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Who's who? Comparison of the advertisement calls of two East African sister species of *Hyperolius* (Anura: Hyperoliidae)

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Abstract. The advertisement calls of *Hyperolius mitchelli* and *Hyperolius puncticulatus*, two taxonomically frequently confused syntopic species, are described. The calls of both species are distinctly different and show only minor overlap. The main differences can be found in temporal patterns, such as note duration, and a different pattern in call series, as well as in the frequency patterns of notes.

Key words. Amphibia, Anura, Hyperoliidae, *Hyperolius mitchelli*, *H. puncticulatus,* bioacoustics.

Hyperolius mitchelli Loveridge, 1953 and *Hyperolius puncticulatus* (Pfeffer, 1893) are two medium-sized, sympatric sister taxa, which are morphologically (Fig. 1) and ecologically quite similar. *Hyperolius mitchelli* is known from north-eastern Tanzania to Mozambique (Schiøtz 1975, 1999) and Zanzibar (Pakenham 1983), where it inhabits a broad range of habitats including forest and bushland localities. *Hyperolius puncticulatus* is distributed in East African forest areas from southern Malawi northward to coastal Kenya (Schiøtz 1999) also including Zanzibar (Pfeffer 1893, Poynton & Broadley 1987). It was suggested that *H. puncticulatus* might occur in northern parts of Mozambique and northeastern Zambia (IUCN et al. 2006), but voucher specimens from this region are lacking. Moreover, Poynton & Broadley (1987) noted that records from Zimbabwe and South Africa might actually correspond to misidentified *Hyperolius argus* Peters, 1854. Nevertheless, both species occur in sympatry in almost their entire ranges (Fig. 2), which is remarkable since no other species pair of anurans in this area shows a similar distribution pattern (IUCN, Conservation International, & NatureServe: Global Amphibian Assessment. <www.globalamphibians.org>. Downloaded 15 May 2008). Also microhabitat requirements of both species seem to be nearly identical (Schiøtz 1975, Schiøtz 1999, Channing & Howell 2006, Pickersgill 2007). As pointed out by several authors (e.g. Schiøtz 1975, 1999, Köhler et al. 2005), the morphological similarity of *H. mitchelli* and *H. puncticulatus* has frequently caused confusion and misidentifications in the past. Here, advertisement call properties may be a useful tool for proper species identification. Although bioacoustic data have in principal been published for both species (e.g. Schiøtz 1975, 1999, Köhler et al. 2005, Channing & Howell 2006, Pickersgill 2007), a direct comparison of the calls of both species and a description of the structure of call series is lacking.

In December 2007, specimens of *H. mitchelli* and *H. puncticulatus* were collected in north-eastern parts of Tanzania and imported to Germany for pet trade. An interview with the exporter revealed that the origin of the specimens was most likely the Uluguru Mts. This was further confirmed since several specimens of *Melanoseps emmrichi* and *Leptopelis uluguruensis*, endemic to these mountains, were present in the same shipment. Four males of *H. mitchelli* and five males of *H. puncticulatus* were kept separately in two terraria illuminated for 12 hrs per day, whereby temperature ranged between 18 and 28 °C. Species were assigned to the species based on the presence of whitish heel spots in *H. mitchelli*, absent in *H. punctícu-*

Tab. 1. Numerical call parameters of *Hyperolius mitchelli* and *H. puncticulatus*. The range is followed by the mean value ± standard deviation in parentheses.

	H. mitchelli		*H. puncticulatus*
call type	type 1	type 2	
voucher specimens	ZFMK 87604-87608		ZFMK 87612-87615
air temperature (°C)	25	25	25
number of individuals / calls analysed	5 / 12	2 / 5	3 / 35
note duration (s)	0.21 - 0.42 (0.25 ± 0.07)	0.33 - 0.39 (0.37 ± 0.024)	0.04 - 0.10 (0.06 ± 0.01)
notes / second	0.43		0.24
pulses / note	indistinct	6 - 8 (7 ± 0.70)	indistinct
pulses / second	indistinct	17.85 - 20.40 (19.05 ± 1.18)	indistinct
intervals between calls in series (s)	0.89 - 2.75 (1.42 ± 0.57)	1.56 - 1.82 (1.70 ± 0.20)	0.18 - 0.82 (0.25 ± 0.14)
dominant frequency range (kHz)	1.68 - 4.63	2.20 - 4.35	2.21 - 4.33
maximum call energy at (kHz)	2.50 - 3.76 (3.37 ± 0.52)	3.70 - 3.80 (3.77 ± 0.05)	2.98 - 3.72 (3.48 ± 0.25)

