

glands is more or less the same (5.5 to 6.0) in all the three species.

However, there is no marked difference in the pH milieu of the gut of *Pila*, *Bellamya* and *Achatina*. All are slightly acidic. Gut of *Pila* is more acidic and oesophagus of *Bellamya* shows slight alkalinity.

Since *Pila*, *Bellamya* and *Achatina* are mainly phytophagous, similar pH environment in their gut is not unexpected. Amongst insects, pH of the gut appears to be characteristic of taxonomic group rather than feeding habit³⁻⁵. The same may be true for molluscs as well. Slightly acidic gut may be characteristic of gastropod molluscs.

1. Owen, G., Cited from *Physiology of Molluscs* (eds. Wilbur, K. M. and Young, C. M.), Academic Press, New York, London, 1966, vol. 2, pp. 53-88.
2. Reid, G. R. and Raucher, K., *Comp. Biochem. Physiol.*, 1972, A41, 887.
3. Sinha, M., *J. Exp. Biol.*, 1975, 13, 88.
4. Srivastava, V. S. and Srivastava, P. D., *Beitr. Entomol.*, 1961, 11, 15; cited from *Physiology of Insects* (ed. Rockstein, M.), Academic Press, New York, 1961, vol. 2, pp. 815-825.
5. Waterhouse, D. F., *Aust. J. Sci. Res.*, 1949, B2, 428.

Received 18 January 1994; revised accepted 15 March 1994

Courtship, amplexus and advertisement call of the frog, *Microhyla rubra*

R. D. Kanamadi, C. R. Hiremath and Hans Schneider*

Department of Zoology, Karnatak University, Dharwad 580 003, India
*Zoologisches Institut, Bonn Universität, Bonn, Germany

Microhyla rubra has a single reproductive season (April–October) in a year. Sexually mature males possess a single subgular vocal sac during breeding season. Males produce advertisement calls which are species-specific and consists of a number of calls produced in series at variable intervals forming a call group. Each call group comprises 8–104 calls. Each call is formed of a pulse group of 15–21 pulses. The frequency spectrum is continuous and broad. The sound energy is concentrated between 300 Hz and 3300 Hz. Gravid females are attracted by the advertisement call, and this results in axillary amplexus.

MICROHYLA RUBRA is a small microhylid frog found in the vicinity of Dharwad (Karnataka, India). The information on its reproductive biology is scarce. Many recent studies demonstrate that acoustic communication has reached a remarkably high level of development of differentiation even though there are surprisingly few different types of calls among various anuran species¹. Bioacoustics in Indian microhylids are limited to *Ramanella variegata*². The present study concerns some aspects of breeding behaviour and advertisement calls of *M. ornata*.

Field observations to study the courtship, amplexus and vocalization of *M. rubra* were carried out for three years (1988–1991). During frog calling, the calls were identified and recorded on a tape recorder (at 4–8 cm/s speed). Microphones were held within a distance of 15–20 cm of a calling frog. Recordings were done at 24–26°C air temperature and 85–90% relative humidity. The sound pressure level was measured by MEONIX sound level meter. Calls of ten frogs ($N=10$) were analysed at the Zoologisches Institut, Bonn Universität by examining oscillogram (Textronix oscilloscope 502 A; Tonnie's Recordine Camera; film speed 25 cm/s) and by sonagram analysis (with computer program MOSIP (R) spectro analyses V6 41/89, MEDAV GmbH). Statistical analysis was carried out with program STSC, Inc. (Knoxville, USA).

M. rubra are burrowing and nocturnal frogs and have a single reproductive period. Males possess a single subgular (Figure 1) vocal sac which assumes black colour during the breeding season. Adult males give advertisement call. The calling is in chorus, and the shortest distance between nearest calling males measured is 10 cm. Calling period begins with the first heavy showers of premonsoon (April/May)/monsoon (June) rains and ends in October. Between April and June calling is maximum, and from July onwards the number of callers becomes less and less, calls becoming rare between September and October. The advertisement call attracts the gravid female. Females come out of their burrows and quickly jump towards calling males. Sometimes females come jumping from a distance of 15–20 m and move nearer the calling males. With the next call the female moves quickly to reach the calling male and pushes itself under it. Then it is suddenly clasped by the male. After proper adjustment between both, it results into axillary amplexus (Figure 2). After the amplexus the male does not produce advertisement call.

