

A new species of the genus *Physalaemus* Fitzinger, 1826 (Anura, Leptodactylidae) from the Atlantic Rain Forest of southern Bahia, Brazil

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Abstract. A new species of the *Physalaemus signifer* group from the Atlantic Rain Forest of the state of Bahia is described and illustrated. It is characterized by a well-developed vocal sac, second finger with the same size or longer than fourth, finely rugose dorsal skin, and distinct structure of advertisement call, composed of densely aggregated pulses. Information on tadpole external morphology and advertisement call structure are presented.

Resumo. Uma nova espécie do grupo de *Physalaemus signifer* da Mata Atlântica do Estado da Bahia é descrita e ilustrada. É caracterizada pelo saco vocal bem desenvolvido, o segundo dedo com comprimento igual ou maior que o quarto, pele do dorso finamente rugosa e estrutura distinta do canto de anúncio, composto por pulsos densamente agregados. Informações sobre a morfologia externa do girino e a estrutura do canto de anúncio são apresentadas.

Introduction

The neotropical frog genus *Physalaemus* Fitzinger currently contains 45 valid species (Gorzula and Señaris, 2000; Frost, 2002). Lynch (1970) characterized the *P. signifer* group by its small to moderate size (15-35 mm snout-vent length), slender body, smooth dorsal skin, first finger shorter than second, no inner tarsal tubercle, small, non-compressed metatarsal tubercles, small to large inguinal glands, and absence of parotoid glands. This group is distributed along the Atlantic Rain Forest Domain (*sensu* Ab'Saber, 1977), from the state of Alagoas, in northeastern Brazil, to the state of Rio Grande do Sul, in southern Brazil (Frost, 2002), and is currently composed of 11 species: *P. bokermanni* Cardoso and Haddad, *P. caete* Pombal and Madureira, *P. crombiei* Heyer and Wolf, *P. maculiventris* (A. Lutz), *P. maximus* Feio, Pombal and Caramaschi, *P. moreirae* (Miranda-

Ribeiro), *P. nanus* (Boulenger), *P. obtectus* Bokermann, *P. signifer* (Girard), and *P. spiniger* (Miranda-Ribeiro) (Feio et al., 1999). Some of them are very similar morphologically, making difficult the identification of specimens deposited in museums (Cardoso and Haddad, 1985). Through the development of audio recording equipment for the field, descriptions and recognition of species of this group are being made using advertisement call as one of the diagnostic characters (e.g., Cardoso and Haddad, 1985; Heyer and Wolf, 1989; Haddad and Pombal, 1998).

Herein, we describe a new species of the *P. signifer* group from the southern region of the state of Bahia, Brazil, and also describe its advertisement call and the morphology of the tadpole. Some information on the habitat is also provided.

Materials and methods

Comparisons of specimens of the new species with those of known species were based on observations of museum specimens and on literature information from Bokermann (1966), Lynch (1970), Cardoso and Haddad (1985), Heyer and Wolf (1989), Heyer et al. (1990), Caramaschi and Caramaschi (1991), Pombal and Madureira (1997), Haddad and Pombal (1998), and Feio et al. (1999). Specimens used in the description or examined for comparisons are deposited in EI (Eugenio Izecksohn collection, housed in

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Abbreviations used for the measurements of adult specimens are SVL (snout-vent length), HL (head length), HW (head width), ED (eye diameter), TD (tympnum diameter), UEW (upper eyelid width), IOD (interorbital distance), IND (internarial distance), END (eye-nostril distance), THL (thigh length), TBL (tibia length), and FL (foot length, including tarsus). All measurements are in millimetres and, except for FL, follow Duellman (1970). SVL, HL, HW, THL, TBL, and FL were measured with callipers, whereas other measurements were made with an ocular grid on a stereo dissecting microscope.

Tadpole description and measurements are based on 14 specimens (table 2) in stage 36 (Gosner, 1960). Comparisons of the tadpole of the new species with those of known species were based on observations of museum specimens and on literature information from Bokermann (1963), Cardoso and Haddad (1985), Heyer and Wolf (1989), Heyer et al. (1990), Pombal and Madureira (1997), Haddad and Pombal (1998), and Weber and Carvalho-e-Silva (2001). Nomenclature and measurements of tadpoles follow Altig and McDiarmid (1999), except for the interorbital and internarial distances, which were taken between the inner margins of eyes and nostrils, respectively. Measurements (in millimetres) were made using an ocular grid on a stereo dissecting microscope.

