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Vocalization in Maskey's Burrowing Frog, *Sphaerotheca maskeyi* (Anura: Dicroglossidae)

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Although India is home to more than 440 species of amphibians, little is known about the behavior, breeding biology, and vocalization of most species (Nair et al. 2012). Bioacoustics is a powerful tool used to better understand ecology, behavior, and phylogenetic relationships of anurans (Gerhardt and Huber 2002; Wells 2007). Most anuran species have species-specific advertisement calls that are used by males to establish territories and attract conspecific females (Littlejohn 1977). These calls also can be used to identify cryptic species (e.g., Schneider et al. 1988; García-Lopez et al. 1996; Angulo and Reichle 2008; Micancin and Mette 2009; Phuge et al. 2020). Although most anuran species employ a single call for advertisement and to establish and maintain territories, some species use distinct calls that differ in spectral and temporal properties for these purposes (e.g., Goin 1949; Hardy 1959; Duellman 1967; Schneider 1967; Rosen and Lemon 1974; Schneider et al. 1998).

Six of eight currently recognized species of frogs in the genus *Sphaerotheca* occur in India (Deepak et al. 2020a; Frost 2021). Maskey's Burrowing Frog (*Sphaerotheca maskeyi*), described from Royal Chitwan National Park in central Nepal by Schleich and Anders (1998), has an extensive distribution on the Indian Subcontinent (Prasad et al. 2019; Dandekar et al. 2020; Deepak et al. 2020b; Sreekumar and Dinesh 2020). Recently, Jablonski et al. (2021) provided a confirmed record in Pakistan and declared *S. pashchima* and *S. magadha* to be junior synonyms of *S. maskeyi*. Prasad et al. (2020) analyzed one call type of *S. maskeyi*. Herein we describe three different calls of this species.

Sangli, Sangli District, Maharashtra, India (16.853°N, 74.583°E), located at an elevation of 549 m asl on the bank of the Krishna River, and the surrounding area was classified as a scarcity agroclimatic zone (Dakhore et al. 2017), which is characterized by an arid climate with moderate rainfall during monsoons. During regular herpetological expeditions in 2020, we found amplecting pairs, egg clutches, and tadpoles of *S. maskeyi* near agricultural fields in roadside pools, wet grasslands, and puddles until the end of the monsoon in September. We identified the species using characteristics described in Schleich and Anders (1998).

Fig. 1. Male Maskey's Burrowing Frog (*Sphaerotheca maskeyi*) emitting type-A calls near Sangli, Sangli District, Maharashtra, India. Photographs by Gosavi Ninad Amol.

