



Male Advertisement Call of the Endangered *Leptobranchella tengchongensis* (Anura: Megophryidae) from Mount Gaoligongshan, Yunnan Province, China

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Abstract We present the first description of the acoustic characters of the endangered Tengchong leaf litter toad (*Leptobranchella tengchongensis*), aiming to inform future ecological studies of the species and taxonomic studies in the genus *Leptobranchella*. A total of 1179 calls, belonging to 6 adults male individuals, were recorded using TASCAM DR-40 digital sound recorder from its type locality in May 2015 and then analyzed using Raven Pro v.1.6.1 software. The advertisement call of male *L. tengchongensis* consists of primary advertisement call and secondary advertisement call. The primary advertisement call is invariably composed of two notes and has a call duration of 61 ± 5 ms (23–87 ms, $n = 1142$). The secondary advertisement call is composed of 3–10 notes (mean 5.25 ± 1.41 notes/call, $n = 37$) with a call duration of 90 ± 6 ms (37–127 ms, $n = 37$). The mean inter-call interval is 212 ± 121 ms (88–1121 ms, $n = 1092$). An introductory note is absent in advertisement calls and the dominant of calls is 4.1–4.8 kHz (at 20 °C). We discuss the interspecific and intraspecific variations on advertisement calls in *L. tengchongensis* and among *Leptobranchella* species, and provide a summary on the major acoustic characters of all *Leptobranchella* species occurring north of the Isthmus of Kra.

Keywords acoustic analysis, amphibians, bioacoustics, breeding ecology, *Leptolalax*, taxonomy, Tengchong

1. Introduction

Vocalizations is the main communication mechanism in anuran amphibians, at both interspecific and intraspecific levels (Köhler *et al.*, 2017). Almost all anurans depend on acoustics signals to locate each other during breeding season (Wells and Schwartz, 2007). Advertisement calls are the main type of vocalization in anurans (Köhler *et al.*, 2017). Advertisement calls are species specific and, therefore, considered a prezygotic mechanism of reproductive isolation (Littlejohn, 1998). They also provide informative characters for identifying and delimiting species and, as such, are widely used in taxonomic research (Goicoechea *et al.*, 2010).

The Asian leaf litter toads of the genus *Leptobranchella* Dubois, 1983 is widely distributed from southern China to northeastern India and Myanmar, through Indochina mainland to peninsular Malaysia and the island of Borneo (Frost, 2020). Frogs in the genus inhabit the forest floor and rocky streams in hilly evergreen forest (Fei *et al.*, 2012). Due to their small size and cryptic coloration, *Leptobranchella* are often difficult to detect and identify in the field; advertisement calls produced by adult males during the breeding seasons are a major clue to trace these elusive anurans (Matsui *et al.*, 2009). Moreover, acoustic data can assist in rapidly surveying anurans, and further offer a new insight into species diversity, species boundaries and evolutionary relationships within this morphologically conserved group (Rowley *et al.*, 2011; Rowley *et al.*, 2016). Acoustic data has become increasingly important in the taxonomic study of the genus *Leptobranchella* in recent years (see Rowley *et al.*, 2016; Yang *et al.*, 2018 as examples), and the use of an integrative approach incorporating acoustic, morphological, and molecular data has resulted in the continued discovery of new anuran species in the region (Yang *et al.*, 2018; Wang *et al.*,

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2019; Li *et al.*, 2020).

The Tengchong leaf litter toad (*Leptobrachella tengchongensis*) is a recently described species discovered on Mount Gaoligongshan in Yunnan Province in China (Yang *et al.*, 2016). The species is currently categorized as Endangered by the IUCN Red List of Threatened Species due to its restricted and small distribution range as well as ongoing habitat degradation (IUCN SSC Amphibian Specialist Group, 2020). However, the male advertisement call of this endangered species remains undocumented. Herein, we describe the acoustic characteristics and calling behavior of *L. tengchongensis* based on recordings of male advertisement calls from the type locality of the species. We aim to provide informative characters for future ecological studies of the species and for taxonomic research in the genus *Leptobrachella*.