Vocalizations were recorded with a Sony TCD-D8 DAT-recorder with a Sennheiser K6/ME66 microphone set. Sonograms were produced with the software Avisoft-SASLab Light for Windows, version 3.74, using 16bit resolution, 22 kHz sampling frequency, and FFT with 256 points. Terminology follows Duellman (1970).

Physalaemus camacan sp. nov. (figs. 1-2)

Holotype. MNRJ 33337, adult male, collected at Reserva Biológica de Una (15° 10' S, 39° 04' W; 35 m above sea level), Municipality of Una, State of Bahia, Brazil, by B.V.S. Pimenta and D.L. Silvano, on 25 September 2001.

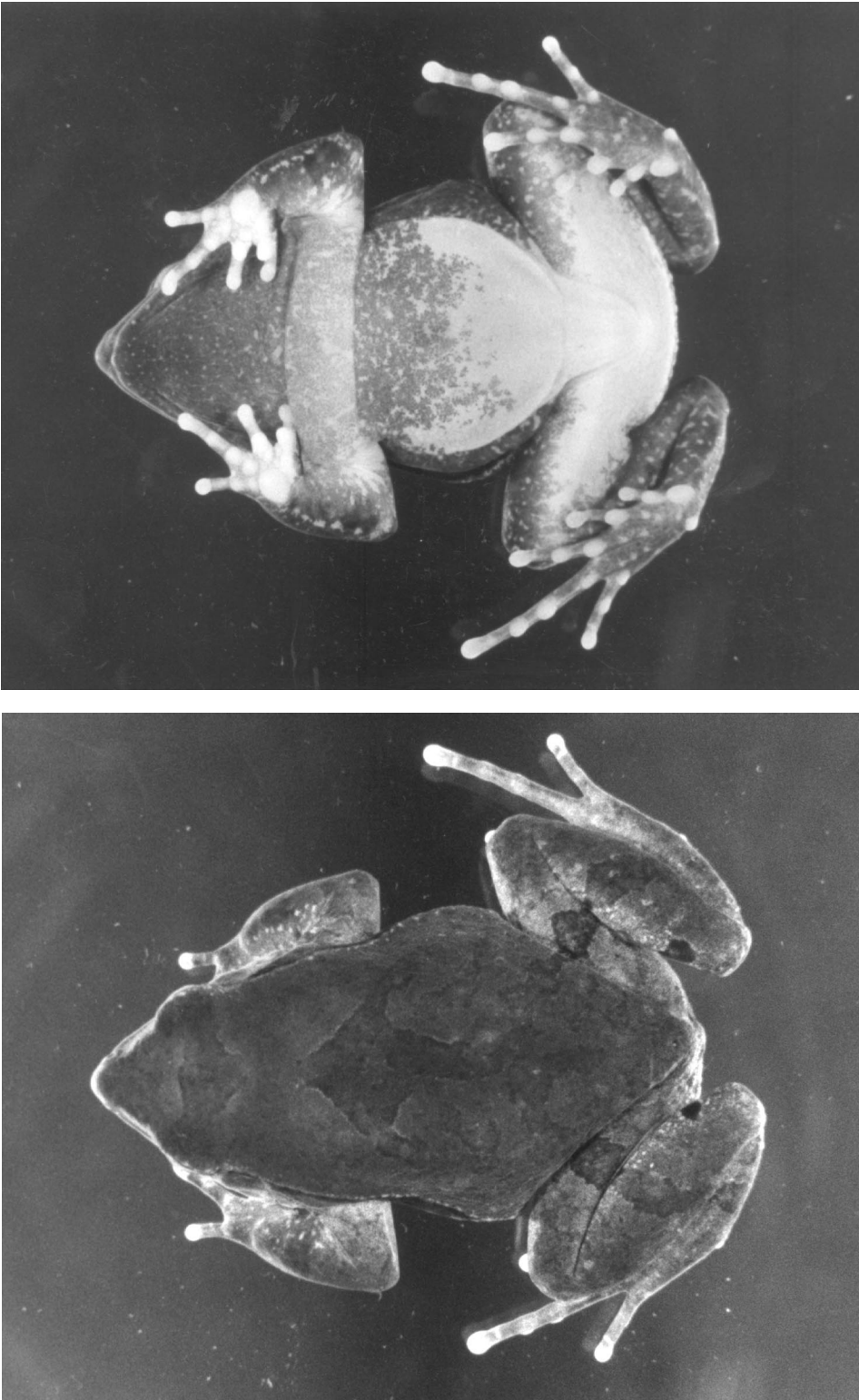
Paratypes. MNRJ 33339, adult female; and MNRJ 33338, MNRJ 33340-41, and MCN 2510, four adult males, collected with the holotype.

