J. Natn. Sci. Coun. Sri Lanka 1981 9 (1) :

SHORT COMMUNICATION

Anuran Responses To Signal Attenuation In Environments Of High Noise

F. R. SENANAYAKE

Department of Wildlife and Fisheries Biology, University of California, Davis, California 95616, U. S. A.

(Date of receipt: 10 June 1980)
(Date of acceptance: 26 January 1981)

Anuran vocalizations, especially breeding calls in the sense of Bogert,[1] have been demonstrated to function as effective isolating mechanisms in some groups.[12] It has been shown that isolation is not the only role of this call; it may serve various other functions such as advertising the presence of a potential mate, synchronizing mating activity,[13] serving as a sex attractant,[7] or increasing female receptivity.[10] For each role the call must transmit information; indeed, the emitter and the receiver of the call represents a co-evolved unit.[3,6]

Calls are species specific and often used as taxonomic characters.[4] Studies on call structure seem to suggest that the calls may demonstrate common, discernable patterns within closely related groups of Anurans. The relationship demonstrated by such features are only consistent at the generic level, but lose validation of call characteristics with other phenomena such as habitat differences and types of mating call chorus, suggesting that these factors must exert a strong selective presence on call evolution.[9] These conditions require the shape of the call to reflect a compromise among the multiple pressures being exerted upon it.[7]

We can then define 'competitive' environments, as those in which signal intelligibility is lost, either through auditory saturation or sound attenuation. Thus we could expect species in a slightly 'competitive' environment to have call elements that demonstrate its phylogeny much clearer than species in a highly 'competitive' environment.

Animals suggest three ways in which acoustic interference leading to loss of signal information, may be reduced: frequency separation, spatial separation and temporal separation.[12] These are interspecific responses that usually occur in an environment in which two or more species call at the same spatio-temporal point. However, the physical characteristics of the environment may also influence the character of the call. Sound attenuation in amphibian voices is a function not only of call frequency but also of the physical character of the environment.[8] Other factors, such as wave reflections[2] and habitat complexity[11] have been considered. Yet another feature of the sound environment that should effect the evolution of the call structure, is the base level of background noise, termed basal noise bands, which would be a characteristic of any natural environment.

Basal noise bands would constitute abiotic noise that is sufficiently common in a given environment to provide a selective pressure on the information transmission system. Its occurence would suggest that all information transmission systems are operating at some energetically higher or more complex degree than in a free field. The increase would be rather insignificant when the basal noise level is low and the effect minimal, relative to their selective forces. When it represents a major selective force, evolutionary response to it should be demonstratable.

Some environments of high ambient noise; i.e., waterfalls and torrents, may be good breeding habitats for amphibians. Their utilization requires a solution to the problems of sound attenuation. To utilize the immediate area of such an environment, a breeding unit utilizing auditory communication could develop three basic strategies to overcome attenuation and signal loss.

The first strategy would be to develop a call of higher intensity or greater sound pressure level than background noise. This strategy may be used when the maximum background noise is lower than the biotic potential of the organism. It is also useful in environments that demonstrate a temporal variance, interspersing periods of low noise with some regularity. As every environment has some degree of random noise associated with it, all Anuran calls should incorporate response to this basal noise level. The contrasting calls of the 'quiet' frogs of the forest floor with the 'loud' calls of frogs of the African Savannah[15] may demonstrate this principle.

A second possible strategy would be to call at a higher or lower frequency than that of the ambient noise. This would be useful if the noise has a higher degree of predictability in terms of the frequency and temporal pattern. The utilization of this strategy may be demonstrated in aggregations, the species of which utilise unoccupied frequency bands to minimize call overlap with other sympatric species calling at the same time.[16]

The third strategy would be to send the call on band widths within the noise environment, but to codify the call elements. This may be accomplished by frequency modulation and amplitude modulation or both, of which there are multiple examples. Also available are the temporal units; namely call pulse rates and rate pattern which would enhance recognition without affecting attenuation.

The sound environment of the breeding habitats of the non-arboral Anurans of Sri Lanka was analyzed. (Table 1). A qualitative measure of the degree of expression of the random noise was obtained by ranking signal environments as a function of the percentage of noise occupying the sonogram trace. For the purpose of the study, areas of high ambient noise were those that demonstrated noise bands in the region of 0-5 KHz, which essentially overlaps the normally utilized band of Anurans.