Frogs call during night by sitting in open field and also hiding under grass within a distance of about 10 m from the pond. Advertisement call is audible to human beings from a distance of 20–25 m. The sound pressure level of the call varies from 83 to 96 dB. Table 1 shows analysis of the call. The advertisement call of *M. rubra* consists of a number of calls produced in series at variable intervals forming a call group³. Each call group comprises 8–104 calls. Duration of call group varies from 7 to 76 seconds. The call duration varies between 138 ms and 228 ms. Each call is formed of a pulse group of 15–21 pulses (Figure 3) and the pulses overlap in any part of the call. The amplitude of the first pulse is always low and rises quickly in second pulse. By 4th or 5th pulse it reaches a maximum and is followed by a gradual decrease. The frequency spectrum is continuous and broad. The sound energy is concentrated between 300 Hz and 4150 Hz. The fun-



Figure 1. Calling *M. rubra*, note the single subgular vocal sac



Figure 2. Axillary amplexus of *M. rubra*

Table 1. Acoustical features of the advertisement call of *Microhyla rubra*

Parameter	Sample size	
	(No)	Mean \pm SE
Pulse number	40	18.0 \pm 0.2
Pulse/s (Hz)	39	108.0 \pm 20.4
Pulse duration (ms)	39	9.5 \pm 0.3
Calls/call group (N)	41	30.3 \pm 3.3
Call duration (ms)	39	168.4 \pm 3.2
Call interval	34	847.3 \pm 88.2
Call period	34	1045.0 \pm 91.0
Call group duration(s)	52	32.0 \pm 3.6

damental frequency lies at 1101 ± 18 Hz and the dominant frequency at 2268 ± 43 Hz.

The term courtship is used to refer to the interaction between males and females leading to pair formation and mating. The courtship may be simple in that the male may call until a female contacts him; then he clasps the female⁴. *M. rubra* exhibits simple courtship. It is well known that in anurans the amplexus may be either inguinal or axillary. Axillary amplexus is adap-

