformis* (55%) and *Hyla boans* (42%). Screaming is far more common in large neotropical species than in their similar sized counterparts in Europe and North America. It appears improbable that distress calls in frogs have evolved as intraspecific warning signals. Startling an attacking predator and attraction of secondary predators capable of interfering with a threatening raptor are discussed as possible functions of distress calls.

Introduction

Frogs when grasped by a predator may emit screams for which the term "distress call" is used (Bogert, 1960). Such calls have been observed in both males and females as well as in juveniles and newly metamorphosed froglets (Sazima, 1975). Distress calls have been most frequently reported in frogs of the genus *Rana* (Bogert, 1960; Capranica, 1968; Weber, 1975; Tunner and Hödl, 1978) but the occurrence of these vocalizations is known in various genera and families (see Lescure, 1977; Knorr, 1977; Elzen, 1978; Weber, 1978). Bufonids produce distress calls with their mouths closed (Weber, 1978; pers. obs.). In all other reported cases except the "catlike screams" of *Rana catesbeiana* (Hoff and Moss, 1974) the vocalizations are given with the mouth opened widely (Fig. 1), while air is rapidly expelled from the lungs by contractions of the trunk muscles. In spite of the widespread, yet occasional occurrence of distress calls among anurans little is known about their intra- and interspecific variations.

This paper reports on the distress calls of ten Central Amazonian frog species. Data on the frequency of their occurrence as well as analyses of the variation of several call parameters are presented. The results are discussed in relation to the yet unsolved question of the adaptive significance of distress calls in anuran amphibians.



Fig. 1. Male *Hyla boans* during emission of distress call. Frontal (left) and lateral (right) view.

Material and Methods

All frogs examined in this study were caught in Central Amazonia, Brazil, in 1975, 1978 or 1981 and most of them were kept in a 6 m² field terrarium at the Instituto Nacional de Pesquisas de Amazônia (INPA), Manaus, for several days. Five species of leptodactylids (*Adenomera hylaedactyla*, *Hydrolaetare schmidti*, *Leptodactylus fuscus*, *Leptodactylus ocellatus*, *Leptodactylus pentadactylus*), three species of hylids (*Hyla boans*, *Hyla lanciformis*, *Hyla raniceps*) and two bufonids (*Bufo granulatus*, *Bufo typhoni*) were included in this investigation (for data on individual frogs see tables 1 and 2).

Prior to recording the frogs were grasped by the hind limbs leaving the rest of the body untouched. In this situation the frogs usually began a rapid uptake of air through the nostrils and adopted a stiff puffed-up posture with the forearms extending sideways. In such a position some frogs vocalized while others remained mute. In vocalizing individuals distress calls could be induced repeatedly by tapping slightly on the dorsal parts of the head. Three frogs produced only a single scream immediately following capture in the field, and like all initially mute individuals they could never be provoked to give distress calls in captivity.

Recordings were made in the field or in a laboratory at INPA at temperatures between 24.5°C and 27.5°C using a Uher Report 4000 or a Nagra IV SJ taperecorder in connection with an AKG 140 D microphone. Sound pressure levels (db (C-weighted), RMS fast or peak hold) were measured at a distance of 25 cm with a sound level meter (CS 183 A, Castle Associates) regularly calibrated with a sound level calibrator (CA 13, Castle Associates). The tapes were analyzed by means of a Kay Electronic 7030 A sonograph and an oscilloscope (Tektronix 502 A) in connection with a camera (Toenies Recordine). The fundamental frequency (f_0) was determined by fourier analysis using a digital signal processor (SD 360, Spectral Dynamics). Data are given to the nearest 0.05 kHz.

Results

In the leptodactylid species — except *Leptodactylus ocellatus* — head tapping was usually followed by a series of up to three (*Hydrolaetare schmidti*, *Leptodactylus fuscus*) or five (*Adenomera hylaedactyla*, *Leptodactylus pentadactylus*) distress calls. Under hand held conditions a tactile stimulus on the head was regularly answered with a single call by *Hyla boans* and *Hyla raniceps*. With this method over 100 distress calls could be provoked in a fullgrown male of *H. boans* within five minutes. Reactions were unpredictable in *Hyla lanciformis*, *Bufo granulosus* and *Bufo typhonius*.