2. Material and Methods

2.1. Study site The advertisement calls of male *Leptobrachella tengchongensis* were recorded at the type locality of the species, at the Linjiapu substation of the Tengchong Section of Gaoligongshan National Nature Reserve, Tengchong County, Yunnan Province, China (25°17'51.26" N, 98°42'03.93" E, 2100 m above sea level). See Yang *et al.* (2016) for detailed information and photos regarding the macro- and micro-habitats of the locality. The call recordings were made between 21:00 to 23:40 h on 16 May 2015 by J. Yang, and the ambient air temperature was approximately 20 °C. The ambient air temperature of the calling site was taken with a digital thermometer (Peakmeter MS6508).

2.2. Call recording Advertisement calls were recorded using a TASCAM DR-40 digital sound recorder held within ca. 30–50 cm of the calling individuals. All recordings consist of a minimum duration of 30 seconds call. The sound files in wave format were resampled at 48 kHz with sampling depth 24 bits.

2.3. Acoustic analyses The sonograms and waveforms were generated by Raven Pro 1.6.1 software (The Cornell Lab of Ornithology, available from <http://www.birds.cornell.edu/raven>) with Fast Fourier samples 512 points and overlap 50%, from which all parameters and characters were measured as following Rowley *et al.* (2012, 2016) and Yang *et al.* (2018): call duration (ms), call repetition rate (calls/s), Inter-call interval (ms), number of notes per call and dominant frequency (kHz). The recordings of the advertisement call of the male holotype was deposited at Amphibiaweb and is available at the url https://amphibiaweb.org/sounds/Leptobrachella_tengchongensis56.mp3.

2.4. Data comparison Comparative advertisement call characters for *Leptobrachella* species occurring north of the

Isthmus of Kra were taken from references (Jiang *et al.*, 2002; Xu *et al.*, 2005; Matsui, 2006; Rowley and Cao, 2009; Rowley *et al.*, 2010a, 2010b, 2010c, 2011, 2012, 2013, 2015a, 2015b, 2016, 2017a, 2017b; Poyarkov *et al.*, 2015; Nguyen *et al.*, 2018; Yang *et al.*, 2018; Chen *et al.*, 2019; Ding *et al.*, 2019; Wang *et al.*, 2019; Li *et al.*, 2020). The minimum and maximum values are given as min–max, all numeric parameters are given as mean ± SE.

3. Results

3.1. Calling behavior During the survey, males of *Leptobrachella tengchongensis* were mostly found calling on the forest floor with dense understory, close to the main stream and near a seepage. The majority of calling males were found perched on or hidden under leaf litter. Some were found calling under rocks by the side of the main stream.

Sympatric amphibians recorded in the locality during the survey in May 2015 included the Spiny stream toad (*Bufo tuberospinus*), Glandular horned toad (*Megophrys glandulosa*), Yunnan spiny frog (*Nanorana yunnanensis*), Anderson's frog (*Odorrana andersonii*), Chaochiao brown frog (*Rana chaochiaoensis*), Green-spotted torrent frog (*Amolops viridimaculatus*), Burmese treefrog (*Rhacophorus burmanus*), and an unidentified small-sized *Megophrys*. Among them, advertisement calls of *M. glandulosa*, *R. burmanus* and the unknown *Megophrys* sp. were also heard during the survey.

3.2. Acoustic characteristics analyses Recordings of six calling males of *L. tengchongensis* were obtained during the survey. A total of 271 seconds of recordings contained 1179 clear advertisement calls and were used for acoustic analyses. Within the recordings sampled, all individuals emitted a continuous call series with durations of minimum 15 seconds to maximum 120 seconds.

We recognized two different types of advertisement calls among the recordings sampled (Table 1 and Figure 1), namely the primary advertisement call (PAC) and secondary advertisement call (SAC), following Rowley *et al.* (2013; 2017a, b). While PACs were the dominant call of a continuous call series, SACs were rarely and irregularly emitted within a call series and sometimes absent. PACs invariably contained two notes per call and were repeated rapidly with a regular call duration and inter-call interval (Figures 1A and B). SACs consisted of 3–10 notes per call with an irregular call duration (Figures 1A and C), but shared the same dominant frequency with PACs in a call series. The call duration was longer in SACs (Table 1 and Figure 1). To the human ear, the PAC is a very rapid, high-pitched ticking, similar to calling songs of orthopteran species, while the SAC sounds like an irregular, prolonged PAC.

