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# COMPARISON OF ENVIRONMENTAL CONDITIONS AND THEIR EFFECTS ON CALL CHARACTERISTICS OF FIVE FROG SPECIES IN A COLOMBIAN HIGHLAND COMMUNITY

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Abstract: Among five syntopic frog species in the Colombian highlands at 3500 m altitude we found one aquatic-calling species and four terrestrial-calling species. The terrestrial frogs called from six different plant species, whose relative abundance differed between calling areas and the general study area. Plants provide elevated perches and shelter to the frogs. We tape-recorded advertisement calls of focal males of each species under field conditions, and measured substrate or water temperature at the calling site, as well as air temperature. During each recording session we also estimated the number of conspecific neighbours calling and likely to be heard by the focal male. We measured three call characteristics (call duration, call repetition rate, pulse repetition rate). We found that each of the five species had a distinct call pattern. The call characteristics of species with water-dependent reproductive modes were more affected by substrate temperature and by social environment than those of the species with terrestrial reproductive modes. We conclude that these differences depend in part on temperature fluctuations experienced by callers of each species, and in part on relative abundance of essential resources according to reproductive mode.

KEY WORDS: Neotropical frogs, mountains, habitat use, temperature effect, social environment

## INTRODUCTION

Males in frog communities often use particular calling sites according to each species' reproductive mode (Hödl, 1990). In montane environments there is a trend towards water-independent reproductive modes (Tihen, 1965), accompanied by a shift towards terrestrial calling sites (Drewry and Rand, 1983). Microclimates may differ considerably from the macroclimate (Bartholomew, 1987). High-altitude environments in the tropics experience large daily temperature fluctuations (Sarmiento, 1986), but highland frogs may largely avoid the effects of extreme temperatures on their vocal perforeach species and measured the substrate (plant or water) temperature at the calling site, as well as air temperature about 1 m above the ground. We identified the plant species on which terrestrial males were calling. Further, during 5-minute samples repeated every hour over three daily calling periods of each species, separated by at least one week, we tape-recorded the vocal activity of focal males, using different models of SONY tape recorders (WM D6C, TCM-7, TCM-S68V), and estimated the number of conspecific calling neighbours likely to be heard by each.

Five calls per focal male were analised using Canary 1.2 software (Charif et al., 1995) on a Power Macintosh computer. Temporal call characteristics were measured on oscillograms and related to environmental factors using simple regression analysis.

We sampled the relative abundance of the plant species identified as calling sites in the areas where focal males were calling. Within four 17 x 17 m squares we randomly selected a representative number of exclusive circles of 3.8 $m^2$ surface area, and inside each circle we counted the plant specimens belonging to each of the plant species used as calling sites. In the same way we sampled the general study area at 15 ramdomly selected points along each of four randomly established transect lines of 100 m length.

## Results

The local frog community consisted of five species belonging to three different families. We found one species of hylid frog (*Hyla labialis*), three leptodactylid species (*Eleutherodactylus elegans*, *E. bogotensis*, and *E. nervicus*), and one dendrobatid species (*Colostethus subpunctatus*).

The temporal structure of the advertisement call was species specific (fig. 2). *Hyla labialis* and *Colostethus subpunctatus* made

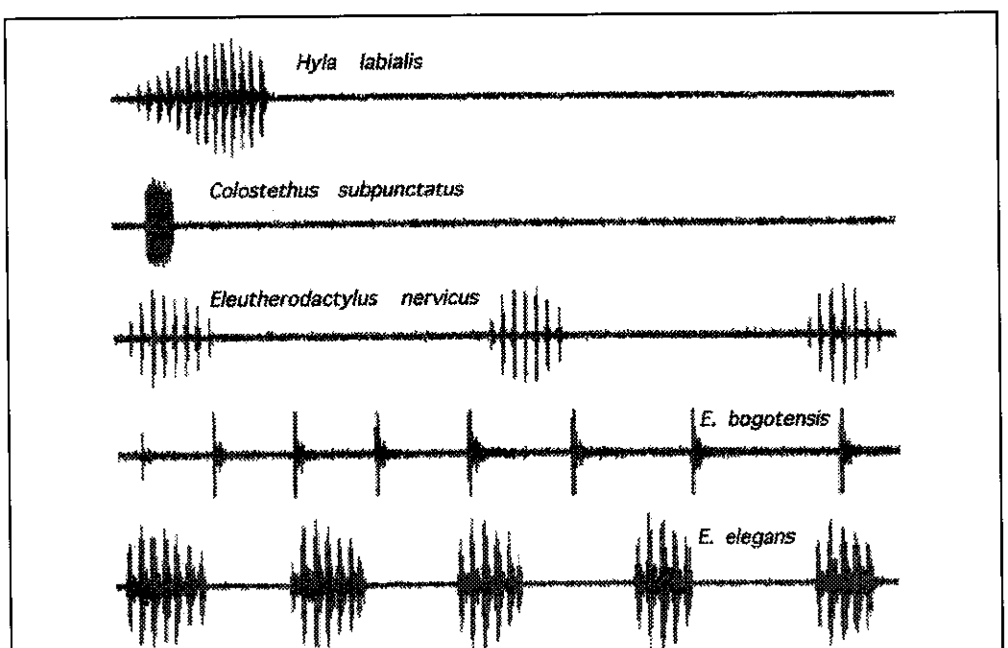


**Fig. 2:** Oscillograms of a single call of each of five syntopic frog species, recorded under field conditions. Time axes equal 1.5 s. See text for details.