Diagnosis. A species belonging to the *Physalaemus signifer* group, characterized by (1) medium size (SVL males 22.3-24.1 mm, female 23.9 mm); (2) robust body; (3) nostrils closer

to the tip of snout than to eye; (4) tympanum distinct, large, close to eye; (5) inguinal gland covered by a black spot; (6) well-developed vocal sac; (7) second finger with the same size or longer than fourth; (8) large, protruding tubercles on hands and feet; (9) finely rugose dorsal skin; (10) dorsolateral fold beginning at the posterior corner of eye and ending at the inguinal region, covered by a line of small white granules starting on upper eyelid; and (11) distinct structure of advertisement call, composed of highly aggregated pulses.

Comparison with other species. *Physalaemus camacan* is distinguished from *P. maximus* and *P. olfersii* by the smaller size (combined SVL for males of latter two species, 28.5-48.5 mm). The snout of *P. camacan* is more protruded in lateral view than in *P. caete*, *P. crombiei*, *P. maculiventris*, *P. olfersii*, *P. moreirae*, and *P. signifer*. It is distinguished from *P. caete*, *P. maximus*, *P. moreirae*, *P. nanus*, *P. olfersii*, and *P. spiniger* by the close proximity of nostrils to the tip of snout. The distinct tympanum distinguishes *P. camacan* from *P. bokermanni*, *P. maximus*, *P. nanus*, *P. olfersii*, and *P. spiniger*; and the larger size and close proximity of the tympanum to the posterior corner of eye distinguishes *P. camacan* from *P. maculiventris*, *P. moreirae*, *P. obtectus*, and *P. signifer*. The supratympanic fold in *P. camacan* is more developed than in *P. crombiei*, *P. maculiventris*, and *P. moreirae*, and less developed than in *P. caete* (absent in *P. maximus* and *P. olfersii*). The well-developed vocal sac distinguishes *P. camacan* from *P. bokermanni*, *P. caete*, *P. crombiei*, *P. maculiventris*, *P. maximus*, and *P. obtectus*. By its slightly expanded finger tips, *P. camacan* is distinguished from *P. maculiventris*, *P. nanus*, *P. signifer*, and *P. spiniger*, which show no expanded finger tips.

Description of holotype. Body robust; head longer than wide; snout sub-elliptical in dorsal view, protruding in lateral view (fig. 2A, B); nostrils elliptical, slightly protuberant, located and oriented laterally, closer to tip of snout



(B)

(A)

Figure 1. *Physalaemus camacani* sp. nov., holotype (MNRJ 33337; SVL 22.9 mm), (A) dorsal and (B) ventral views.