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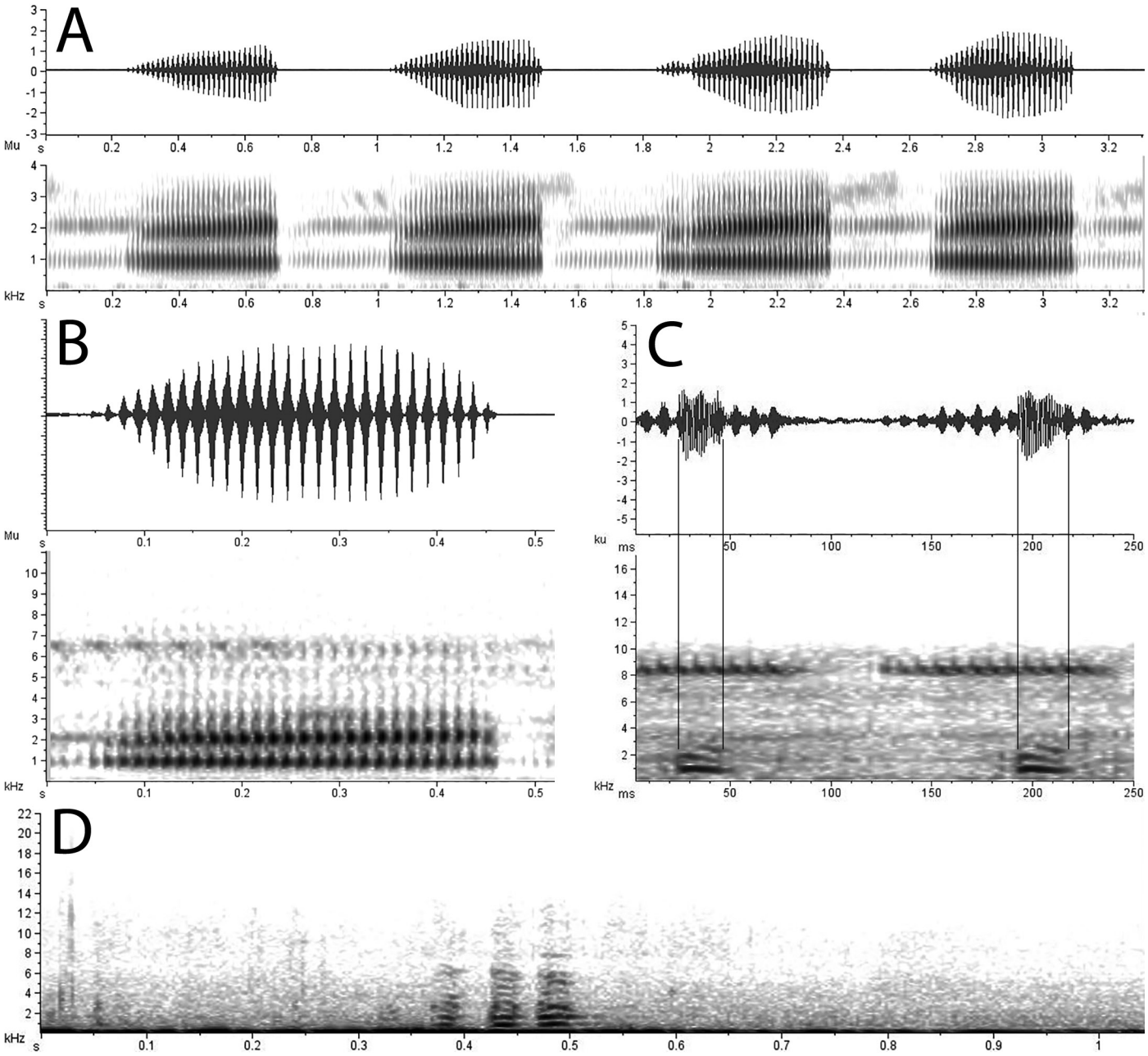

Fig. 2. Spectrograms of calls of Maskey's Burrowing Frog (*Sphaerotheca maskeyi*): Waveform and spectrogram of a series of type-A calls (A); waveform and spectrogram of a single type-A call (B); waveform and spectrogram of two notes of a type-B call (C); and spectrogram of the release call (D).

Using a solid-state digital recorder (Tascam DR40, 44.1 kHz sampling rate, 16-bit resolution) equipped with a Sennheiser ME67 unidirectional microphone with windscreen at distances of 30–50 cm, we recorded 77 type-A advertisement calls of 16 males (Fig. 1), 14 type-B encounter calls of four males, and six release calls of six males at a single breeding site at 2000–2200 h near Haripur Village, Sangli District, Maharashtra, in July and August 2020.

We analyzed recordings using Raven Pro 1.4 (K. Lisa Yang Center for Conservation Bioacoustics 2011) and created spectrograms in Hann window with a spectrogram window size of 256 samples, using a call-centered approach (Bonneel et al. 2008; Köhler et al. 2017) to describe temporal and spectral properties of calls. To evaluate call intervals, we selected recordings of continuously calling males, and rejected recordings of choruses to avoid overlap of signals.

Pulse-repetition type-A calls (Fig. 2A–B; Table 1) were most frequently emitted during breeding activity and are considered advertisement calls. Mean call duration = 0.395 ± 0.039 s, coefficient of variation (CV) = 10.02% (n = 77), with rhythmically spaced pulses within the sequence; mean number of pulses = 27 ± 2 (24–30, CV = 7.36%, n = 77); mean pulse rate = 72.85 ± 3.08 pulses/sec (CV = 4.23%); mean call interval = 0.69 ± 0.40 s (CV = 57.83%, n = 48); and mean

Table 1. Call characteristics of type-A, type-B, and release calls of Maskey's Burrowing Frogs (*Sphaerotheca maskeyi*) recorded at Sangli, Maharashtra, India.

