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A collection of amphibians from Río San Juan, southeastern Nicaragua

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Abstract. We report upon the amphibians collected during seven expeditions carried out between the years 2000–2006 to thirteen localities in both Refugio de Vida Silvestre Río San Juan and Reserva Biológica Indio-Maíz, southeastern Nicaragua. We include morphometric data of around one-half of the adult specimens in the collection, and provide a brief general overview and discuss zoogeographic and conservation considerations of the amphibians known to occur in the Río San Juan area.

Keywords. Amphibia, conservation, ecology, morphometry, zoogeography.

Introduction

The San Juan River is an approximately 200 km slow-water current river located in southeastern Nicaragua. It constitutes the water exit of Lake Nicaragua (also known as Lake Cocibolca, the largest lake in Central America) and has its origin in the southeastern part of the lake at San Carlos (about 32 m elev.). It drains into the Caribbean Sea near San Juan del Norte, also known as Greytown. It is the most water-rich river in Nicaragua and flows mostly through homogeneous lowlands except for a few rapids, e.g. at El Castillo and Machuca. Its tributaries (Fig. 1) receive water from small surrounding hills that do not exceed about 600 m elevation (MARENA 1999, 2005). The San Juan River was traditionally the main entrance to Nicaragua by boat on the Caribbean side and in the past the area had received international attention because of the areas potential of holding America's first interoceanic channel and also because it was part of the sea route to travel from eastern to western United States. Nowadays, most of the San Juan River and a vast portion of adjacent land are protected (Reserva de la Biosfera del Sureste de Nicaragua; MARENA 2007) and are increasingly visited by tourists seeking one of Nicaragua's best-preserved and most impressive biodiversity hotspots.

The Reserva de la Biosfera del Sureste de Nicaragua (18,340 km^2) is located in the departments Río San Juan and Región Autónoma Atlántico Sur and contains seven distinct protected areas: Reserva Natural Cerro Silva, Reserva Natural Punta Gorda, Reserva Biológica Indio-Maíz, Refugio de Vida Silvestre Río San Juan, Refugio de Vida Silvestre Los Guatuzos, Monumento Nacional Archipiélago de Solentiname, and Monumento

Figure 1. Typical tributary of the San Juan River. Photograph: S. Lotzkat.

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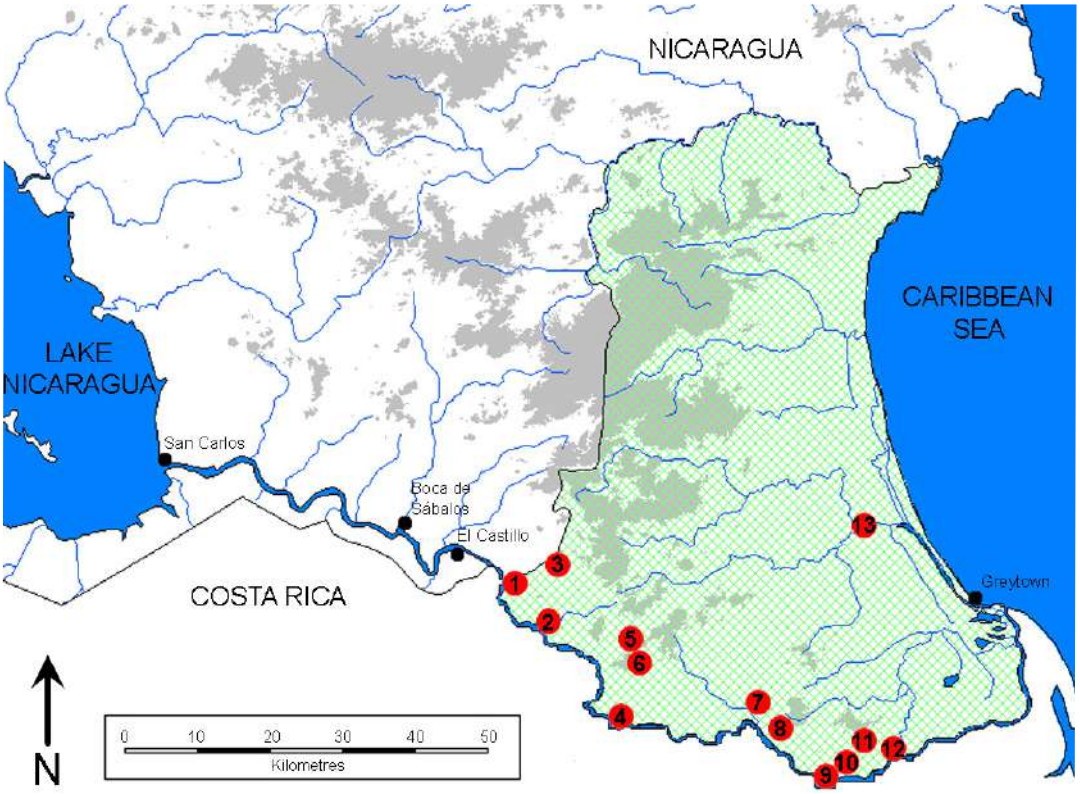