With the exception of *H. boans*, *H. raniceps* and *B. typhonius* the distress calls of all species studied show clear harmonic structures with sound energy distribution over a wide range of frequencies. Although call length and frequency modulation vary considerably, even in successive screams of the same individual, distinct differences between vocalizations of different species can be found (Tables 1 and 2, figs. 2-5).

Table 1. Comparison of distress call parameters in leptodactylid frogs (Snout-vent length in mm; collection sites: Itapurus (A), island of Careiro (B), city of Manaus (C), Reserva Ducke (D)). Mean \pm standard deviation (sample size) and range given for call duration and intercall interval. (*) Frogs of which individual distress calls are presented in Figs. 2 and 4.

	Call Duration ms	Intercall Interval ms	db(C) RMS fast	dB(C) Peak hold	f ₀ kHz	Dominant Frequency Range (kHz)
<i>A. hylaedactyla</i> male, 23 mm (C)	23 \pm 0.8 (5) 22 - 24	29 \pm 13.4 (4) 15 - 52	68	—	1.5	1.5 - 3.0
<i>H. schmidti</i> * female, 68 mm (A)	312 \pm 78.6 (43) 202 - 480	375 \pm 89.8 (17) 203 - 480	91	100	0.45	0.9 - 4.5
<i>L. fuscus</i> male, 43 mm (C)	265 \pm 64.2 (17) 172 - 405	423 \pm 248.0 (7) 165 - 875	81	—	2.5	2.5 - 5.0
<i>L. ocellatus</i> * male, 73 mm (B)	808 \pm 110.7 (8) 615-960		96	104	0.45	0.9 - 3.2
<i>L. pentadactylus</i> male, 133 mm (D)	224 \pm 30.7 (29) 128 - 293	134 \pm 27.0 (17) 83 - 203	—	—	1.4	1.4 - 5.6
<i>L. pentadactylus</i> male, 98 mm (C)	213 \pm 57.1 (33) 135 - 390	208 \pm 47.5 (19) 135 - 308	94	102	0.5	0.5 - 2.5
<i>L. pentadactylus</i> male, 81 mm (D)	231 \pm 39.4 (42) 165 - 315	205 \pm 41.0 (26) 143 - 285	96	104	1.1	1.1 - 3.3
<i>L. pentadactylus</i> male, 87 mm (D)	230 \pm 32.2 (20) 165 - 285	270 \pm 44.3 (12) 202 - 345	—	—	0.9	0.9 - 4.5
<i>L. pentadactylus</i> * female, 119 mm (D)	312 \pm 53.0 (41) 165 - 435	257 \pm 96.5 (17) 135 - 502	—	—	0.9	0.9 - 4.5
<i>L. pentadactylus</i> female, 126 mm (C)	285 \pm 44.8 (21) 210 - 375	287 \pm 92.1 (14) 172 - 495	97	104	0.55	0.5 - 2.2

Table 2. Comparison of distress call parameters in tree frogs (Hylidae) and toads (Bufonidae) (Snout-vent length in mm; collection sites: City of Manaus (C), Reserva Ducke (D), Lago Janauari (E)). Mean \pm standard deviation (sample size) and range given for call duration. (*) Frogs of which individual distress calls are presented in Figs. 3 and 5.

