

# Bioacoustics in the genus *Adenomera* (Anura: Leptodactylidae) from Santa Catarina, southern Brazil

Axel Kwet

**Abstract.** Bioacoustic variation recorded from different *Adenomera* populations in southern Brazil is presented and discussed. Recent recordings of advertisement calls from Santa Catarina and southern Paraná states are compared with calls published from other regions in the southern Atlantic Rain Forest domain, including those of *Adenomera araucaria* and *Adenomera marmorata*. Our data allow to differentiate between at least four species of *Adenomera* occurring in Santa Catarina.

## Introduction

Eight species are currently recognized in the leptodactylid genus *Adenomera*. Three nominal species are distributed in the Atlantic rain forest domain of southern Brazil. *Adenomera araucaria* is restricted to northeastern Rio Grande do Sul and southeastern Santa Catarina (Kwet & Angulo, 2002), whereas both *Adenomera marmorata* and *A. bokermanni* have a wide distributional range and are suspected to be composites of several cryptic species (Heyer, 1973, 1977, 1984). Heyer (1984) and Angulo et al. (2003) suggested the use of bioacoustic data as a means of resolving the systematics in this group. Advertisement calls of *Adenomera* from several localities in Santa Catarina, Rio Grande do Sul and Paraná were recorded and analysed. These preliminary data revealed the occurrence of different taxa and suggest that the species diversity of *Adenomera* in this limited region is much higher than currently acknowledged.

## Materials and methods

Advertisement calls of *Adenomera* were recorded from 1995-2004 at 16 different localities in the Atlantic rain forest of southern Brazil (states of Rio Grande do Sul, Santa Catarina and Paraná; for localities see Fig. 1 and Table 1). Recordings were made with a Sony WM-D6C tape recorder and a Sennheiser Me-66 microphone with K6 module. Acoustic analysis was performed using a Macintosh-based signal analysis software (Canary 1.2, Cornell University) at a sampling frequency of 44.1 kHz. Voucher specimens are deposited in the Museu de Ciências e Tecnologia da PUCRS (MCP, Porto Alegre, Brazil).

## Results

The bioacoustic data presented from 16 localities in southern Brazil revealed six different call types representing at least five distinct, partly sympatrically occurring taxa of *Adenomera* (Table 1, Figs. 2-6).

(1) The advertisement call of *Adenomera araucaria* (Fig. 2) from Rio Grande do Sul and southern Santa Catarina consists of single notes, each of which presenting some amplitude modulation that can take the form of 6-11 weak pulses (Table 1, Fig. 7 left; see also Kwet & Angulo, 2002). The call duration is 85-140 ms and call rate is 26-45 calls per minute. The call is further characterized by its high dominant frequency of 4.6-5.4 kHz and a notable upward frequency modulation of 500-1200 Hz.

(2) Two different call types were recorded from the island of Ilha de Santa Catarina and nearby continental localities. One of these calls differs only in subtle nuances from the call of *Adenomera araucaria*, mainly by a shorter call duration (65-100 ms) and a lesser frequency modulation of about 500-700 Hz (Table 1, Fig. 7 right). Pending further studies, individuals of these presumably conspecific populations are referred to as *Adenomera* cf. *araucaria* (Fig. 3). A recording from Blumenau with similar characteristics but differing in a significant longer call duration (173-220 ms) is most likely an aggression call of this species.

(3) The second call type from Ilha de Santa Catarina (Table 1, Fig. 8 left) and nearby continental localities has a much lower dominant frequency (3.5-4.3 kHz) without a notable frequency or amplitude modulation. The call rate lies between 10 and 24 calls per minute, the call duration is 95-160 ms. This recording belongs to an undescribed

**Figure 1.** Map of southern Brazil showing recording localities.



species (*Adenomera* sp. I, Fig. 4) which is also morphologically distinguishable from *Adenomera araucaria* by its differently shaped snout ending in a small spatula and toe tips that are more expanded. (4) Populations of *Adenomera* from Jaraguá do Sul near the type locality of *Leptodactylus nanus* Müller, 1922 in northern Santa Catarina (Humboldt = Corupá) are currently assigned to *Adenomera marmorata*. However, they belong to a different taxon (*Adenomera* sp. II, Fig. 5) which is morphologically similar to *Adenomera* sp. I. but having a smaller snout-vent length. *Adenomera* sp. II differs from *Adenomera* sp. I. also in call parameters, i.e., the higher dominant frequency of 4.6-5.4 kHz and the shorter call duration of 70-120 ms (Table 1, Fig. 8 right). For these populations the name *Adenomera*

