Zootaxa 3796 (3): 401–434
www.mapress.com/zootaxa/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

http://dx.doi.org/10.11646/zootaxa.3796.3.1
http://zoobank.org/urn:lsid:zoobank.org:pub:FE38169D-6687-42DF-B29B-444A954D1E08

Two new species of *Kalophrynus* Tschudi, 1838 (Anura: Microhylidae) from the Annamite mountains in southern Vietnam

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Abstract

We describe two new mountain-dwelling microhylid species of the genus *Kalophrynus* from the southern part of the Annamite Mountains in Vietnam. The two new species differ from all known congeners in morphological characters and mtDNA; phylogenetically, they form a sister clade to the large-bodied *K. interlineatus* (1009 bp, 16S rRNA gene, mtDNA). Both species share the following characteristics: snout pointed in dorsal and lateral views, slightly sloping in profile; tympanum distinct, smaller than eye in diameter; toe webbing moderate; outer metatarsal tubercle present; light dorsolateral line absent. *Kalophrynus cryptophonus* **sp. nov.** from Loc Bao, Lam Dong Province is a small-sized species distinguishing from its congeners by a combination of: SVL 27.9–30.4 mm in males, 23.4 mm in female; canthus rostralis indistinct; males with large sharp conical spines on the skin covering mandible margins and finely asperous nuptial pads on the dorsal surface of fingers I–III; dark ocelli in the inguinal region usually present, small, without a light border; anterior palatal dermal ridge short, restricted to medial part of palate. *Kalophrynus honbaensis* **sp. nov.** from Hon Ba, Khanh Hoa Province is a medium-sized *Kalophrynus*, distinguishing from its congeners by a combination of: SVL 26.7–36.8 mm in males; canthus rostralis distinct; males without distinguishable spines on the mandible margins nor the nuptial pads; dark ocelli in the inguinal region present, large, without a distinct light border, anterior palatal dermal ridge developed, parallel to posterior one. *Kalophrynus cryptophonus* **sp. nov.** reproduces in hollow bamboo stems; we describe larval morphology and bioacoustics of this species in relation to phytotelm breeding. A review of the distribution of the genus *Kalophrynus* in Indochina is provided.

Key words: Indochina, taxonomy, 16S rRNA, advertisement call, tadpole, phytotelm breeding, *Kalophrynus cryptophonus* **sp. nov.**, *Kalophrynus honbaensis* **sp. nov.**

Introduction

The genus *Kalophrynus* Tschudi, 1838, or sticky frogs, is the only representative of the subfamily Kalophryninae Mivart, 1869 and is recovered as a phylogenetically divergent group of Microhylidae, showing affinities to Melanobatrachinae and Asterophrynae (Van Bocxlaer *et al.* 2006; Frost *et al.* 2006; Pyron & Wiens 2011). The assumed Mesozoic origin of the group allow some authors to regard it as a distinct family of anurans (Bossuyt & Roelants 2009). At present, the genus *Kalophrynus* encompasses 19 species of small to medium sized litter frogs widely distributed in Southeast Asia, from northeastern India (Assam State) through Myanmar, southern China, Indochina (Vietnam, Cambodia and Laos) and southwards to Thailand, Malaysia, Indonesia, and the Philippines (Frost 2014; AmphibiaWeb 2014).

The species diversity of *Kalophrynus* is found in Peninsular Malaysia and on Borneo (Inger 1966; Ohler & Grosjean 2005; Matsui 2009). The Indochina and neighboring areas are notably depauperate in *Kalophrynus* diversity, with only two of 19 recognized species of this genus being recorded from this region. One of these, the

Accepted by J. Rowley: 19 Apr. 2014; published: 20 May 2014

Vocalization. To date, the advertisement calls of eight *Kalophrynus* species have been described (see Table 5); they can be divided in two main groups: the relatively long-duration and low-frequency calls like those of *K. interlineatus* and *K. pleurostigma*, and the short-duration, and higher frequency calls of *K. barioensis*, *K. baluensis*, *K. calciphilus*, *K. limbooliati*, *K. nubicola, K. yongi*, and *Kalophrynus cryptophonus* **sp. nov.** Other acoustic features, such as presence and number of pulses, as well as the occurrence of frequency modulation, vary between species. Since the temporal acoustical properties in amphibians are temperature-dependent (Gerhardt, Huber 2002), the difference between the species groups may be explained partially by the environmental factors; however, the frequency of calls in anurans is known to be correlated mainly with body size (see review in Wells, 2007). *K. interlineatus* and *K. pleurostigma* are among the largest representatives of the genus, and other acoustically studied species belong to the group of relatively small *Kalophrynus*, including *Kalophrynus cryptophonus* **sp. nov.**