Table 1 – The sound environment of habitats utilized by breeding frogs in Sri Lanka

Noise Level	High	Medium	Low
Habitat Type	Wet Cliff Rapid stream Brook	Slow – Stream	River Permanent Pond Temporary Pond
Noise Expressed As Percentage Of Sonogram Trace	Over 50%	25% – 50%	0 –25%
Anurans Record	*Nannophrys ceylonensis* *Bufo kelaartii* *Rana (Hylarana) temporalis*	*Rana corrugata* *Rana greeni* * *Rana c. cyanophlictis* *Rana (Hylarana) gracilis* *	*Rana tigrina crassa* *Rana (Hylarana) aurantiaca* *Rana (Tomopterna) breviceps* *Rana hexadactyla* *Rana l. limnocharis* *Ramanella palmata* *Ramanella variegata* *Microhyla zeylanica* *Microhyla rubra* *Microhyla ornata* *Uperodon systoma* *Caloula pulchra taprobanica* *Bufo melanostictus* *Bufo fergusonii* *Bufo atukoralaei*

All Anurans calling from areas of high ambient noise utilise note modulation, suggesting some degree of correlation between the occurrence of modulation and the sound environment (Figures 1-3).None of the Anurans recorded from areas of low noise exhibit this characteristic. Note modulation itself is not an uncommon character among Anurans. It has been demonstrated in most Leptodactylids.[5] Only *Bufo quericicus* shows it in the Bufonids[14] and in the Ranids it has been demonstrated only in *Rana nigrovittata*.[9] *Bufo quericicus* does not breed in an area of high ambient noise, nor do many of the Leptodactylids

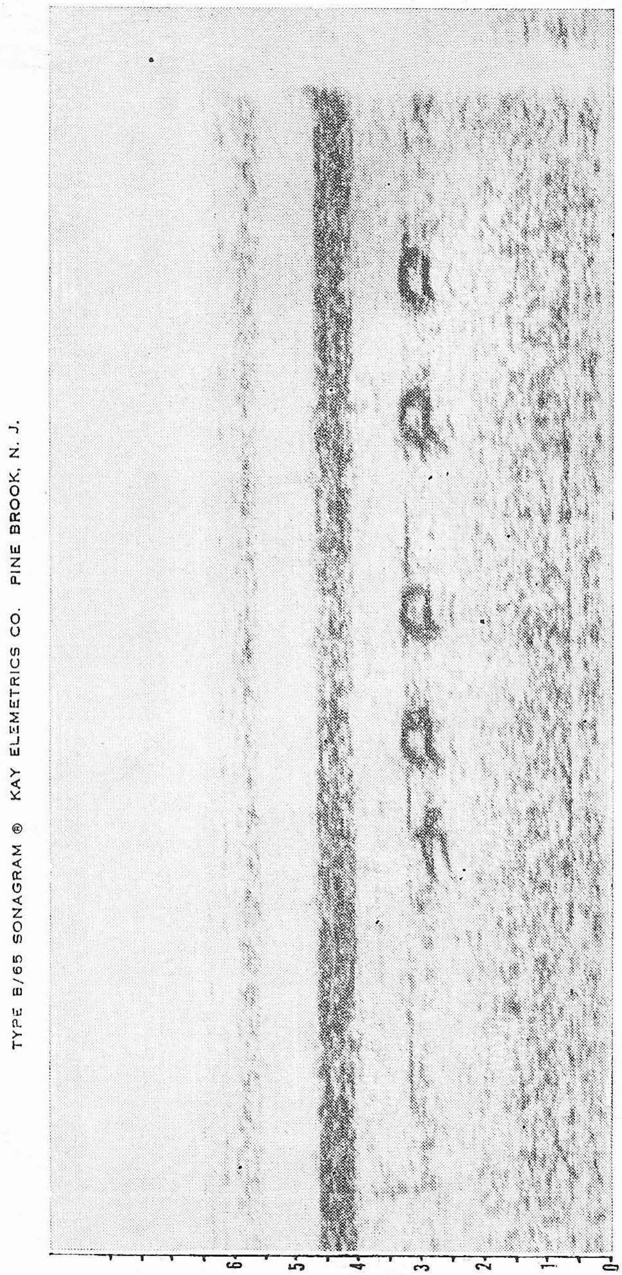

Figure 1 – Call of *Bufo kelaarti*, Kanneliya Forest 5. 16. 74, 7.00 pm; Air Temperature 26°C