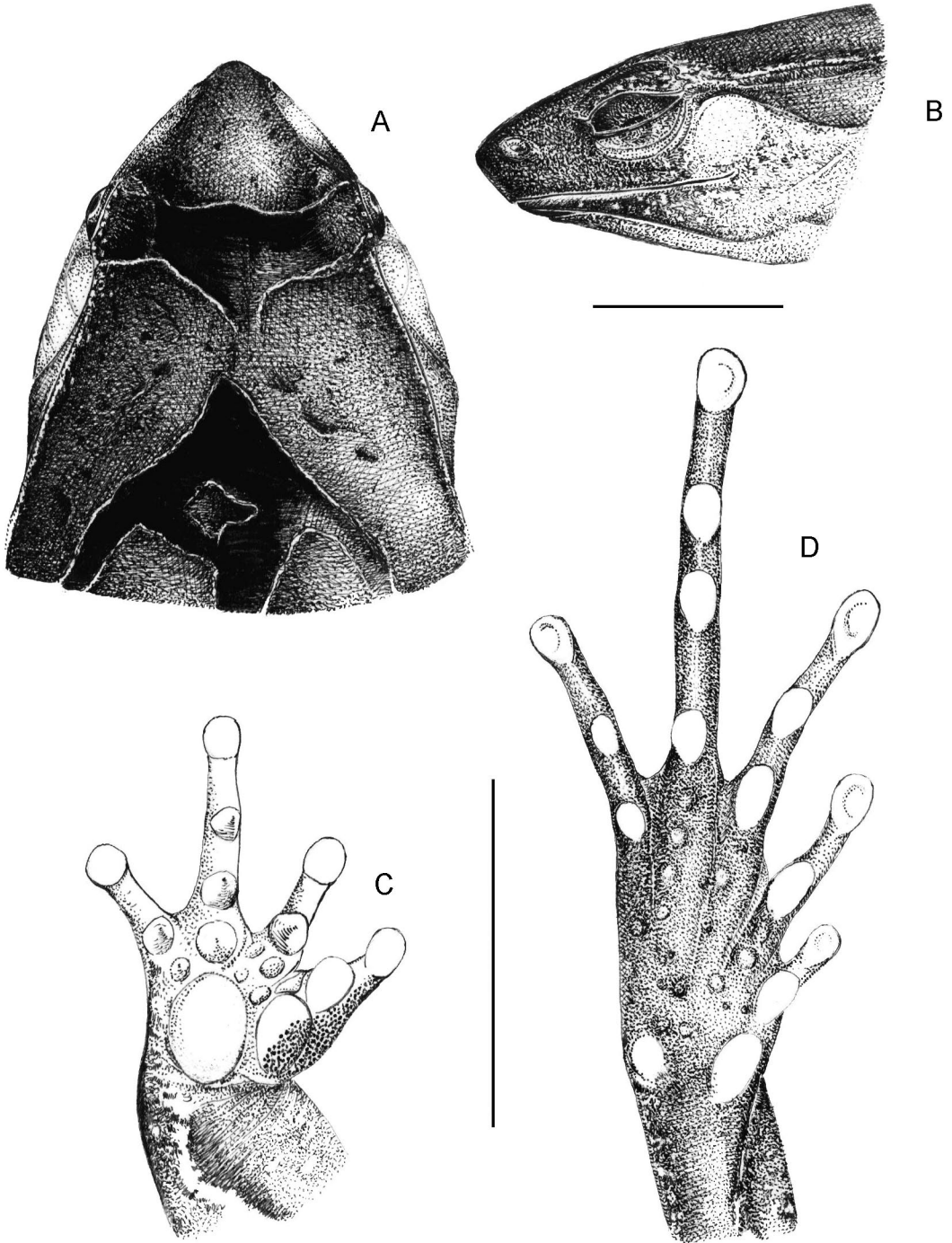


Figure 2. *Physalaeumus camacan* sp. nov., holotype (MNRJ 33337). (A) Dorsal and (B) lateral views of head (scale = 5 mm); ventral views of (C) hand and (D) foot (scale = 1 mm).

than to eye; canthus rostralis weakly marked; loreal region almost vertical, nearly concave; eyes slightly protuberant; tympanum large, distinct, its diameter approximately 75% of eye diameter; anterior margin of annulus tympanicus close to posterior corner of eye; distinct supratympanic fold, straight from the posterior corner of the eye to shoulder; presence of a dorsolateral fold starting on the posterior corner of eye, immediately above the supratympanic fold, delimiting the dorsal region from the flank, and ending at the inguinal region; vocal sac subgular, well-developed, extending to the border of chest with belly; choanae large, round; tongue narrow, long, free posteriorly on approximately one third of length; maxillary and premaxillary teeth not visible, but discernible by probe; vomerine teeth absent. Arms short, robust, upper arms shorter and moderately more robust than forearms; fingers slender and short, not fringed, finger lengths $I < IV \leq II < III$ (fig. 2C); extensive brown nuptial asperities on thumbs, covering also half of the inner metacarpal tubercle; subarticular tubercles single, large, protruding, conical; outer metacarpal tubercle very large, elliptical, covering almost the entire carpal region; inner metacarpal tubercle large, elliptical, approximately two thirds the size of outer metacarpal tubercle; presence of small supernumerary tubercles; finger tips slightly expanded. Legs moderately robust; tibia slightly longer than thigh, the sum of their lengths slightly shorter than SVL; a poorly developed inner tarsal fold on distal half of tarsus; toes slender, long, weakly fringed; toe lengths $I < II < V < III < IV$ (fig. 2D); subarticular tubercles large, single, protruding, conical; inner metatarsal tubercle medium-sized, ovoid; outer metatarsal tubercle small, protruding, approximately half the size of inner metatarsal tubercle; supernumerary tubercles small; toe tips slightly expanded. Dorsal surfaces finely rugose; dorsolateral fold covered by a conspicuous line of small white granules starting on upper eyelid, also present as an arch above the vent; scattered small white granules on poste-

rior region of flanks, near the inguinal region; inguinal glands evident. Undersurfaces smooth, except on posterior surface of thighs and cloacal region, which are covered by large granules. A distinct ventral disc observed in preserved specimens.