The PACs of six individuals were uniform in call structure, which invariably consisted of two pulsed notes with amplitude

Table 1 Measurements of male advertisement call parameters in *Leptobrachella tengchongensis*.

	Individual A	Individual B	Individual C	Individual D	Individual E	Individual F	All Individuals
Voucher specimen No.	None	None	None	None	None	Holotype (SYS a004600)	N/A
Primary advertisement call (PAC)							
Number of calls measured	203	75	26	125	685	28	1142
Duration (ms)	67 ± 6 (54–87)	60 ± 11 (23–79)	63 ± 15 (29–77)	58 ± 5 (49–77)	54 ± 4 (43–79)	65 ± 3 (56–70)	61 ± 5 (23–87)
Notes/Call	2	2	2	2	2	2	2
Dominant Frequency (kHz)	4.52 ± 0.04 (4.48–4.57)	4.73 ± 0.08 (4.48–4.82)	4.53 ± 0.12 (4.31–4.82)	4.63 ± 0.06 (4.57–4.74)	4.39 ± 0.12 (4.31–4.74)	4.48 ± 0.06 (4.22–4.67)	4.55 ± 0.12 (4.22–4.82)
Secondary advertisement call (SAC)							
Number of calls measured	4	Not recorded	33	Not recorded	Not recorded	Not recorded	37
Duration (ms)	86 ± 3 (82–89)	N/A	94 ± 24 (37–127)	N/A	N/A	N/A	90 ± 6 (37–127)
Notes/Call	4.25 ± 0.05 (4–5)	N/A	6.24 ± 2.28 (3–10)	N/A	N/A	N/A	5.25 ± 1.41 (3–10)
Dominant Frequency (kHz)	4.52 ± 0.05 (4.48–4.57)	N/A	4.48 ± 0.12 (4.12–4.74)	N/A	N/A	N/A	4.5 ± 0.03 (4.12–4.74)
Inter-call interval (ms)	175 ± 49 (95–361, n = 206)	199 ± 13 (180–219, n = 13)	452 ± 145 (273–1023, n = 41)	157 ± 69 (104–606, n = 121)	117 ± 69 (88–1121, n = 684)	170 ± 54 (102–260, n = 27)	212 ± 121 (88–1121, n = 1092)
Call repetition rate (calls/s)	4.06 (n = 1)	3.26 ± 0.09 (3.19–3.33, n = 2)	1.63 ± 0.43 (1.32–1.93, n = 2)	4.39 (n = 1)	5.85 (n = 1)	6.49 (n = 1)	4.28 ± 1.76 (1.32–6.49, n = 8)