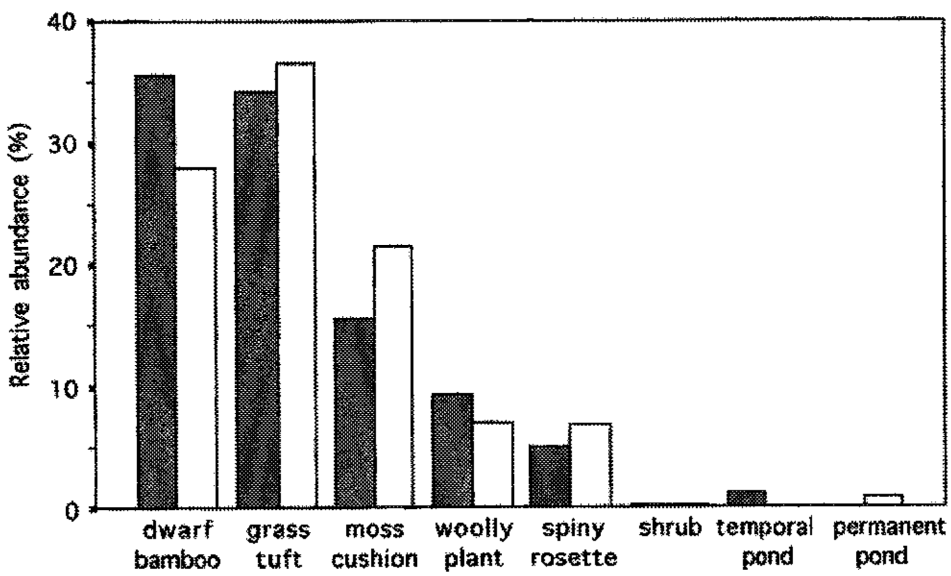


**Fig. 4:** Relative abundance of the plant species used as terrestrial calling sites in the areas where focal frogs were sampled (grey columns) and in the general study area (white columns). For comparison, ponds (aquatic calling sites of *Hyla labialis*) and small puddles (tadpole deposition sites of *Colostethus subpunctatus*) are also included.

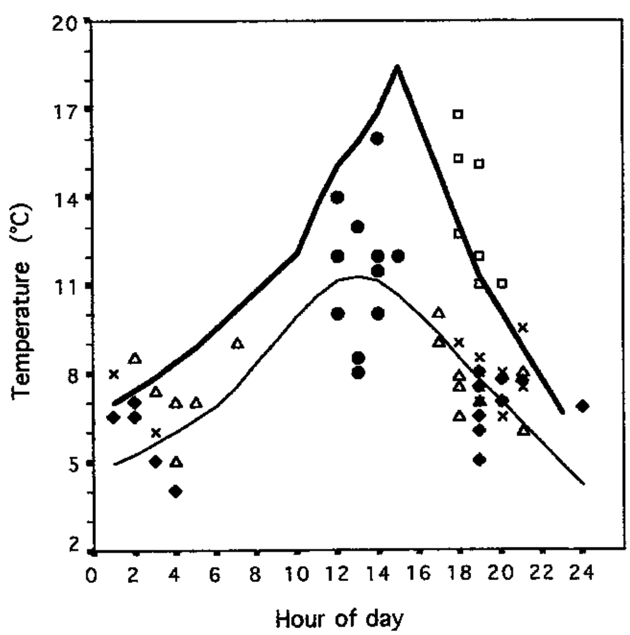


**Fig. 5:** Comparison of the daily course of air (thin line) and water (thick line) temperature in the study area (temperature readings were LOWESS regressed against daytime), with corresponding substrate temperatures at calling sites of focal frogs. Sample sizes are noted between parentheses: ◆: *Eleutherodactylus nervicus (n =14)*, ✖: *E. bogotensis (n = 15)*, Δ: *E. elegans (n = 15)*, ● :*Colostethus subpunctatus (n = 15)*, □: *Hyla labialis (n = 7)*.