	Call Duration ms	dB(C) RMS fast	dB(C) Peak hold	f ₀ kHz	Dominant Frequency Range (kHz)
<i>H. boans</i> * male, 100 mm (C)	615 \pm 137.3 (23) 427 - 1050	98	107	0.15	0.3 - 3.0
<i>H. boans</i> male, 88 mm (C)	756 \pm 213.5 (24) 465 - 1350	98	106	0.15	0.4 - 2.5
<i>H. boans</i> male, 126 mm (D)	637 \pm 40.1 (3) 585 - 682	97	103	—	0.5 - 4.0
<i>H. lanciformis</i> juv., 52 mm (E)	380 \pm 19.2 (6) 345 - 405	—	—	0.8	0.8 - 5.6
<i>H. lanciformis</i> * juv., 46 mm (E)	510 \pm 78.6 (8) 420 - 695	94	—	0.55	2.2 - 8.0
<i>H. lanciformis</i> male, 73 mm (E)	1091 \pm 385.9 (11) 442 - 1680	97	106	0.35	1.0 - 8.0
<i>H. lanciformis</i> * male, 68 mm (E)	569 \pm 177.0 (12) 360 - 1120	98	108	0.55	1.0 - 8.0
<i>H. raniceps</i> male, 47 mm (E)	191 \pm 23.5 (9) 165 - 225	84	—	—	0.3 - 8.0
<i>B. granulosis</i> male, 48 mm (D)	56 \pm 37.7 (14) 15 - 165	72	—	2.0	2.0
<i>B. typhonius</i> male, 52 mm (D)	129 \pm 19.4 (4) 105 - 157	74	—	—	0.2 - 8.0

The percentage of adult individuals emitting distress calls is given in table 3. Distress calls in *L. pentadactylus* and *H. boans* are commonly known among herpetologists dealing with living neotropical frogs. To the best of our knowledge Goin and Layne (1958) were the first to report the "startlingly loud screams of distress" of these species. Together with *H. lanciformis* and *Leptodactylus rhodomystax* they are the only ones out of 48 common anuran species occurring in the Central Amazon basin that produce distress calls frequently (i.e., over 20% screamers out of at least 16 adult frogs). Bufonids are not included in table 3 since somewhat rough handling will bring any puffed-up individual to the point where it expels air into the closed mouth cavity, thus giving rise to squeaklike noises.