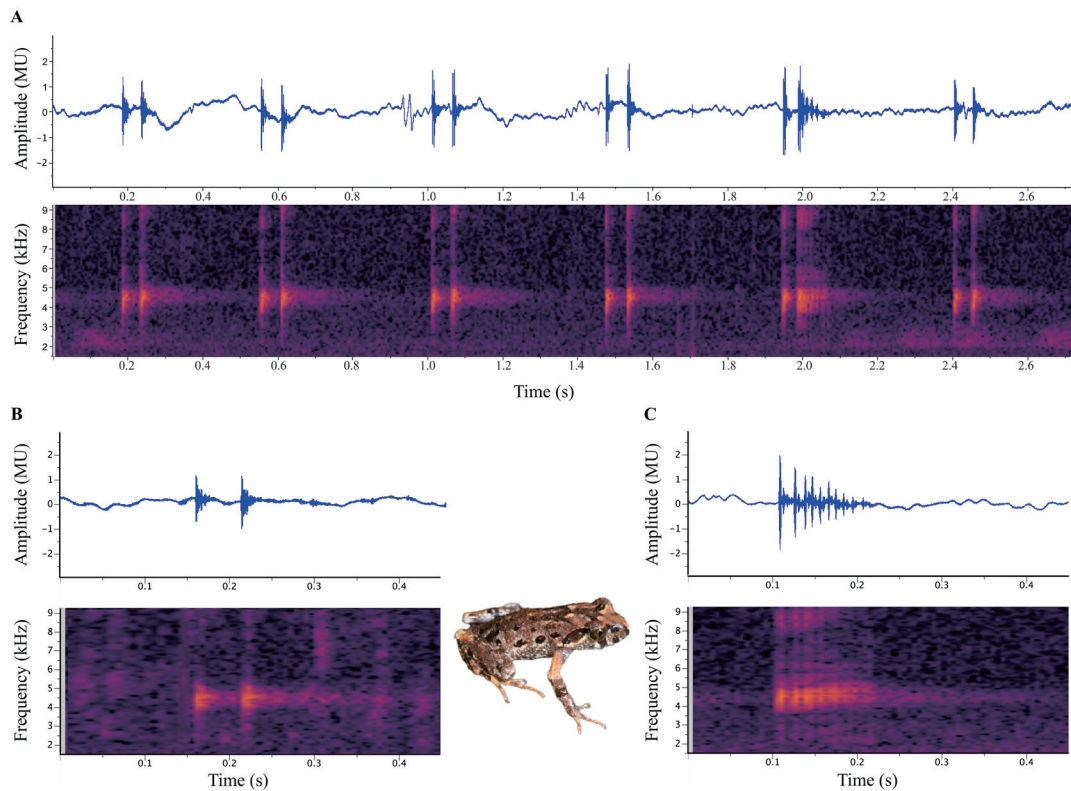


Figure 1 Advertisement call of male *Leptobrachella tengchongensis*. A: waveform (MU) and spectrogram (kHz) showing a six-call portion of five PACs and a SAC (the 5th call) in a continue call series. B: waveform (MU) and spectrogram (kHz) showing a 2-notes PAC. C: waveform (MU) and spectrogram (kHz) showing a 10-notes SAC.

peaking at the start of each note. The call durations of PACs were similar among individuals, with the average duration ranging between 54–67 ms (Table 1).

SACs were only recorded in two individuals (individual A and C, see Table 1). Unlike the PACs, the call durations and notes/call of SACs showed great variations (see Table 1). The 37 SACs measured were in highly variable in both call structure and call duration (90 ± 6 ms, 37–127 ms, see Table 1).

The advertisement calls of *L. tengchongensis* were typically emitted in continuous call series. The average inter-call interval of continuous call series sampled was 212 ± 121 ms (88–1121 ms, $n = 1092$). Within call series, advertisement calls were repeated at a rate of approximately 4.28 ± 1.76 calls per second (1.32–6.49 calls/s, $n = 8$).

The dominant frequency of advertisement calls presented a certain degree of variation both within and among individuals (see Table 1). The dominant frequency ranged from 4.12 to 4.82 kHz in individual C, and the mean dominant frequency ranged between 4.39–4.73 kHz among six individuals. We found two individuals (individual A and B) calling simultaneously nearby (ca. 3 meters apart) during the survey. While call durations and inter-call intervals of these two individuals were relatively similar, the mean dominant frequency was slightly different, 4.52 kHz and 4.73 kHz in individual A and individual B respectively.

4. Discussion

The advertisement calls of the three other *Leptobranchella* species from northern Vietnam and northern Laos, namely *L. botsfordi*, *L. petrops* and *L. puhoatensis*, were also reported containing both PACs and SACs (Rowley *et al.*, 2013; Rowley *et al.*, 2017a, b). Furthermore, based on our field observations, most species of *Leptobranchella* from China (i.e., *L. laui*, *L. liui*, *L. mangshanensis*, *L. oshanensis*, and *L. ventripunctatus*) can also emit SACs as part of long call series of PACs (J. Yang and H. Y. Yeung, unpublished data). Thus, we assume that the SAC may actually commonly occur in advertisement calls of *Leptobranchella* species from China and northern Indochina (=lineage A of the genus in Chen *et al.*, 2018), and the lack of descriptions of SACs in some previous studies in the region may be due to the insufficient sample size of recordings and/or the fact they have been overlooked by other author(s). In general, SACs are similar to the dominant PACs in note structure, but have more notes per call and longer call durations, which sounds to the human ear like prolonged PACs (Rowley *et al.*, 2013; Rowley *et al.*, 2017a, b; this study). However, SACs are rarely and irregularly emitted in a continuous call series. Taking this study as an example, only recordings of two out of six individuals of *L. tengchongensis* sampled in the wild contained SACs. Therefore, more calling