latus while resting during day time (Schiøtz 1975, 1999). Both species are able to change the intensity of their colour patterns between day and night, whereby many specimens of both species are nearly completely yellowish during the night, complicating identification in the field. DNA samples of the call vouchers of both species were analysed subsequently and confirmed their identity (S. Schick, unpubl. data). Voucher specimens were deposited in the Zoologisches Forschungsmuseum Alexander Koenig (ZFMK), Bonn. Calls were recorded by the first author using a Philips SBC ME570 microphone, a Realtec PC-Soundcard and Audacity 1.2.6. They were sampled at a frequency of 96 kHz and 32 bit resolution. Air temperature during recording was 25 °C. Call recordings were cut and analysed with Adobe Audition 3.0 (Adobe) and Syrinx (Burt, J; available at http://zipprong.psych.washington.edu/index.html, downloaded May 2007). Spectral information was obtained by Fast Fourier Transformation at a width of 1024 points. Terminology in call descriptions follows Köhler (2000).

Shortly after sunset (19:00 hrs CET, shortly after turning off the light), males of both species started to call. Call activity was recorded between 19:00 and 1:00 h, with a maximum call activity between 19:30 and 22:00 h. Occasionally, calls of *H. puncticulatus* were noted during the day. We were able to identify two call types emitted by *H. mitchelli* and one type emitted by *H. puncticulatus*. Call type 1 of *H. mitchelli* can be characterised as a dull scream. It consists of a single, indistinctly pulsed note (Fig. 3) repeated in series of 4 – 11 notes in relatively regular intervals. The duration of single notes is variable in our recordings, ranging from 0.21 to 0.42 s. Two peaks in call energy are identifiable at 2.30 and 3.76 kHz within the dominant frequency range (Fig. 4, Table 1), whereby frequency modulations are absent. Call type 2 emitted by *H. mitchelli* can be characterised as a series of six to eight distinctly pulsed notes with a length of 0.33 to 0.39 s (Figs. 3, 5). Notes within calls show an increasing intensity (Fig. 3) and two frequency maxima at about 3.75 and 3.00 kHz. Frequency modulations within calls are absent. Males emitted this type preferably alternating in chorus. Advertisement calls of *H. puncticulatus* consist of a single, indistinctly pulsed note (Fig. 3), which is shorter and higher pitched at the beginning compared to the call 1 of *H. mitchelli* (Table 1). The frequency intensities of the notes increase steadily between 1.8 and 3.75 kHz with a single maximum at about 3.48 kHz (Fig. 4). A second energy maximum, as reported for *H. mitchelli*, and frequency modulations are lacking. Call series recorded of *H. puncticulatus* consisted at the beginning of the chorus of series of single notes or of groups of two to eight notes during phases of higher call activity (Fig. 6). Intervals between notes in such groups have a mean duration of 0.25 s and intervals between note groups within a call series have a mean duration of 1.00 – 11.73 s (mean = 3.99 ± 3.48 s).

Advertisement call type 1 of *Hyperolius mitchelli* resembles Schiøtz's (1975) description of the advertisement call, composed of an irregular series of screams with call durations of more than 0.05 s and an indistinct frequency intensity maximum at about 3.5 kHz. Schiøtz (1999) noted call durations of 0.5 s which compared with the provided spectrogram is apparently a typing error and should rather be 0.05 s, which is only slightly above the range of our measurements. The variable call duration might be possibly be due to the indistinct pulsatile structure of the call, making it difficult to decide where the call actually terminates, especially when some background noise is involved. Pickersgill (2007) presented generalised call descriptions based on calls recorded at Muheza, Morogoro, Mzuzu and Chinteche in Tanzania. Recordings taken at Muheza showed a considerable frequency modulation between 215 and 237 Hz, which is lacking in our recording and less pronounced in his other recordings. The dominant frequencies listed by Pickersgill (2007) are comparable to ours (2.9 to 3.6 vs. 1.68 to 4.63 kHz), but our recordings lack distinguishable harmonics. The call duration reported by Pickersgill (2007) ranges between 0.054 and 0.101 s, which is much shorter, compared to our recording. In conclusion, Pickersgill´s (2007) descriptions more likely resemble calls of *H. puncticulatus* as described by Köhler et al. (2005) and by us. Advertisement call type 2 of *H. mitchelli* was most often emitted when two or more males called simultaneously. It was not described previously by other authors and it is unclear whether it is an advertisement or rather an aggressive call. Anyway, aggressive interactions were not observed and it was also emitted by a specimen separated from other specimens.