Color in preservative of the holotype. General pattern brown. A characteristic arrow pattern on dorsum and an interocular transverse dark brown bar, both margined by a cream line. Loreal region dark brown, region between the corner of mouth and the supratympanic fold light brown. Broad longitudinal stripes on flanks dark brown, dorsally margined by a white line of small granules. Inguinal region yellowish-cream with a black spot covering the inguinal gland. Dorsal surfaces of arms brown with dark brown blotches and scattered white dots; legs brown with a dark brown transverse stripe and scattered white dots; a dark brown blotch immediately anterior to heel. Posterior region of belly and ventral surfaces of hands and thighs cream. Gular region brown with scattered cream dots. Chest and anterior region of belly marbled brown. Ventral surfaces of feet brown with cream tubercles, and ventral surfaces of tarsus darker. Cloacal region covered by a dark brown triangular blotch, margined by a line of white small granules above the vent; large cream granules present.

Measurements of the holotype (mm). SVL 22.9; HL 8.0; HW 7.3; ED 1.9; TD 1.6; UEW 2.2; IOD 1.7; IND 1.6; END 3.6; THL 10.6; TBL 10.8; FL 10.8.

Variation. Arms of females longer and more slender than in males. Specimens MNRJ 33339 and MCN 2510 present thighs and tibiae with the same length, whereas the other paratypes show tibiae slightly longer than thighs. General color pattern varies from light brown with a well-defined arrow pattern, stripes, and blotches to dark brown with an indistinct arrow pattern. Black spots covering inguinal glands vary in size and sometimes are absent. Table 1 shows variations in measurements of five males.

Table 1. Mean (\bar{x}), standard deviation (SD), and range of measurements (mm) of five males of *Physalaemus camacan* sp. nov.

	\bar{x}	SD	Range
SVL	23.3	0.7	22.3-24.1
HL	7.6	0.4	7.1-8.0
HW	7.4	0.2	7.2-7.7
ED	2.2	0.1	2.1-2.2
TD	1.5	0.1	1.3-1.7
UEW	1.6	0.2	1.4-2.0
IOD	3.5	0.2	3.3-3.8
IND	2.0	0.1	1.9-2.2
END	1.9	0.2	1.6-2.1
THL	10.9	0.5	10.4-11.7
TBL	11.1	0.4	10.7-11.6
FL	10.4	0.4	10.0-10.8

Tadpole. MNRJ 33342, Stage 36 (Gosner, 1960). Mean total length 16.0 ± 0.95 mm ($n = 14$). Body robust, oval in dorsal and ventral views, elliptical in lateral view; round-shaped snout in dorsal and lateral views (fig. 3A-C); body width approximately 75% (70-81%) of body length; body length about 37.5% (32.5-41%) of total length. Nostrils large, nearly rounded, located and oriented dorsally, closer to eyes than to tip of snout; eyes dorsolateral; spiracle single, sinistral, short, and projected, its opening situated on the beginning of the last third of body length, posterodorsally oriented; vent tube medial, long, attached to ventral fin, its opening oriented posteriorly. Tail approximately 62.5% of total length, with nearly the same height of body; moderate tail musculature; dorsal fin originating on posterior third of body, and ventral fin originating on the beginning of tail; ventral fin wide arched, smaller than dorsal; tail tip straight, slightly directed upwards. Oral disc ventral, its width approximately 47% of body width, laterally emarginated; a double marginal row of papillae on upper lip interrupted by a wide medial gap, lateral margins with one series of marginal papillae, and lower lip with two to three series; labial tooth row formula 2(2)/3(1). The two anterior teeth rows with approximately the same length, longer than posterior rows; posterior teeth rows approximately the same size; upper jaw sheath arch-

Table 2. Mean (\bar{x}), standard deviation (SD), and range of measurements (mm) of 14 tadpoles of *Physalaemus camacan* sp. nov. in stage 36.

	\bar{x}	SD	Range
Total length	16.0	0.95	14.8-17.4
Body length	6.0	0.38	5.2-6.5
Body width	4.5	0.30	4.2-4.9
Body height	3.6	0.32	3.1-4.2
Tail length	10.0	0.73	8.8-11.1
Tail height	1.6	0.19	1.3-1.8
Distance nostril-snout	1.0	0.11	0.8-1.3
Distance eye-nostril	0.5	0.04	0.5-0.6
Interorbital distance	1.0	0.08	0.9-1.2
Internarial distance	0.7	0.04	0.7-0.8
Eye diameter	0.9	0.05	0.9-1.1
Oral disc width	2.1	0.17	1.8-2.4

shaped and lower sheath “V”-shaped (fig. 3D). Table 2 shows variations in measurements of fourteen tadpoles.