	Type-A Call	Type-B Call	Release Call
Number of pulses	27 ± 2.03	3.6 ± 1.54	3.33 ± 0.51
Pulse rate	72.85 ± 3.08	8.42 ± 2.52	24.76 ± 4.54
Pulse duration (s)	0.009 ± 0.001	0.028 ± 0.008	0.029 ± 0.006
Pulse interval (s)	0.005 ± 0.0008	0.15 ± 0.07	0.022 ± 0.003
Call duration (s)	0.395 ± 0.039	0.38 ± 0.2	0.17 ± 0.11
Call interval (s)	0.69 ± 0.4	1.71 ± 0.25	1.32 ± 1.01
Dominant frequency (kHz)	2.085 ± 0.21	0.561 ± 0.017	0.752

dominant frequency = 2.085 ± 0.21 kHz. The high CV of the call interval suggests that this character is not appropriate for use in taxonomic studies. The spectrogram shows two energy-centered frequency bands arranged vertically (Fig. 2B). For all 77 calls, the first pulse was always lower in amplitude than subsequent pulses. Mean duration of a single pulse = 0.009 ± 0.001 sec. (0.006–0.015 s, CV = 16.39%) with a pulse interval = 0.005 ± 0.0008 s (n = 67). The duration of the first pulse was always shortest, with duration of pulses increasing until the temporal center of the call before decreasing thereafter.

Type-B calls (Fig. 2C; Table 1), with 2–6 pulses, were most frequently emitted at the onset of choruses and less frequently during peaks of breeding activity and are considered encounter calls (*sensu* Wells 2007). In five instances, males began emitting type-B calls in response to the approach of another male. Mean call duration = 0.38 ± 0.2 s (n = 14); mean pulse duration = 0.028 ± 0.008 s (n = 32); mean call interval = 1.71 ± 0.25 s (n = 12); mean number of pulses = 3.6 ± 1.54 sec; mean pulse interval = 0.15 ± 0.07 s (CV = 46.27%, n = 32); mean pulse rate = 8.42 ± 2.52 pulses/sec (n = 32); and mean dominant frequency = 0.561 ± 0.017 kHz (0.365–3.654 kHz, n = 14). The spectrogram shows short pulses with three bands of frequencies arranged vertically. Few pulses showed frequency modulation over time.

All six release calls (Fig. 2D; Table 1) recorded were emitted by mature males when another male tried to engage in amplexus. A spectrogram showed an unorganized call comprising 2–3 closely spaced pulses. Mean call duration = 0.17 ± 0.11 s (CV = 67%, n = 6); frequency range = 0.453–5.612 kHz; mean call interval = 1.32 ± 1.01 s (CV = 76%, n = 5); mean pulse duration = 0.029 ± 0.006 sec (CV = 23%, n = 19); mean pulse interval = 0.022 ± 0.003 s; mean number of pulses = 3.33 ± 0.51 (CV = 15.49%, n = 6); and mean pulse rate = 24.76 ± 4.54 pulses/s (CV = 18.35%). The dominant frequency of the release call of a single male was 0.752 kHz. However, because of the very small sample size, further studies of the release call are necessary.

Calling frogs have evolved patterns of vocalization that reduce the risk of overlapping acoustic signals (Klump and Gerhardt 1992), and we have observed neighboring male *S. maskeyi* adjust the timing of their calls with respect to each other.

Deepak et al. (2020a) demonstrated considerable variation in this species across its extensive distribution, indicating that species-level identification could be difficult without handling frogs. The description of the call of *S. maskeyi* (as *S. pashchima*) by Prasad et al. (2020) from the Penna Tiger Reserve, Madhya Pradesh, matches the type-A call described herein, suggesting that this call could be a good character for identifying *S. maskeyi*. However, Kanamadi et al. (1994) described the call of *S. breviceps* (as *Temopterna breviceps*) from Dharwad, Karnataka. It was similar to and could be confused with the type-A call of *S. maskeyi* without analyses of the calls. Consequently, further studies of the calls of other species in the genus *Sphaerotheca* might be necessary before relying solely on call recognition as a diagnostic character.