individuals sampled and longer recordings are desirable in order to determine whether SACs are present in the male advertisement call of a species.

For most species of the *Leptobranchella applebyi* species group (= lineage B of the genus in Chen *et al.*, 2018) from the central highlands of southern Indochina, the advertisement call typically contains a distinct introductory note, which is a longer note occurring at the beginning of each call (Rowley *et al.*, 2010b, 2016). However, this introductory note was not observed in *L. tengchongensis* in this study, and has never been documented for other *Leptobranchella* species from China, northern Indochina and south of Isthmus of Kra (see Matsui, 1997; Matsui, 2006; Matsui *et al.*, 2009; Rowley *et al.*, 2013; Yang *et al.*, 2018 as examples). Therefore, we assume that the introductory note may only occur in advertisement calls of *L. applebyi* species group, and may be considered as a unique acoustic character of this species group, although not present in all species in the group.

Our results indicate that while the SACs of *L. tengchongensis* had great intraspecific variations in both call structure (no. of notes per call) and call duration, PACs had a stable call structure and had very small intraspecific variations in call duration among all individuals (Table 1), which can be considered as a key diagnostic character of the species. However, PACs do show a certain degree of intraspecific variations in call structure in some *Leptobranchella* species (Table 2).

The dominant frequency of advertisement calls is commonly used as an important diagnostic acoustic character in the species comparison of the genus *Leptobranchella* (see Rowley *et al.*, 2013; Rowley *et al.*, 2017a, b; Yang *et al.*, 2018; Chen *et al.*, 2019 as examples). It is worth noting that, in this study, we observed a certain degree of intraspecific variation on the dominant frequency in *L. tengchongensis*, ranging in between 4.1–4.8 kHz. Such variation had also been documented in some congeneric species, for examples *L. aerea* (6.2–7.9 kHz, Rowley *et al.*, 2010b) and *L. firthi* (5.4–6.6 kHz, Rowley *et al.*, 2012). Similar great intraspecific variation in inter-call interval and call repetition rate were also found in *L. tengchongensis* and in other *Leptobranchella* species (see Tables 1 and 2). As a result, we recommend that researchers pay more attention to the intraspecific variation in these parameters when using acoustic data in taxonomic work, and try to obtain advertisement call recordings that are longer in duration, from more individuals, and from a greater number of locations.

According to Yang *et al.* (2019), three *Leptobranchella* species occur on Mount Gaoligongshan, namely *L. tengchongensis*, *L. ventripunctata* and an unknown *Leptobranchella* sp.. Acoustic characteristics and breeding behaviors appear to different among the species. The peak frequency is 4.2–4.8 kHz in *L. tengchongensis* (20 °C), 6.1–6.6 kHz in *L. ventripunctata* (15 °C), and 4.1–4.3 kHz in *Leptobranchella* sp. (3 °C); the PACs are composed

Table 2 Summary of male advertisement call parameters for species of *Leptobrachella* occurring north of the Isthmus of Kra with documented calls.