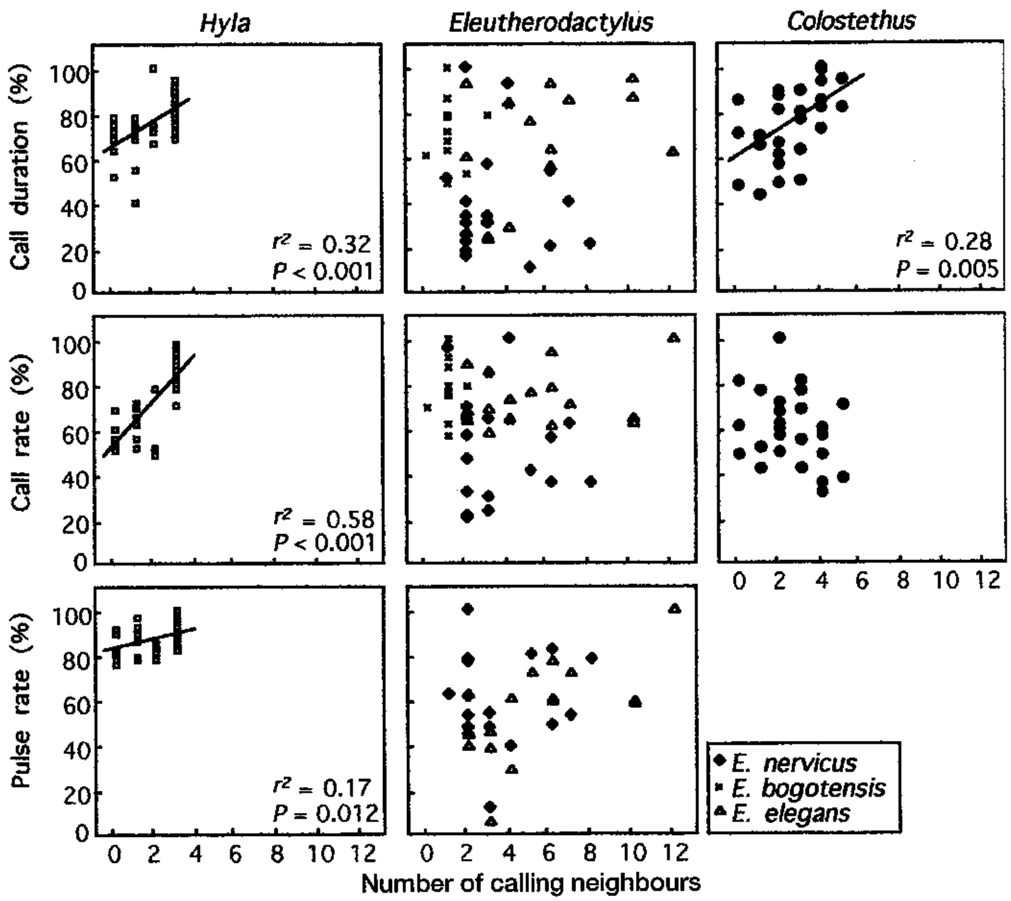


**Fig. 7:** Relationships between the number of calling neighbours, relative call duration and call or pulse repetition rate in five syntopic frog species. For interspecific comparison all crude data were converted separately for each species to percentage values, the maximum value of each variable in each species being equal to 100%. Each symbol represents the average value for one individual. Sample sizes are from top to bottom $n = 36, 32, 36$ for *Hyla labialis*, $n = 26$ for *Colostethus subpunctatus*, $n = 18$ for *Eleutherodactylus nervicus*, from top to bottom $n = 13, 14, 18$ for *E. bogotensis*, and $n = 16$ for *E. elegans*.

## Discussion

*Hyla labialis* was the species most affected by temperature (fig. 8), primarily in call duration and pulse repetition rate, in addition to a significant temperature effect on calling rate reported by Navas (1996a). This author also reports a significant temperature effect on the calling rate of *Colostethus subpunctatus* (Navas, 1996a) and a significant correlation between temperature and number of vocalising males of this species (Navas, 1996b), but his result is based on pooling data from two altitudinally separated populations. Although in all terrestrial species we found trends in the same direction as reported for other anuran species whose calls were recorded within a wider temperature range (Bellis, 1957), the differences between the four highland species cannot be explained exclusively by the difference in temperature ranges within which frogs called. Although tropical highland frogs may be able to call at very low temperatures (Navas, 1996a), in our study only the *Eleutherodactylus*-species called exposed to very harsh their calling neighbours may differ between species (Sullivan and Wagner, 1988; Perrill and Shepherd, 1989; Sullivan and Hinshaw, 1990), and are still insufficiently understood.

The considerable intraspecific variation in call parameters in most of the five highland species could be related to factors other than temperature and social environment, for instance to their prolonged breeding seasons. Although their calling activity increased in the course of many weeks, it never seemed to become stable, possibly due to fluctuating environmental conditions (rainfall, moon phase), and to recruitment of additional males and drop-out of mated or exhausted males. There could be large differences in reproductive vigor between conspecific males calling on consecutive days as well as on any given day, and irregular changes in call rate may even occur in individual males in the course of one night (López and Narins, 1991).

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