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Literature Cited

Angulo, A. and S. Reichle. 2008. Acoustic signals, species diagnosis, and species concepts: the case of a new cryptic species of *Leptodactylus* (Amphibia, Anura, Leptodactylidae) from the Chapare region, Bolivia. *Zoological Journal of the Linnean Society* 152: 59–77. https://doi.org/10.1111/j.1096-3642.2008.00447.x.

Bonneel, N., G. Drettakis, N. Tsingos, I. Viaud-Delmon, and D. James. 2008. Fast modal sounds with scalable frequency-domain synthesis. *ACM Transactions on Graphics* 27(3): 1–9. https://doi.org/10.1145/1360612.1360623.

Dakhore, K.K., A. Karunakar, J.D. Jadhav, D.N. Jagtap, P.B. Pawar, and P.V. Kumar. 2017. *Agroclimatic Atlas of Maharashtra*. Vasantro Naik Marathwada Krishi Vidyapeeth, Parbani, Maharashtra, India.

Dandekar, N., S. Sulakhe, and A. Padhye. 2020. Range extension of the Western Burrowing Frog, *Sphaerotheca pashchima* (Anura: Dicroglossidae), in central and northern India, with an overview of the distribution of other Indian species in the genus *Sphaerotheca*. *Reptiles & Amphibians* 27: 390–396. https://doi.org/10.17161/randa.v27i3.14853.

Deepak, P., K.P. Dinesh, A. Ohler, K. Shanker, B.H. Channakeshavamurthy, and J.S. Ashadevi. 2020a. A new species of *Sphaerotheca* Günther, 1859 (Anura: Dicroglossidae) from the degraded urban ecosystems of Bengaluru, Deccan Plateau, India. *Zootaxa* 4885: 423–436. https://doi.org/10.11646/zoo-

taxa.4885.3.6.

Deepak, P., K.P. Dinesh, V.K. Prasad, A. Das, and J.S. Ashadevi. 2020b. Distribution status of the Western Burrowing Frog, *Sphaerotheca pashchima* in India. *Zootaxa* 4894: 146–150. https://doi.org/10.11646/zootaxa.4894.1.10.

Duellman, W.E. 1967. Social organization in the mating calls of some neotropical anurans. *American Midland Naturalist* 77: 156–163. https://doi.org/10.2307/2423435.

Frost, D.R. 2021. *Amphibian Species of the World: an Online Reference*. Version 6.1. American Museum of Natural History, New York, New York, USA. <https://amphibiansoftheworld.amnh.org/index.php>. https://doi.org/10.5531/db.vz.0001.

García-Lopez, J.M., W.R. Heyer, and A.J. Cardoso. 1996. Advertisement call variation in the *Leptodactylus mystaceus* species complex (Amphibia: Leptodactylidae) with a description of a new sibling species. *Amphibia-Reptilia* 17: 7–31.

Gerhardt, H.C. and F. Huber. 2002. *Acoustic Communication in Insects and Frogs: Common Problems and Diverse Solutions*. University of Chicago Press, Chicago, Illinois, USA.

Goin, C.J. 1949. The peep order of peepers: a swamp water serenade. *Quarterly Journal of the Florida Academy of Sciences* 11: 59–61.

Hardy, D.F. 1959. Chorus structure in the striped chorus frog, *Pseudacris nigrita. Herpetologica* 15: 14–16.

Jablonski, D., R. Masroor, and S. Hofmann. 2021. Revisited molecular phylogeny of the genus *Sphaerotheca* (Anura: Dicroglossidae): The biogeographic status of northernmost populations and further taxonomic changes. *Diversity* 13: 1–18. https://doi.org/10.3390/d13050216.

K. Lisa Yang Center for Conservation Bioacoustics. 2011. *Raven Pro: Interactive Sound Analysis Software*. Version 1.4. The Cornell Lab of Ornithology, Ithaca, New York, USA. <https://ravensoundsoftware.com/>.

Kanamadi, R.D., C.R. Hiremath, and H. Schneider. 1994. Advertisement calls of two anuran amphibians, *Rana tigrina* and *Tomopterna breviceps*. *Journal of Biosciences* 19: 75–80.

Klump, G.M. and H. C. Gerhardt. 1992. Mechanisms and function of call-timing in male-male interactions in frogs, pp. 153–174. In: P.K. McGregor (ed.), *Playback and Studies of Animal Communication*. NATO ASI Series A: Life Sciences Vol. 228. Springer US, Boston, Massachusetts, USA. https://doi.org/10.1007/978-1-4757-6203-7.