Color of tadpole in 5% formalin. General color pattern varies from pale to dark brown, over a cream background. A dense aggregation of brown dots from the region between the eyes to the base of tail musculature makes this area darker than others. Tail musculature has a cream background covered by many brown dots. Tail fins translucent with scattered brown blotches. Venter translucent, showing the cream colour of the intestine in some specimens. Cream-colored legs covered by many dark brown dots on dorsal surfaces.

Larval external morphology of the *P. signifer* group is quite homogeneous, making very difficult a description of diagnostic characters for tadpoles. The tadpole of *P. camacan* is larger than *P. caete* and *P. signifer* (combined total length for these species 14.9-16.0 mm in stages 28 and 33, respectively) and differs from the latter and *P. maculiventris* by its “V”-shaped lower jaw sheath and medial vent tube (“U”-shaped lower jaw and dextral vent tube in *P. maculiventris* and *P. signifer*). From these two and *P. bokermanni*, *P. camacan* is also distinguished by the presence of two rows of marginal papillae on lower lip (single row in *P. bokermanni*, *P. maculiventris*, and *P. signifer*).

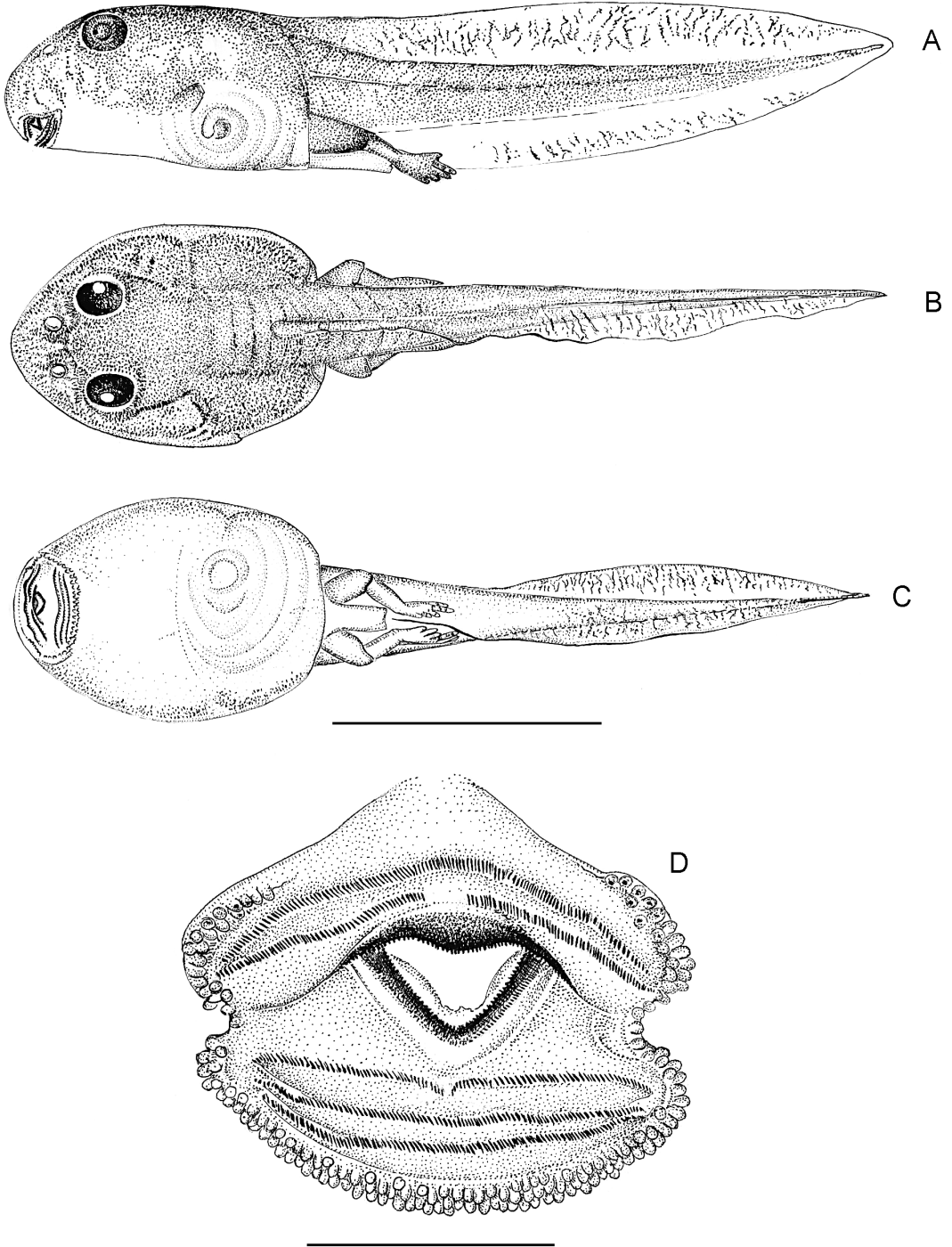


Figure 3. Tadpole of *Physalaemus camacan* (MNRJ 33342, stage 36). (A) lateral, (B) dorsal, and (C) ventral views (scale = 1 mm); and (D) oral disc (scale = 0.5 mm).

Table 3. Comparison among acoustic parameters of calls of the *Physalaemus ssignifer* group. Data from Bokermann (1966), Haddad and Cardoso (1985), Heyer and Wolf (1989), Heyer et al. (1990), Haddad and Pombal (1998), Wogel et al. (2002), and present study. boke = *P. bokermanni*; camc = *P. camacan*; crom = *P. crombiei*; macv = *P. maculiventris*; more = *P. moreirae*; nanu = *P. nanus*; obtc = *P. obtectus*; olfs = *P. olfersii*; sign = *P. signifer*; spin = *P. spiniger*. H = harmonic structure; P = pulsed structure.

	boke	camc	crom	macv	more	nanu	obtc	olfs	sign	spin