The calling strategy in *Kalophrynus* also may differ; for example, males *K. interlineatus* vocalize in dense and loud, easy to localize choruses near the breeding ponds (Orlov & Ananjeva 2007; our observations), and small *Kalophrynus* call in rather loose choruses or singularly, often from diverse hides, and are rather hard to localize (Matsui 2009; Dehling 2011; Matsui *et al.* 2012; this study). Among small species the advertisement calls of *Kalophrynus cryptophonus* **sp. nov.** and *K. yongi* are the most similar in call duration, call repetition rate and frequency. Given that both these species are phytotelm breeders with similar male calling strategy (they call while hidden near the breeding sites), their acoustic features may be related to their reproductive ecology. Such sites (e.g. burrows and tree holes) may perform important acoustic functions, acting as resonators enhancing the frequency of maximal amplitude (Bailey & Roberts 1981; Penna & Solis 1999) or increasing sound propagation. The hollow bamboo stems are obviously good resonators, and to the human ear the calls of the males vocalizing from their natural hides sounded markedly louder than the same calls uttered inside the collector containers.

Phytotelm breeding provides a specific ecological niche for anurans, which appears relatively important for mountain-dwelling taxa in the region. Recent field studies in mountainous areas of southern Vietnam indicate that not only do typical phytotelm breeding groups of frogs, such as the rhacophorid genus *Theloderma*, reproduce in water-filled tree hollows (*T. palliatum* Rowley, Le, Hoang, Dau & Cao, *T. nebulosum* Rowley, Le, Hoang, Dau & Cao, *T. stellatum* Taylor; see Rowley *et al.* 2011a; Orlov *et al.* 2012) or bamboo internodes (*T. bambusicola*, see Orlov *et al.* 2012), but other anuran taxa that typically breed in stream or ponds show remarkable adaptations to phytotelm breeding (e.g. *Rhacophorus vampyrus* Rowley, Le, Thi, Stuart & Hoang; see Rowley *et al.* 2010; 2012; Vassilieva *et al.* 2013). The present paper is the first report of phytotelm breeding Microhylidae for Vietnam.

Acknowledgements

All fieldwork was conducted under the permission of the Department of Forestry, Ministry of Agriculture and Rural Development of Vietnam (permits No. 170/TCLN–BTTN and 831/TCLN–BTTN). We thank the Administration of Hon Ba Nature Reserve for facilitating the research expedition, and rangers of the Park for their hospitality and assistance in the field. We are grateful to Vitaly L.Trounov for the photographic work and help in preparation of illustrations, to Andrey N. Kuznetsov for help with plant identification and to Prof. W. Böhme for his recommendations concerning the species epithet. We are sincerely grateful to Dr. Jodi J.L. Rowley, Dr. Indraneil Das, Dr. Nguyen Van Truong and Dr. Nikolai L. Orlov for their kind help and useful comments which helped us to improve the previous version of the manuscript. We are deeply obliged to Jonathan Perez for his kind help with proofreading of the manuscript. The study was supported by the Russian Foundation of Basic Research (Grant RFBR-No.-13-04-00031a) and by a Grant of the President of Russian Federation (Grant No. MK-5815.2014.4) and the Russian Science Foundation (Grant RSF-No. 14-14-00388).

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APPENDIX. Material examined.

Kalophrynus interlineatus (5 specimens): southern Vietnam (Cat Tien National Park, Dong Nai Province), approximate coordinates 11°26' N, 107° 25' E, nearly 120 m a.s.l. (ZMMU A-4606; individual field numbers from ABV-00405 to ABV-00409); (5 specimens): Laos (Khammouane Province) (private collection of Nikolai L. Orlov, Zoological Institute of Russian Academy of Sciences, St. Petersbourg)

Kalophrynus pleurostygma (2 specimens): Thailand (Hala-Bala Wildlife Sanctuary, Narathiwat Province) (Herpetological collection of the Prince of Songhkla University, Hat Yai; no numbers).

Kalophrynus cryptophonus sp. nov. (6 specimens, adults): southern Vietnam (Loc Bao, Lam Dong Province), coordinates 11°44' 17" N, 107° 42' 25" E, elevation 800 m. a.s.l. (ZMMU A-4944; ZMMU A-4858; ZMMU A-4859; individual field numbers ABV-00136, and from ABV-00222 to ABV-00226); tadpoles, from the same locality as adults (ZMMUA-4986; field number ABV-00234).

Kalophrynus honbaensis sp. nov. (2 specimens): southern Vietnam (vicinity of the Yersin station on Hon Ba Mountain, Hon Ba Nature Reserve, Cam Lam District, Khanh Hoa Province), coordinates 12°07' 16" N, 108° 56' 55" E, elevation 1500 m a.s.l. (ZMMU A-4941, ZMMU A-4943; individual field numbers ABV-00302 and ABV-00320).