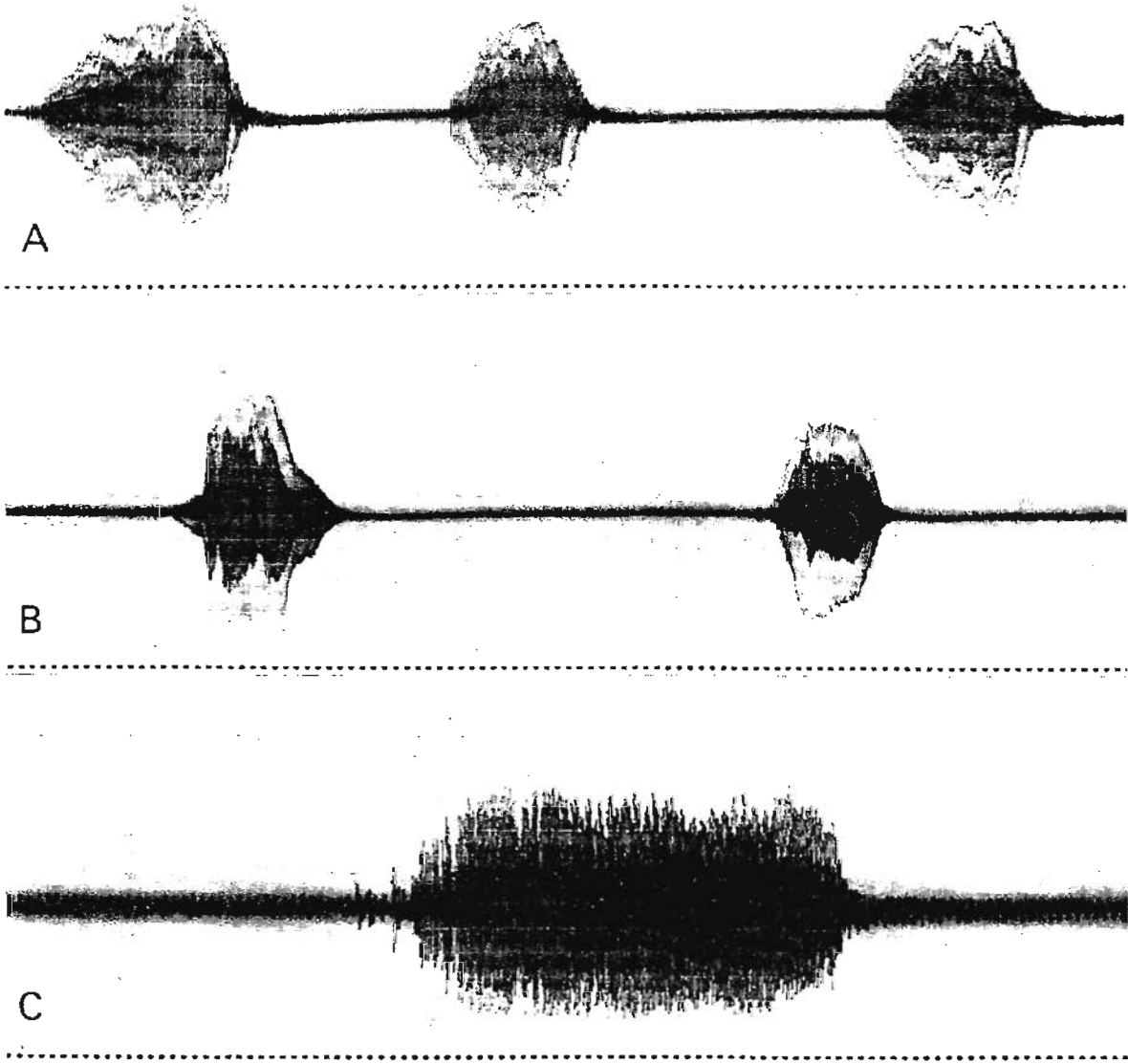


Fig. 2. Oscillograms of distress calls of *Hydrolaetare schmidti* (A), *Leptodactylus pentadactylus* (B) and *Leptodactylus ocellatus* (C). Time markings: 50 Hz.