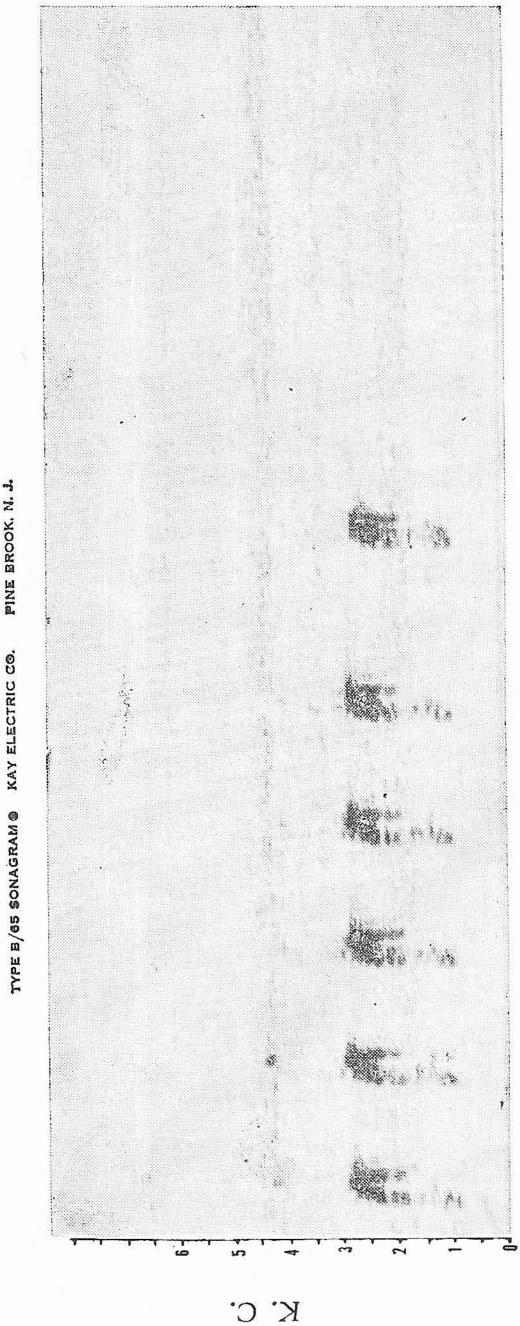

Figure 2 – Call of *Nannophyrs ceylonensis* Labugama 5. 28. 75, 7.30 pm; Air. Temperature 27°C