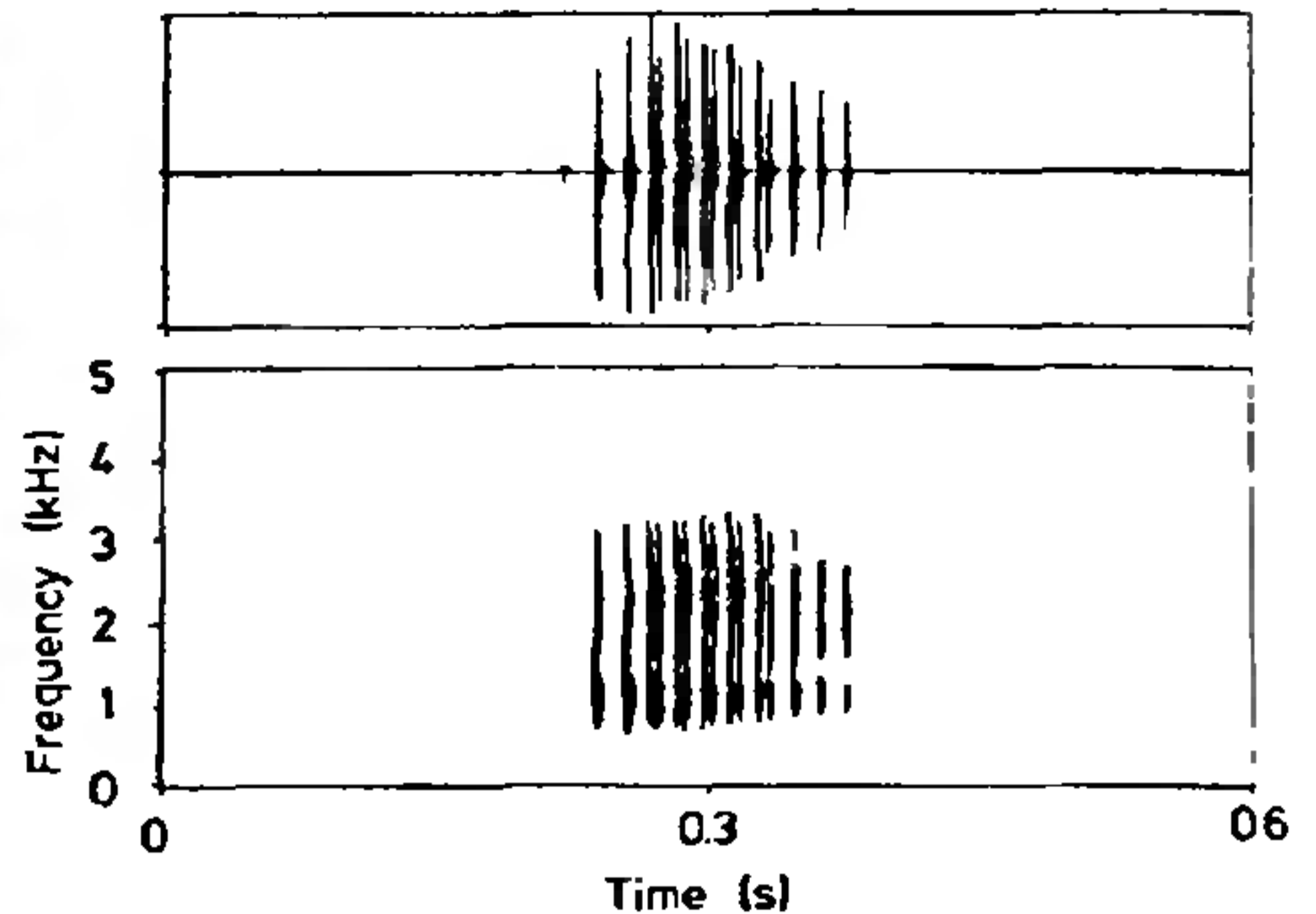


Figure 3. The oscillogram (upper) and sonagram (lower) of the advertisement call of *M. rubra*. Note the oscillogram of a call consisting a pulse group of 15 pulses.

tively superior in that it allows closer juxtaposition of cloacae, thereby promoting more efficient fertilization⁵. In *M. rubra* the amplexus is of axillary type.

Acoustic signals are of central importance to the biology of anurans. Males call to attract females, and these calls play a critical role in both species recognition and female male choice³. Advertisement call of *M. rubra* is species-specific and serves to attract the conspecific females. The call consists of call group similar to sympatric species *R. variegata*² but differs from it in the absence of harmonics. Overlapping of pulses in any part of the call is a notable feature (Figure 3). In the absence of any histological studies on gonadal cycles, the period of calling may be taken as a criteria to determine (approximate) the breeding period of a species⁶. In the present study in *M. rubra*, it is suggested that the duration of calling from April to September/October may be considered as breeding period.

- Schneider, H., in *The Evolution of Amphibian Auditory Systems* (eds. Fritsch, B., Wilczynski, M. J., Hetherington, T. E. and Walkowiak, W.), John Wiley, New York, 1988, p. 537.
- Kanamadi, R. D., Hiremath, C. R. and Schneider, H., *J. Herpetol.*, 1933, 27, 218-219.
- Wagner, W. E., *Ethology*, 1989, 82, 27-45.
- Wells, C. D., in *The Reproductive Biology of Amphibians* (eds. Taylor, D. H. and Guttman, S. I.), Plenum Press, New York, 1977, p. 233
- Rabb, G. B. and Rabb, M. S., *Z. Tierpsychol.*, 1963, 20, 215-241.
- Kanamadi, R. D. and Hiremath, C. R., *Environ. Ecol.*, 1990, 8, 1055-1056.

ACKNOWLEDGEMENTS. We thank UGC, New Delhi, India, and the German Academic Exchange Service, Bonn, FRG, for selecting the first author for the study visit.

Received 30 December 1993; revised accepted 2 March 1994