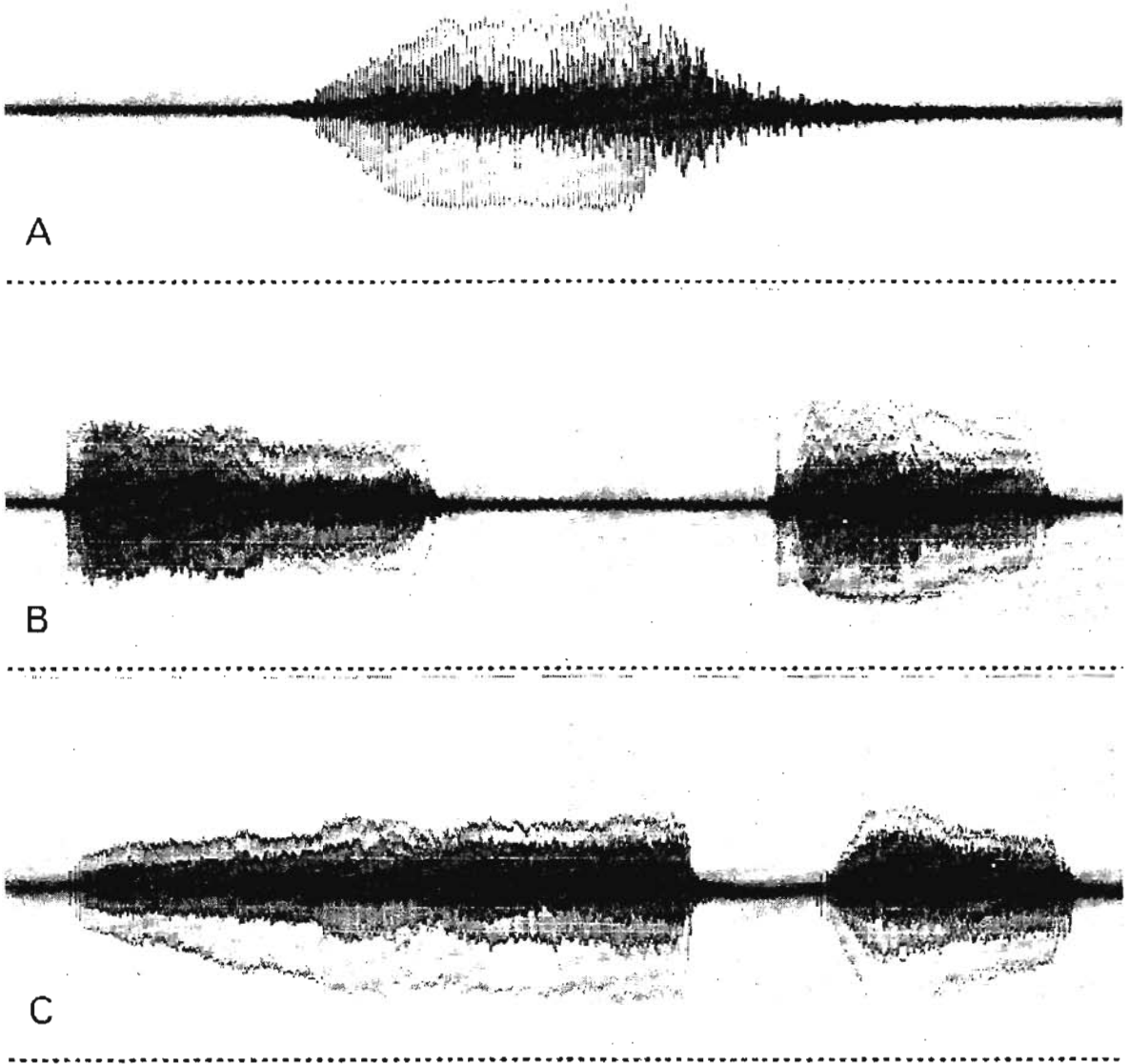


Fig. 3. Oscillograms of distress calls of *Hyla boans* (A) and *Hyla lanciformis* (juvenile (B) and adult (C)). Time markings: 50 Hz.