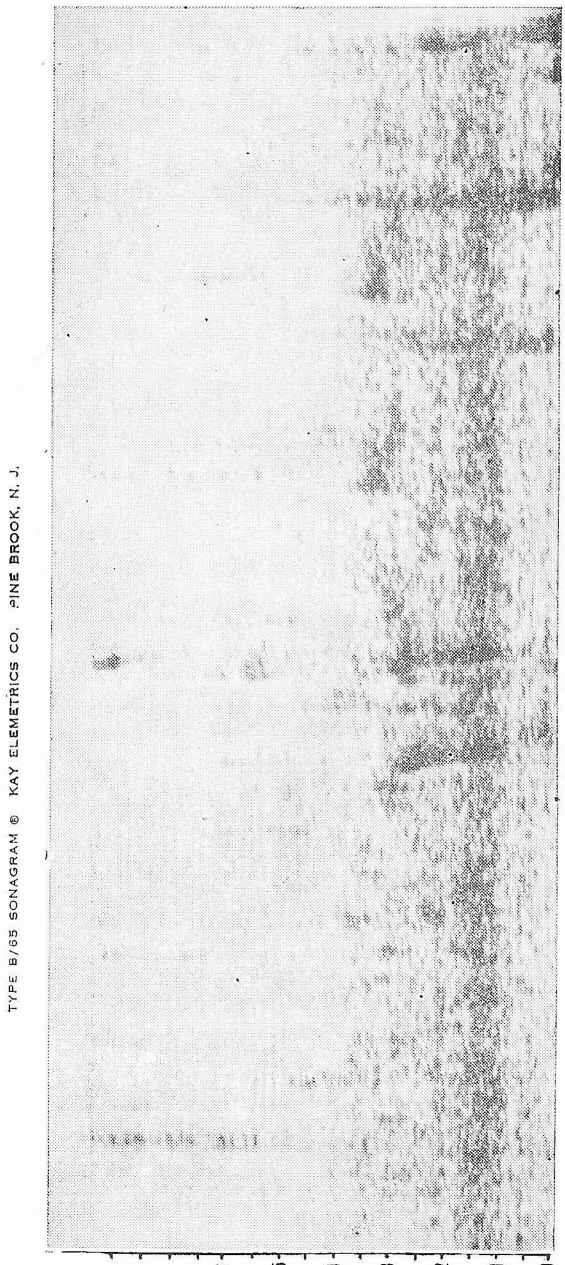

Figure 3 – Call of *Rana (Hylarana) temporalis*, Hakgala 6. 12. 74, 6.30 pm; Air Temperature 22°C.

described by Fouquette.[5] Thus, note modulation may have other causes than high ambient noise, although its high frequency in such environments indicates its adaptive significance in overcoming high levels of background noise.

Acknowledgements

I wish to thank Prof. Carl Gans of the University of Michigan for his helpful comments and criticisms during the preparation of this paper.

References

1· BOGERT. C. M. (1960) *The influence of sound on the behavior of amphibians and reptiles.. In Animal sounds and communication,* W. E. Lanyon *and* W. N. Tavolga eds·*Amer. Inst Biol. Sci.* Publ. 7 Washington D. C. p. 137—320.

2· BUSNEL. R. (1977) *Acoustic Communication* In *How animals communicate.* T. A. Sebok ed Indiana Univ. Press·Bloomington and London p 233—251.

3· CAPRIANCA, R·R, (1965) *The evoked vocal response of the Bullfrog resmonograph* 33 Mass. Univ. press. Cambr. Mass. p. 1—110·

4· DUELLMAN, W·E (1968) *The taxonomic status of some American Hylid frogs. Herpetologica* **21** : 124—207.

5· FOUQUETTE, M. J. (1960) *Call structure in frogs of the family Leptodactylidae. Texas J. Sci* **12** : 201—215.

6· FRITKOFF, L·S· & N. H·GOLDSTEIN jr· (1963) *Responses to acoustic stimuli from single units in the eighth nerve of the Bullfrog. Journ. Acoust. Soc. Amer.* **35** : 1219—1228·

7· GANS, C. (1974) *Sound production in the Salientia, Mechanism and evolution of the emitters Amer. Zoll* **13**(4) :1179—1194·

8· GERHARDT, H·C. (1975) *Sound Pressure Levels and Radiation Patterns of the Vocalizations of some North American Frogs and Toads. Journ. Comp. Physiol. A. Sens. Neural Behav.* **102**(1): 1—12·

9· HEYER,W·R·(1971) *Mating calls of some frogs from Thailand·Fieldiana. Zool*·**58** (6):61—82·

10· HUESSER, L· (1968) *Die Lebensweise Der Erderote bufo bufo* (L); *Laichzet, umstimmung ovulation, Veirteljahres, Naturforsch, Ges Zurich* **113** (3):257—289

11. KONISHI, M· (1970) *Evolution of design features in the coding of species specificity. Amer. Zool* **10**(1) :67—72·

12· LITTLEJOHN, M· J· & MARTIN, A·A· (1969) *Acoustic interaction between two species of Leptodactylid frogs. Anim. Behav.* **17**:785—791·

13· MAYR E·, (1963)*Animal Speciation and Evolution. Cambridge P·i—xv,* 1—797.

14· MARTIN, W·F. (1972) *Evolution of Vocalization in the genus Bufo In evolution in the genus Bufo.* W·F·Bair (ed) Univ. of Texas Press, Austin Texas p 459·

15· SCHILZ, A· (1973) *Evolution of Anuran mating calls Ecological Aspects, In Evolutionary biology of the Anurans,* J·C·Vial (ed) Proc 13 th annual meeting of the Study of Amphibians and Reptiles·Kansas City Mo·1970;Univ·Missouri Press, Columbia Mo·p 322—327·

16· STRANGHN, I. R· (1973) *Evolution of Anuran mating calls,* Bioacoustical *aspects· In Evolutionary biology of the Anurans,* J· C· Vial (ed) Proc. 15th annual meeting of the Soc· for the study of Amphibians and Reptiles· Kansas City Mo· 1970; Univ· Missouri Press, Colombia Mo· p. 311 -- 319·