Identification	Temp. air (°C)	Number calls (indivi.)	Call duration (ms)	Calls/min	Pulse per call	Dominant frequency (Hz)	Fundam. frequency (Hz)	Other frequencies (Hz)	Frequen. modulation
(1) <i>A. araucaria</i>									
São Francisco Paula	16-26	40 (4)	119.2 (85-137)	26-45	6-11	4620-5400	2200-2640	6990-7960	500-1200
(2) <i>A. cf. araucaria</i>									
São Bonifácio	28.5	10 (1)	71.2 (68.0-90.5)	57	8-12	5300-5640	2650-2980	7700-7800	600
Taquaras	25.5	10 (1)	89.2 (84-96)	56	6-10	4840-5330	2400-2800	7200-7600	650
Santo Amaro	21	10 (1)	88.9 (85-93)	46	6-8	5220-5650	2600-2800	—	620
Ilha de Santa Catar.	21-23	30 (3)	75.7 (64.0-99.6)	46-72	6-13	4750-5540	2400-2830	7200-7950	450-600
Blumenau	21	10 (1)	189.5 (173-220)	22-35	14-18	4200-5050	—	—	700
(3) <i>Adenomera</i> sp. I									
Taquaras	25.5	10 (1)	147.0 (134-155)	18-20	1	3780-3860	—	5700-5850	0-50
Águas Mornas	17	10 (1)	130.0 (122-145)	18	1	3460-4150	—	5400-6040	30-50
Santo Amaro	20	3 (1)	129.7 (123-133)	12-14	1	4130-4290	—	6200-6400	20-40
Ilha de Santa Catar.	22-23	20 (2)	115.6 (96-133)	18-24	1	3850-4240	—	6000-6240	0
São Pedro Alcântara	17	10 (1)	138.3 (112-163)	10-12	1	3820-4050	—	5800-6200	0-20
Porto Belo	20.5	9 (1)	124.6 (118-134)	14	1	3970-4190	—	6020-6200	60
(4) <i>Adenomera</i> sp. II									
Blumenau	21	20 (2)	101.6 (83-113)	22-26	1	4870-5280	—	7300-7400	0-60
Morro do Baú	17	8 (1)	78.1 (67.2-84.5)	20	1	4980-5220	—	7500-7700	10
Ibirama	25	8 (1)	85.9 (76-95)	18-20	1	4750-4900	—	6900-7300	0-20
Rodeio	22	10 (1)	88.1 (82-93)	24-30	1	4620-4750	—	6900-7200	0-80
Guaramirim	—	12 (1)	88.8 (72.7-99.4)	22	1-3	4800-5050	2300-2600	7200-7450	60
Jaraguá do Sul	20	20 (2)	110.7 (98-122)	20-24	1	4620-5320	2400-2700	6900-7900	0-80
Pirabeiraba (call II*)	21.5	10 (1)	75.9 (70.1-80.8)	37	1	5210-5440	—	7800-7900	0-20
(5) <i>Adenomera</i> sp. III									
Guaratuba	23	10 (1)	31.6 (30.6-32.3)	120	6	4000-4200	—	—	300
(6) <i>Adenomera</i> sp. IV									
Pirabeiraba (call I*)	24.5	10 (1)	71.6 (67.7-79.1)	93	1	3030-3070	1440-1610	5950-6120	400

**Table 1.** Acoustic parameters for different populations of *Adenomera*. \* Data from Kwet & Angulo (2002).



**Figure 2.** *Adenomera araucaria* from São Francisco de Paula, RS.

*nana* should be revalidated (see also discussion in Kwet & Angulo, 2002).

(5) A call (Table 1, Fig. 9) from Guaratuba, southern Paraná, with high call rate (about 120 calls/min) and short call duration (30-35 ms) most likely belongs to another undescribed species (*Adenomera* sp. III, Fig. 6). The call of this species, which is larger (about 27 mm) than and morphologically distinct from all other *Adenomera* in southern Brazil, has a dominant frequency of about 4-4.2 kHz without harmonics.

(6) A distinct call (Table 1, published as type I call in Kwet & Angulo, 2002) with uncertain identity was recorded from Pirabeiraba, northern Santa Catarina, by Ronald W. Heyer. This unpulsed call without frequency modulation is also unique in having a very low dominant frequency of about 3 kHz. This call probably belong to another undescribed species (*Adenomera* sp. IV).