Species	Secondary call	Notes/Call	Call duration (ms)	Inter-call interval (ms)	Individuals analyzed	No. of calls analyzed	Introductory note	Dominant frequency (kHz)	Calling season	Elevation (m)	Temperature (°C)	Source
<i>aerea</i>	not documented	2-16	13-130	4-582	6	120	absent	6.2-7.9	Jun, Nov	284-511	22.4-25.7	Rowley et al., 2010b
<i>alpina</i>	not documented	9	270	unknown	1	11	absent	6.7	May	1150-2400	16	Fei et al., 2012; Xu et al., 2005
<i>applebyi</i>	not documented	3-6	213-404	unknown	3	unknown	present	3.9-4.3	Mar, Jul	1200-1500	21.5	Rowley and Cao, 2009; Rowley et al., 2016
<i>ardens</i>	not documented	3-10	114-373	unknown	7	unknown	present (not all calls)	3.1-3.4	Aug	1041-1450	21.4-24.7	Rowley et al., 2016
<i>bidupensis</i>	not documented	5-8	308-400	unknown	3	48	absent	1.9-2.3	May, Jul	1620-1730	19-20.4	Rowley et al., 2011; Rowley et al., 2016
<i>bijie</i>	not documented	2	988-264	101.9-245.2	4	200	absent	4.8-5.1	Jul	1670-1750	18.6	Wang et al., 2019
<i>boisfordi</i>	present	3 (PAC) 1 (SAC)	239-303 (PAC) 194-283 (SAC)	406-1028	1	15	absent	2.6-3.2 (PAC) 2.8-3.4 (SAC)	June	3143	14	Rowley et al., 2013
<i>chishuensis</i>	not documented	1-4	75-353	8-98	1	32	absent	6.1-6.3	May	270-604	20	Li et al., 2020
<i>crocus</i>	not documented	4-6	164-249	400-14100	6	57	absent	2.6-3.0	Jul	1300	21.6-25.1	Rowley et al., 2010a
<i>firthi</i>	not documented	2-5	18-51	327-2285	6	60	absent	5.4-6.6	Mar, Apr	860-1720	18.3-21.2	Rowley et al., 2012
<i>fuliginosus</i>	not documented	6-9	51-80	unknown	unknown	unknown	absent	2.3-2.4	Dec	unknown	19.3-19.6	Matsui, 2006
<i>isos</i>	not documented	3	28-34	248-1060	4	40	absent	5.8-6.2	Jun, Aug, Oct	650-1100	22.4-22.8	Rowley et al., 2015a
<i>kalmensis</i>	not documented	4-5	201	unknown	1	unknown	present	2.8	Aug	200-791	26.4	Rowley et al., 2016
<i>liui</i>	not documented	2-4	26-78	unknown	5	245	absent	4.8-5.5	Apr	730-1400	14.7-20.2	Ding et al., 2019; Fei et al., 2012
<i>maculosa</i>	not documented	7-38	889-907	unknown	2	unknown	indistinct	2.7-2.8	Sep	900-1166	23.3-24.1	Rowley et al., 2016
<i>melicus</i>	not documented	4-11	168-484	214-3821	2	80	present	2.6-4.0	Jun, Oct	600-850	26.1-26.2	Rowley et al., 2010b
<i>oshanensis</i>	not documented	3	29-67	unknown	1	unknown	absent	4.4-4.6	May	720-1800	14	Fei et al., 2012; Jiang et al., 2002
<i>pollidus</i>	not documented	4-7	627-729	unknown	3	unknown	present (short)	2.4-2.7	Jun, Jul	1644-1681	14-21.4	Rowley et al., 2016
<i>patrops</i>	present	1-6 (PAC) 13-28 (SAC)	5-62 (PAC) 196-379 (SAC)	174-805	7	unknown	absent	5.6-6.4 (PAC) 5.3-6.6 (SAC)	May	234-1283	24.5-25.3	Rowley et al., 2017b
<i>puloatensis</i>	present	1 (PAC) 41 (SAC)	6-14 (PAC) 299 (SAC)	74-128	5	100	absent	4.9-5.6 (PAC) 5.3 (SAC)	Jun	1123-1352	22.3-25.8 24.3	Rowley et al., 2017a
<i>purpura</i>	not documented	1	86-117	430-1557	1	20	absent	4.3-4.5	Apr	1615	15	Yang et al., 2018
<i>purpuraventra</i>	not documented	2	90.3-192.2	90.8-217.8	5	193	absent	4.7-4.8	Jul	1600-1900	18.8-19.3	Wang et al., 2019
<i>pyrrhops</i>	not documented	5-6	208-297	3260-5630	1	7	present	1.9-2.2	Apr	800-1100	25	Poyarkov et al., 2015
<i>rowleyae</i>	not documented	4-6	276-517	68-576	4	40	absent	3.2-3.5	Aug to Feb	380-645	20.8-21.5	Nguyen et al., 2018
<i>shangstensis</i>	not documented	1	64-69	184-289	1	30	absent	5.5-6.5	Apr	450-550	21.5	Chen et al., 2019
<i>tadungensis</i>	not documented	4-7	248-353	unknown	4	unknown	present	2.6-3.1	Jul	720-1932	12.9-22.3	Rowley et al., 2016
<i>tengchongensis</i>	present	2 (PAC) 3-10 (SAC)	23-87 (PAC) 37-127 (SAC)	88-1121	6	1179	absent	4.2-4.8 (PAC) 4.1-4.7 (SAC)	Apr, May	2000-2100	20	This study
<i>tuberosus</i>	not documented	1	54-78	1800-13800	3	20	absent	2.6-2.8	Jul	836-1401	22.5-24.5	Rowley et al., 2010a
<i>ventripunctata</i>	present	4-6 (PAC) 9-17 (SAC)	87-562	120-1369	1	73	absent	6.1-6.6	Apr, May, Jun	850-1360	15	This study; Fei et al., 2012
<i>yingjiangensis</i>	not documented	1	28-42	113-174	2	35	absent	5.7-5.9	May, Jun	1615	19	Yang et al., 2018