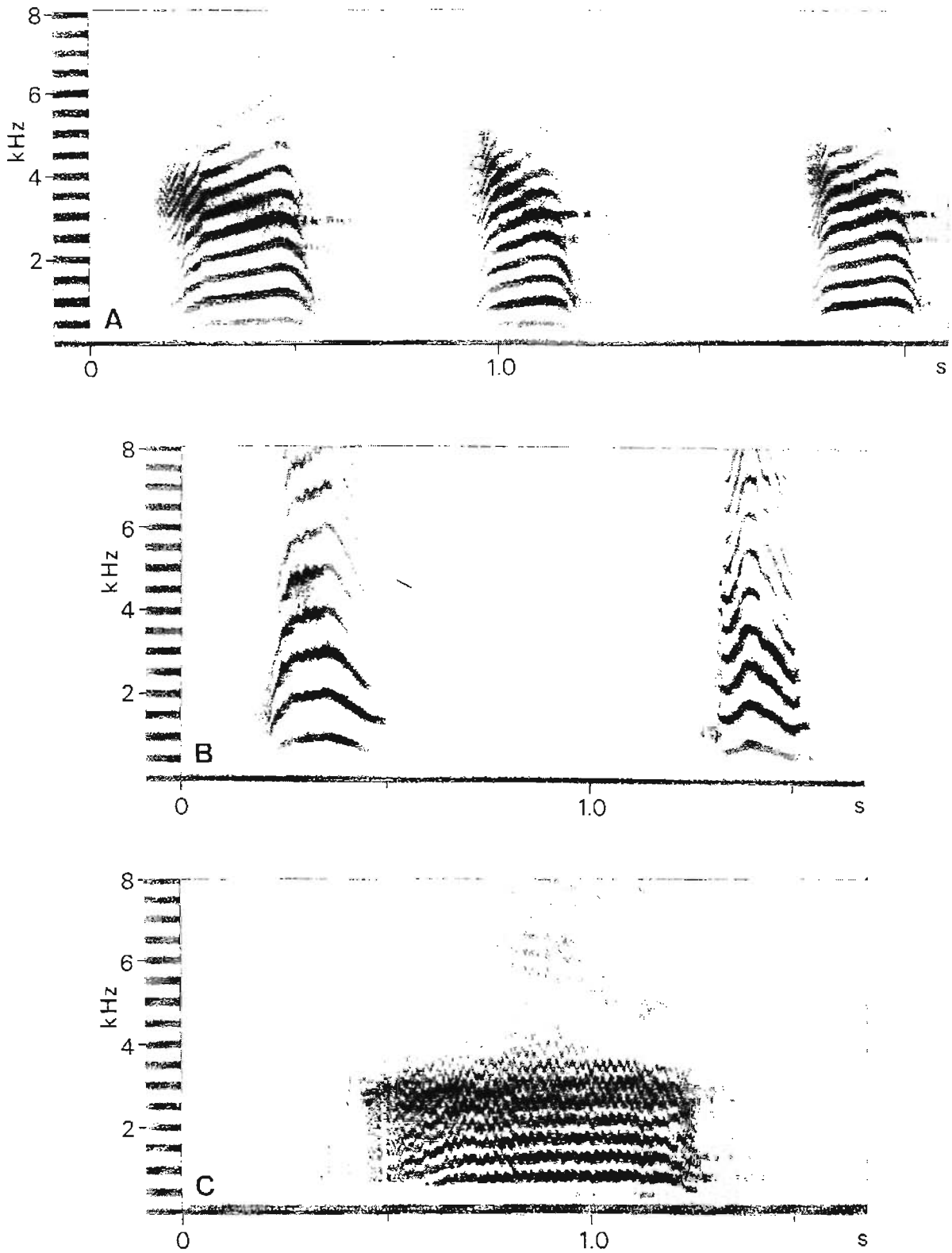


Fig. 4. Sonograms of the distress calls of *Hydrolaetare schmidti* (A), *Leptodactylus pentadactylus* (B) and *Leptodactylus ocellatus* (C) presented in fig. 2.