Fig. 1. *Hyperolius mitchelli* (A) and *H. puncticulatus* (B) from the Uluguru Mts., Tanzania, in life.

Schiøtz (1975, 1999) described the advertisement call of *H. puncticulatus* as a slow series of brief, rather atonal clicks with an intensity maximum at about 2.5 to 3.0 kHz. Schiøtz (1975) reported a single call duration of about 0.02 s and a call rate of 2/s. Call duration in our recordings is similar, but frequency peaks of high intensity in our recordings are higher (mean 3.48 kHz). Köhler et al. (2005) stated that the calls recorded

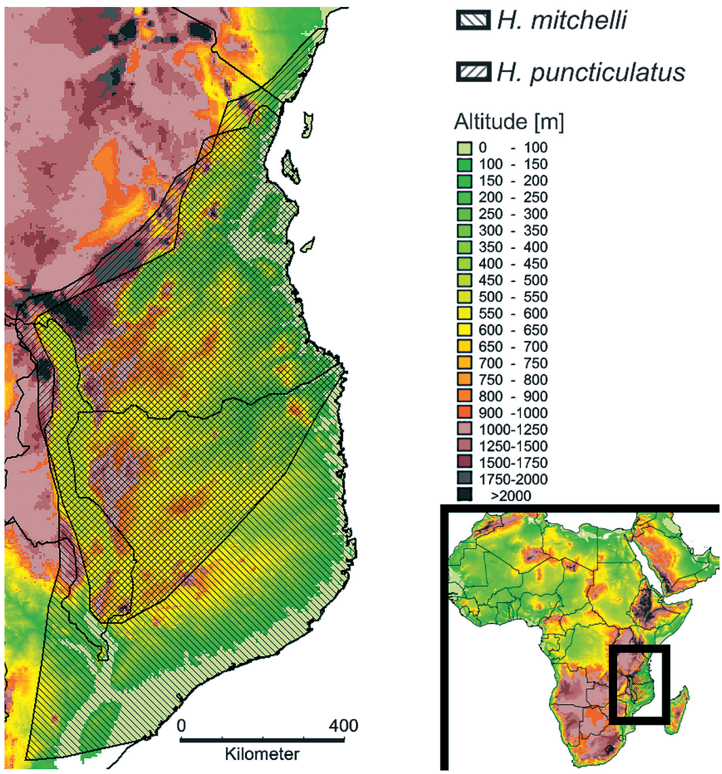

Fig. 2. Schematic map of eastern Africa showing known ranges of *H. mitchelli* and *H. puncticulatus* according to IUCN et al. (2006).

at Lushoto consisted of a single, indistinctly pulsed note emitted in groups of 7 - 11 notes separated by an interval of approximately the duration of a call group. Groups of two to four notes within call series were reported for the species by Pickersgill (2007) (termed *H. substriatus*) at Chiradzulu, groups of nine for Amani, groups of six to seven for Mbam-

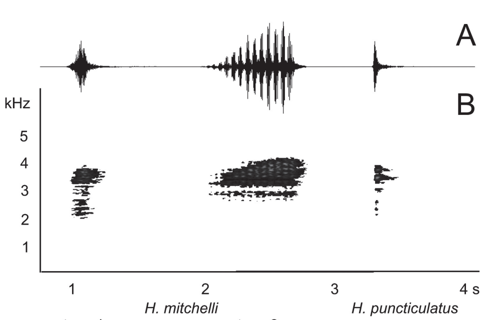

Fig. 3. Oscillogram (A) and sound spectrogram (B) of advertisement call of *Hyperolius mitchelli* (left) and *Hyperolius puncticulatus* (right).

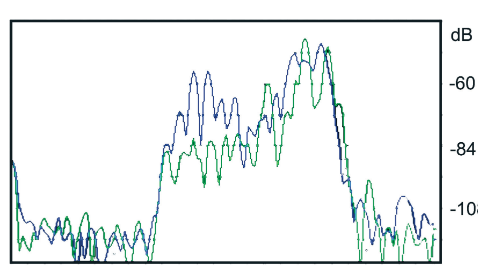

Fig. 4. Comparison of frequency intensities within notes between call type 1 of *Hyperolius mitchelli* (violet) and *Hyperolius puncticulatus* (green).