Call duration (s)	0.2	0.38-0.87	0.38-0.42	0.20-0.75	0.5-0.7	0.16-0.20	0.05-0.10	3.5-4.0	0.30	0.17-0.31
Intercall interval (s)	0.4-0.6	0.33-5.86	0.52-0.65	?	?	?	0.07-0.12	?	0.65	?
Dominant frequency (kHz)	?	0.66-1.69	1.06	0.7-3.7	0.6-1.6	?	1.1-1.5	1.0-2.7	0.7-2.5	?
Call structure	P	P	H	P	H/P	H/P	H	H/P	H	P

Vocalization. On 25 September 2001, specimen MNRJ 33340 was recorded emitting advertisement calls with one note consisting of densely aggregated pulses. Strong sidebands are observed on sonogram due to this pulsed nature of call. Analysis of 111 calls demonstrated that the mean call duration is 0.76 s (SD = 0.06, range = 0.38-0.87), and the mean intercall interval (defined here as the time from the end of one call to the beginning of the next call) is 0.51 s (SD = 0.54, range = 0.33-5.86). Dominant frequency situated between 0.658 and 1.687 kHz (mean = 1.263 kHz) (fig. 4).

Comparative data on advertisement calls of the *P. signifer* group are summarized in table 3, based on Bokermann (1966), Haddad and Cardoso (1985), Heyer and Wolf (1989), Heyer et al. (1990), Haddad and Pombal (1998), Wogel et al. (2002), and the present study. Data are presented as ranges.

Habitat. The region of Una is characterized by the existence of large, well-preserved or secondary forest patches connected by agricultural forest systems, especially cacao and rubber tree plantations. The Reserva Biológica de Una is a protected area comprising all gradients of forest regeneration, along with plantation areas. *Physalaemus camacan* was found in small shallow ponds left by a temporary stream inside a well-preserved forest patch. Males call from the edges of ponds or floating on shallow water. When disturbed, they jump in the water and hide beneath foam nests.

Etymology. The specific epithet “camacan” is a Tupi indigenous name, here used as a noun in apposition. It is composed of the words “cama” and “quá”, meaning “a narrow valley between rounded hills.” The specific name honours the Camacan indians, which inhabited the same region where this new frog was found, between the rivers Pardo and Contas.