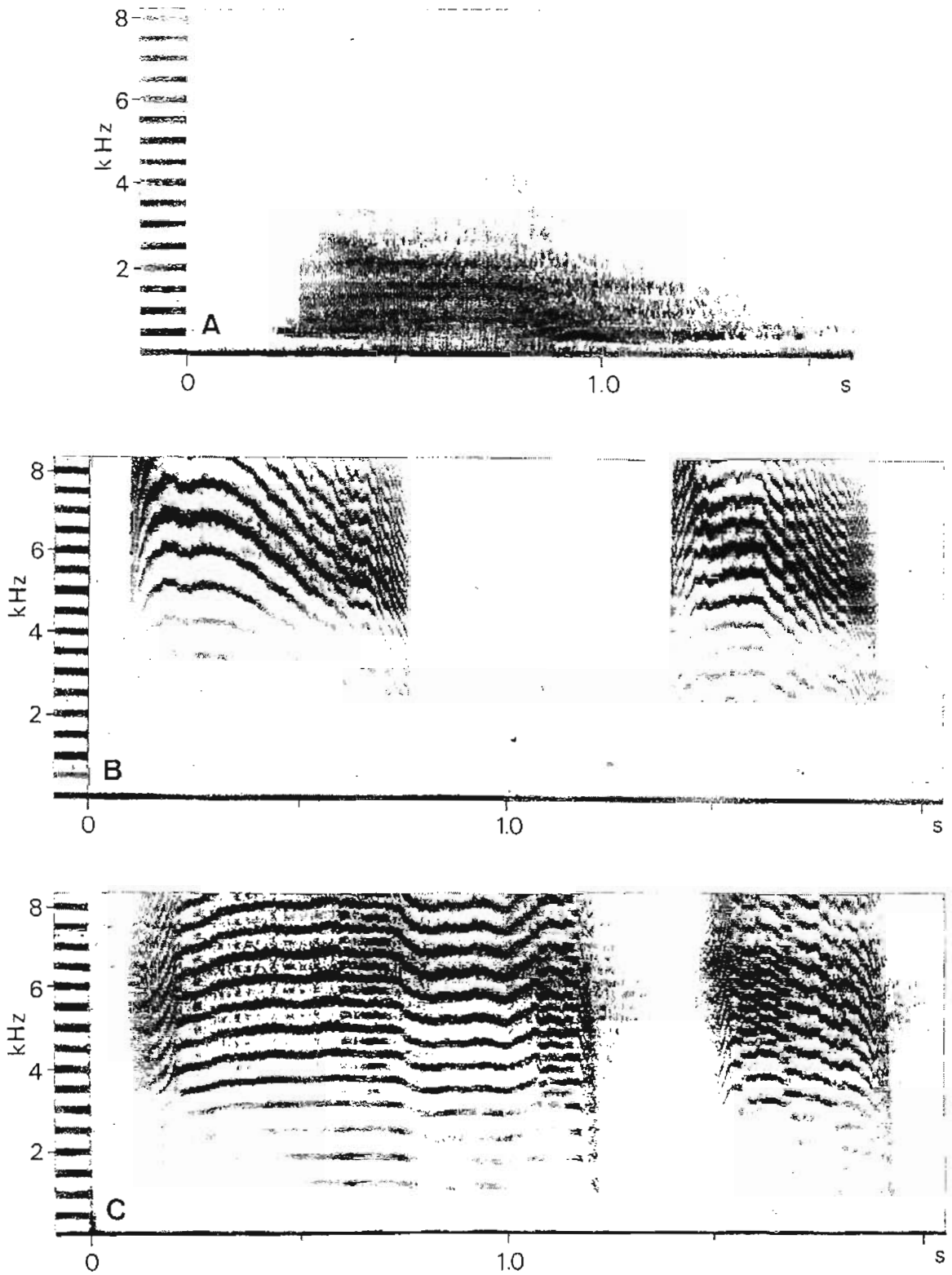


Fig. 5. Sonograms of the distress calls of *Hyla boans* (A) and *Hyla lanciformis* (juvenile (B) and adult (C)) presented in fig. 3.

Table 3. Percentage of Central Amazonian frogs producing distress calls under hand held conditions immediately following capture in the field.

	Sample Size (♂/♀)	Calling Individuals (♂/♀)	Percentage of screamers among adults
<i>Adenomera hylaedactyla</i>	21 (21/0)	1 (1/0)	—
<i>Hydrolaetare schmidti</i>	1 (0/1)	1 (0/1)	—
<i>Leptodactylus fuscus</i>	27 (21/6)	2 (2/0)	7%
<i>Leptodactylus ocellatus</i>	28 (25/3)	3 (3/0)	11%
<i>Leptodactylus pentadactylus</i>	35 (29/6)	21 (17/4)	60%
<i>Leptodactylus rhodomystax</i>	18 (13/5)	4 (2/2)	22%
<i>Hyla boans</i>	24 (24/0)	10 (10/0)	42%
<i>Hyla lanciformis</i>	33 (30/3)	18 (18/0)	55%
<i>Hyla raniceps</i>	38 (34/4)	1 (1/0)	—

Discussion

Distinct differences between calls of different frog species could suggest some significance in intraspecific communication. Distress calls in crocodylians and birds are thought to have evolved in the context of parental protection (Staton, 1978; Högstedt, 1983). We are not aware of parental care for postmetamorphic stages in frogs, except for certain species with direct development, which continue attending their offspring in the nest for the first days after hatching (Townsend et al., 1984). Distress calls in immature individuals seem to be less frequent than in adults. At present there is no evidence that screaming in frogs has any function in intraspecific communication. However, the effect of alerting nearby conspecifics (and members of other frog or even other vertebrate species) cannot be excluded considering experimental playbacks of high frequency sound to various frog species. These frequencies typical for distress calls induce decrease of respiration rate, inhibition of an approach response to moving objects and occasional escape responses (discussion in Capranica, 1968) as well as an increase of the electrodermal response (Brzoska, 1984).