Köhler, J., M. Jansen, A. Rodríguez, P.J.R. Kok, L.F. Toledo, M. Emmrich, F. Glaw, C.F.B. Haddad, M.-O. Rödel, and M. Vences. 2017.The use of bioacoustics in anuran taxonomy: theory, terminology, methods and recommendations for best practice. *Zootaxa* 4251: 1–124. https://doi.org/10.11646/zootaxa.4251.1.1.

Littlejohn, M.J. 1977. Long range acoustic communication in anurans: An integrated and evolutionary approach, pp. 263–294. In: D.H. Taylor and S.I. Guttman (eds.), *The Reproductive Biology of Amphibians*. Plenum Press, New York, New York, USA.

Micancin, J. and J. Mette. 2009. Acoustic and morphological identification of the sympatric cricket frogs *Acris crepitans* and *A. gryllus* and the disappearance of *A. gryllus* near the edge of its range. *Zootaxa* 2076: 1–36. https://doi.org/10.11646/zootaxa.2076.1.1.

Nair, A., S.V. Gopalan, S. George, K.S. Kumar, A.G.F. Teacher, and J. Merilä. 2012. High cryptic diversity of endemic *Indirana* frogs in the Western Ghats biodiversity hotspot. *Animal Conservation* 15: 489–498. https://doi.org/10.1111/j.1469-1795.2012.00539.x.

Phuge, S., A.B. Patil, R. Pandit, N.U. Kulkarni, B.H. Chennakeshavamurthy, P. Deepakand, and K.P. Dinesh. 2020. Importance of genetic data in resolving cryptic species: A century old problem of understanding the distribution of *Minervarya syhadrensis* Annandale 1919, (Anura: Dicroglossidae). *Zootaxa* 4869: 451–492. https://doi.org/10.11646/zootaxa.4869.4.1.

Prasad, V.K., K.P. Dinesh, A. Das, P. Swamy, A.D. Shinde, and J.B. Vishnu. 2019. A new species of *Sphaerotheca* Gunther, 1859 (Amphibia: Anura: Dicroglossidae) from the agro ecosystems of Chota Nagpur Plateau, India. *Records of the Zoological Survey of India* 119: 197–210. https://doi.org/10.26515/rzsi/v119/i3/2019/132173.

Prasad, V.K., K.B. Gautam, S.K. Gupta, R.S. Murthy, K. Ramesh, A.D. Shinde, and A. Das. 2020. Identification of anuran species diversity of the Panna Tiger Reserve, Central India, using an integrated approach. *Zootaxa* 4851: 450–476. https://doi.org/10.11646/zootaxa.4851.3.2.

Rosen, M. and R.E. Lemon. 1974. The vocal behavior of spring peepers, *Hyla crucifer. Copeia* 4: 940–950. https://doi.org/10.2307/1442594.

Schleich, H.H. and C.C. Anders. 1998. *Tompterna maskeyi* spec. nov. from Nepal (Amphibia, Anura), pp. 57–72. In: H,H, Schleich and W. Kästle (eds.), *Contributions to the Herpetology of South Asia (Nepal, India), Band 4*. Veröffentlichungen aus dem Fuhlrott-Museum. Fuhlrott Museum, Wuppertal, Germany.

Schneider, H. 1967. Rufe und Rufverhalten des Laubfrosches, *Hyla arborea arborea* (L.). *Zeitschrift für vergleichende Physiologie* 57: 174–189.

Schneider, H., G. Joermann, and W. Hodl. 1988. Calling and antiphonal calling in four Neotropical anuran species of the family Leptodactylidae. *Zoologische Jahrbücher Abteilung für allgemeine Zoologie und Physiologie der Tiere* 92: 77–103.

Sreekumar, S. and K.P. Dinesh. 2020. Amphibians of agro-climatic zones of Maharashtra with updated checklist for the state. *Records of the Zoological Survey of India* 120: 33–40. https://doi.org/10.26515/rzsi/v120/i1/2020/131811.

Wells, K.D. 2007. *The Ecology and Behavior of Amphibians*. The University of Chicago Press, Chicago, Illinois, USA.