Discussion

Heyer and Wolf (1989) pointed out that the *P. signifer* group had a modest radiation and is composed of species with very limited distributions, indicating that the development of audio recording equipment for the field would improve our knowledge of this group. Since their work, three other species have been described (Pombal and Madureira, 1997; Feio et al., 1999; present study). Furthermore, the geographical distributions of *P. crombiei* and *P. signifer* were largely expanded (Van Sluys, 1998; Izecksohn and Carvalho-e-Silva, 2001; Frost, 2002; Pimenta and Cruz, 2004). *Physalaemus caete* was the only record of a species of this group in northeastern Brazil until the record of *P. crombiei* for Bahia (Pombal and Madureira, 1997; Van Sluys, 1998). The distance between the two localities is ca. 1065 km, so new records for the forests of Bahia were expected. The extreme similarity between species of this group makes almost obligatory the recording of advertisement calls as a tool for species recognition;

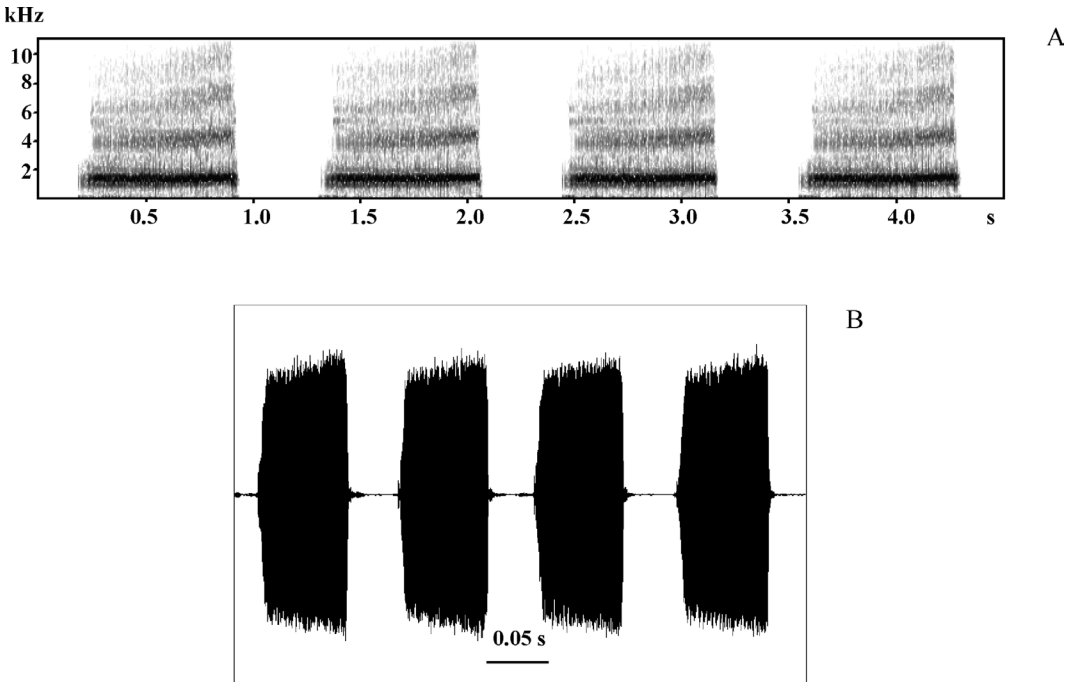


Figure 4. (A) Sonogram and (B) waveform of the advertisement call of *Physalaemus camacan* sp. nov. recorded at Reserva Biológica de Una, Una, Bahia, Brazil, on 25 September 2001, 06:44 PM. Air temperature 24.3°C. Voucher specimen MNRJ 33340.

it is likely that species group composition and species distributions as currently known will change due to continued field and laboratory activities.

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Appendix

Material Examined

- Physalaemus caete*: MNRJ 9803 (holotype), MNRJ 9850 (paratype).
- Physalaemus crombiei*: MZUSP 66253-81 (paratypes).
- Physalaemus maculiventris*: MZUSP 67383-90 (Teresópolis — RJ).
- Physalaemus maximus*: MNRJ 18810 (holotype), MNRJ 18811 (paratype).
- Physalaemus moreirae*: MZUSP 25867-70 (paratypes *P. franciscae*), MZUSP 59935 (holotype *P. franciscae*), MZUSP 77060-61 (Caraguatatuba — SP).
- Physalaemus obtectus*: EI 9466-67 (paratypes).
- Physalaemus olfersii*: MZUSP 82880, 82882, 82884, 82876-77 (Bocaina — SP).
- Physalaemus signifer*: MNRJ 30861 (Bom Jesus do Itapoana — RJ), MNRJ 32994-97 (Tinguá, Nova Iguaçu — RJ).
- Physalaemus spiniger*: MNRJ 28249-67 (Ribeirão Grande — SP), MZUSP 76561 (Estação Ecológica da Juréia — SP), MZUSP 83470-71 (Ilha do Cardoso, Cananéia — SP).

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