Strong intraspecific variation — compared to mating calls — and the unpredictability of screams within frogs may lead to the assumption that their function is to startle the predator into loosening its grip. All humans known to us released *L. pentadactylus* at first experiencing its distress call. However, multiple repetitions of screams and the otherwise somewhat lax reaction of frogs under the grip of predators are suggestive of the idea that distress calls are “cries for help directed at any animal capable of interfering with the threatening predator” as proposed for birds by Högstedt (1983). Piracy based on acoustic cues is not uncommon among birds and mammals (Högstedt, 1983).

Observations on screaming frogs are scarce and inconclusive: On all eight occasions on which Sazima (1975) has heard anuran distress calls in the field they were emitted by frogs which were taken by snakes. Just a single encounter of a mammalian predator

with a frog could be observed by one of us (WH). A male *L. pentadactylus* was caught by a small cat (juvenile *Felis pardalis*?) in the Reserva Ducke near Manaus. The frog emitted several piercing screams of distress. As in Bogert's (1960) observation, where an obviously unstartled raccoon was carrying a screaming *Rana pipiens* in its jaws, the predator seemed unaffected by its vocalizing prey. Merely the pointed beam of the flashlight induced the small cat to release its grip leaving a severely wounded frog at the capture site.

The screams that frogs, reptiles, birds and mammals utter under situations of utmost danger show remarkable similarities (see Frankenberg, 1975, for geckos; Hödl, 1978, for caymans; Högstädt, 1983, for birds; and Gautier and Gautier, 1977, for monkeys). This may be explained by convergent selection on easy locatability and maximized sound dissemination, resulting in high intensity, fast rise and fall times, composition of several more or less distinct energy bands over a wide range of frequencies, and repetition of the signal (see Knudsen, 1980). By means of these acoustic cues secondary predators may be led to an easily obtained prey, may it be the original screaming victim, the primary predator, or both. Pirate attraction can be understood as the ultimate chance to escape a deadly situation once the "intended" surprise by a sudden scream has failed to loosen the predator's grip. Distress calls provide attracting stimuli for various mammals, birds (Högstädt, 1983), crocodylians (Campbell, 1973) and frogs (Smith, 1977). The high percentage of screamers in large species such as *L. pentadactylus* and *H. boans*, representing the largest species of their genera, may be explained by the high intensity of their calls compared to the weak screams of their small relatives. High sound pressure levels may maximize the surprise effect on a predator and will extend the effective distance over which secondary predators may be attracted.

Greater complexity of trophic interactions in tropical than in temperate faunas (see Rand, 1967) may have favoured the more frequent occurrence of distress calls in neotropical frogs. Screaming in large leptodactylids is by far more common than in their similar sized European or North American counterparts. Despite the numerous reports on distress calls in ranid frogs, the occurrence of screaming individuals is extremely rare. Out of more than 1000 adult European marsh frogs (*Rana ridibunda*) measured (Tunner, pers. comm.) only one individual has emitted a series of distress calls (Tunner and Hödl, 1978). Capranica (1968) elicited distress calls in *Rana catesbeiana* with electric shocks applied to the nasal region, yet failed to record screams in the field or terrarium. "Handling many frogs over the years" and experimenting with 25 bullfrogs of both sexes Hoff and Moss (1974) found a single individual producing distress calls.

The function of distress and alarm calls has been of puzzling interest to several knowledgeable "American naturalists" (Maynard Smith, 1965; Charnov and Krebs, 1975; Staton, 1978; Högstädt, 1983; for a recent review see also Klump and Shalter, 1984). The high frequency of distress calls in large neotropical frog species should make feasible experimental studies to explain the functional significance and evolution of frog screaming behaviour.

Acknowledgements. Call structures were analyzed at the Kommission für Schallforschung der Österreichischen Akademie der Wissenschaften, Wien. The kind help of Dr. W. Deutsch is highly appreciated. Studies in Brazil were supported by the Fonds zur Förderung der Wissenschaftlichen Forschung, Wien (Proj. Nr. 3518. 4346), and the Instituto Nacional de Pesquisas da Amazônia, Manaus.

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