Remarks: Notes/call, call duration and dominant frequency were given separately in two different type of advertisement calls, namely primary advertisement call (PAC) and secondary advertisement call (SAC), for some species for which these data were available.

of 2 notes in *L. tengchongensis*, 4–6 notes in *L. ventripunctata* and 3–11 notes in *Leptobranchella* sp. (J. Yang and H. Y. Yeung, unpublished data). Furthermore, while *L. tengchongensis* breeds in April and May and inhabits in 2000–2100 m elevations, calling males of *L. ventripunctata* can be heard from April to June and only recorded at relatively lower elevation at 1,350 m on Mount Gaoligongshan; while *Leptobranchella* sp. only breeds in March when night time air temperature was ca. 3 °C and inhabits in 1 950–2 100 m elevations (Yang *et al.* 2019; J. Yang and H.Y. Yeung, unpublished data).

A summary of the major acoustic characters of the advertisement calls of *Leptobranchella* species occurring north of the Isthmus of Kra for which comparable acoustic data are available is presented in the Table 2, in order to provide a quick key for future taxonomic research on the genus. Compared with its congeners, the major acoustic characters of *L. tengchongensis* include the presence of two types of the advertisement calls, primary advertisement call and secondary advertisement call; the primary advertisement call is invariably composed of two notes and has a call duration of 61 ± 5 ms (23–87 ms, $n = 1142$); the secondary advertisement call is composed of 3–10 notes (mean 5.25 ± 1.41 notes/call, $n = 37$) with a call duration of 90 ± 6 ms (37–127 ms, $n = 37$); the mean inter-call interval is 212 ± 121 ms (88–1121 ms, $n = 1092$); and the dominant frequency of the calls is 4.1–4.8 kHz (at 20 °C).

Anurans can emit different call types that contains different social functions (Camurugi *et al.*, 2015; Köhler *et al.*, 2017). We speculate that the two different types of advertisement call in *L. tengchongensis* should also have distinct different signals. The dominant PACs with stable and regular call characters should serve to attract females and convey territorial information to competitors, which are commonly observed in anuran amphibians as breeding calls (Wells and Schwartz, 2007; Morais *et al.*, 2012). However, the social function of the SACs is unclear and needs to be clarified in further studies.

Currently, advertisement calls for only nine out of the twenty-six *Leptobranchella* species occurring in China have been described. Moreover, most previous descriptions of *Leptobranchella* species in the region were based on only a few dozen advertisement calls (see Table 2), and mostly belonging to only a single individual, which cannot provide a better understanding on the intraspecific variation. Herein, we encourage field herpetologists should record and analysis the undocumented acoustic characteristics of anuran amphibians, and try to obtain more recording samples from more individuals if possible.

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