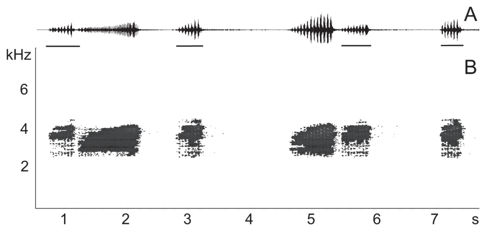

Fig. 5. Oscillogram and spectrogram illustrating call type 2 of *Hyperolius mitchelli* during a male – male interaction. Calls emitted by the same specimen are underscored in the oscillogram.

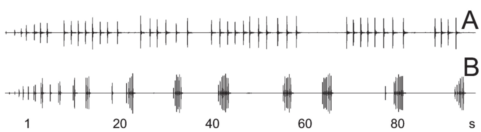

Fig. 6. Oscillograms illustrating different structures of call series of *Hyperolius mitchelli* call type 1 (A) and *H. puncticulatus* (B) at the same time scale.

ba Bay, groups of about 10 for Chiradzulu, and groups of four to eight for Limbe. The temporal patterns of call series analysed by us were slightly different (Fig. 6) probably depending on individual motivation, which strongly triggers call repetition rates (Köhler 2000, Narins et al. 2007). Pickersgill (2007) presented short call descriptions based on calls recorded at above mentioned localities, which largely resemble our results for *H. puncticulatus*, although the dominant frequency range is slightly wider in his recordings (1.7 to 4.8 kHz vs. 2.21 to 4.33 kHz). The note duration is similar.

Our results revealed that the acoustic niches of both species are distinctly different and show only minor overlap. The main differences can be found in temporal patterns, e.g. longer note duration (Fig. 3), two vs. one energy maxima of notes (Fig. 4), and a different pattern in call series (Figs. 3, 6). It was shown that properties of call features can be very variable whereby others may be highly invariant from call to call within and between bouts of calling by an individual (for a review see Narins et al. 2007). Typically these static properties include spectral features such as the fundamental frequency or carrier frequency or frequencies (dominant and specially enhanced frequency components) and fine-scale temporal properties such as the repetition rate, duration, and rise–fall characteristics of pulses and notes (Narins et al. 2007). Therefore, note duration and the different frequency intensity patterns, e.g. the lack of a second frequency intensity maximum in *H. puncticulatus* present in *H. mitchelli*, may be more suitable for species identification than differences in call series. Variations in these call patterns may occur depending on the presence (or absence) of other species which may cause competitive character displacements. Such populations of *H. mitchelli* are possibly present in southern Malawi and Mozambique where *H. puncticulatus* might be absent, and of *H. puncticulatus* in southern Kenya where *H. mitchelli* might not occur.

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References

Channing, A. & K. M. Howell (2006): Amphibians of East Africa. – Cornell University Press, Ithaka, NY.

Köhler, J. (2000): Amphibian diversity in Bolivia: a study with special reference to montane forest regions. – Bonner Zoologische Monographien, **48**: 1-244.

Köhler, J., K. Scheelke, S. Schick, M. Veith & S. Lötters (2005): Contribution to the taxonomy of hyperoliid frogs (Amphibia: Anura: Hyperoliidae): advertisement calls of twelve species from East and Central Africa. – African Zoology, **40**: 127-142.

Narins, P. M., A. S. Feng, R. R. Fay & A. N. Popper (2007): Hearing and sound communication in amphibians. – Springer handbook of auditory research. – Springer, New York.

Pakenham, R. H. W. (1983): The reptiles and amphibians of Zanzibar and Pemba islands (with a note on freshwater fishes). – Journal of the East African Natural History Society and National Museum: 1-40.

Pfeffer, G. (1893): Ostafrikanische Reptilien und Amphibien gesammelt von Herrn Dr. F. Stuhlmann im Jahre 1888 und 1889. – Jahrbücher der Hamburger Wissenschaftlichen Anstalt, **10**: 2-39.

Pickersgill, M. (2007): Frog search – Results of expeditions to southern and eastern Africa from 1993-1999. – Edition Chimaira, Frankfurt a. M.

Poynton, J. C. & D. G. Broadley (1987): Amphibia Zambesiaca 3. Rhacophoridae and Hyperoliidae. – Annales of the Natal Museum, **28**: 161-229.

Schiøtz, A. (1975): The treefrogs of eastern Africa. – Steenstrupia, Copenhagen.

Schiøtz, A. (1999): Treefrogs of Africa. – Edition Chimaira, Frankfurt a. M.

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