### Discussion

Extensive intra- and interpopulational morphological variation has rendered the genus *Adenomera* a taxonomically difficult group. Heyer (1974, 1977, 1984) stated a broad overlap in morphological characters between different populations of *Adenomera* and suggested that bioacoustic data are needed for resolving the systematics in this group. Recently published comparisons of call recordings from different localities in southern Brazil (Kwet & Angulo, 2002) and Peru (Angulo et al., 2003; Angulo & Icochea, 2003) confirmed that the species diversity in these regions is much greater than currently recognized. The preliminar data presented here demonstrate that populations of *Adenomera* in Santa Catarina currently assigned to *Adenomera marmorata* actually belong to several (at least four) different species. Some of the recorded calls are similar to those published from the Amazon or



**Figure 3.** *Adenomera* cf. *araucaria* from Ilha de Santa Catarina, SC.



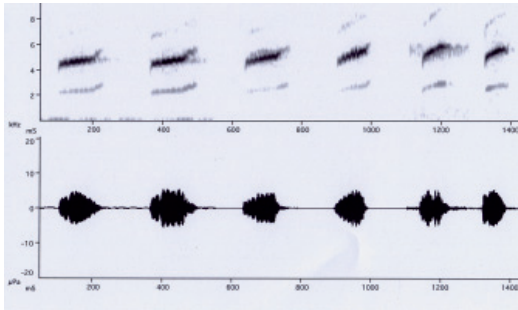
**Figure 4.** *Adenomera* sp. I from Águas Mornas, SC.



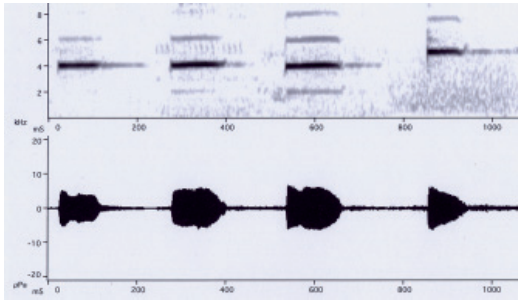
**Figure 5.** *Adenomera* sp. II ("*Adenomera nana*") from Jaraguá do Sul, SC.



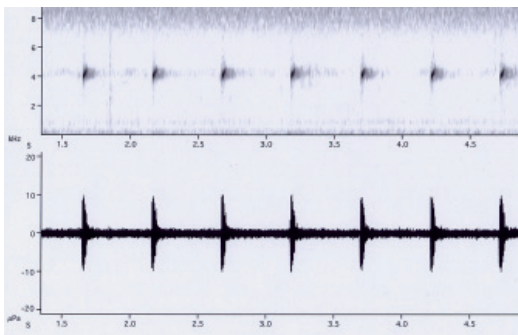
**Figure 6.** *Adenomera* sp. III from Guaratuba (23°C), Paraná.



**Figure 7.** Audiospectrogram (above) and oscillogram (below) of advertisement calls of four males of *Adenomera araucaria* from São Francisco de Paula, RS (left), air temperatures: 19°C, 16°C, 16°C, 26°C); and two males of *Adenomera* cf. *araucaria* (right) from São Bonifácio (28.5°C) and Ilha de Santa Catarina (22°C), SC.



**Figure 8.** Audiospectrogram (above) and oscillogram (below) of advertisement calls of three males of *Adenomera* sp. I (left) from Porto Belo (20.5°C), Ilha de Santa Catarina (22°C), and Águas Mornas (17°C), SC; and one male of *Adenomera* sp. II (left = "*Adenomera nana*") from Morro do Baú (17°C), SC.



**Figure 9.** Audiospectrogram (above) and oscillogram (below) of the advertisement call of *Adenomera* sp. III from Guaratuba (23°C), Paraná.

Paraguay river basin, i.e., *Adenomera hylaedactyla* and *Adenomera andreae* (Angulo et al., 2003; Angulo & Icochea, 2003; Heyer, 1973; Marquez et al. 1995; Zimmerman & Bogart, 1984) and *Adenomera diptyx* from Bolivia (published as *Adenomera andreae* by Marquez et al. 1995). However, they have different acoustic parameters and are also distinctive to the human ear. Further investigations are needed to clarify the species' identity of *Adenomera* in southern Brazil and to make taxonomic decisions.

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