Figure 2. Map of southeastern Nicaragua indicating the collecting sites of our expeditions and other localities mentioned in the text: (1) Bartola, (2) Río Sarnoso, (3) Dos Bocas de Bartola, El Almendro, (4) Boca de San Carlos, (5) Río Las Cruces, (6) Cerro El Bolívar, (7) Río El Chancho, (8) Lomas de Tambor, (9) Intersection of Río Sarapiquí with Río San Juan, (10) Río Chimurria, (11) Cerro El Gigante, (12) Chingo Petaca, (13) Dos Bocas de Río Indio. Both Reserva Biológica Indio-Maíz and Refugio de Vida Silvestre Río San Juan appear combined and remarked in green. Areas above 200 m are shaded gray. The map was created using DIVA-GIS.

Histórico Fortaleza de la Inmaculada Concepción de María. The most diverse of these seven protected areas is the Reserva Biológica Indio-Maíz (3,157 km^2), which constitutes 89% of the biosphere reserve's core zone and is one of the best preserved areas in the country (MARENA 2005, 2007). It is bordered on its southern and southeastern portions by the Refugio de Vida Silvestre Río San Juan (447 km^2), a narrow strip of land that follows the San Juan River along its lower two thirds, bordered on its south by Costa Rica.

Both the Reserva Biológica Indio-Maíz and the Refugio de Vida Silvestre Río San Juan are located in the southeastern-most portion of Nicaragua (Fig. 2) and will be referred to as "the Río San Juan area" throughout the text. The Río San Juan area is within the Lowland Wet Forest (LWF) formation (Holdridge 1967), characterized by lowlands (< 600 m) with a high mean annual temperature (> 24ºC) and very high mean annual precipitation (> 4000 mm) which, although seasonal, is relatively well distributed throughout the year. In Nicaragua, LWF is only found in the Río San Juan area, which thereby constitutes the northern limit of this forest formation in Middle America.

The Río San Juan area has been herpetologically surveyed since the second half of the nineteenth century and a few studies based on amphibians from the area have been made (e.g. Cope 1874; Caldwell 1994; Cody and Köhler 2002; Köhler 2003; Köhler and Sunyer 2006). Several other studies are partially based on amphibians from the area (e.g. Cope 1886; Villa 1972; Savage 1973; Caldwell 1996; Köhler 1999, 2001, 2005; Ruiz and Buitrago 2003; Köhler et al. 2004; Sunyer and Köhler 2007; Sunyer et al. 2008).

Seven currently valid taxa of amphibians have been described based on material collected between El Castillo and San Juan del Norte (see Fig. 2; Cope 1874, 1886; Savage 1973; Köhler and Sunyer 2006; Sunyer et al. 2008): *Bolitoglossa indio*, *Craugastor bransfordii, C.*

Figure 3. A. *Gymnopis multiplicata* (Bartola); B. *Bolitoglossa indio* (Dos Bocas de Río Indio); C. *Bolitoglossa striatula* (near Dos Bocas de Río Indio); D. *Allobates talamancae* (Río La Gloria, Panama); E. *Incilius coniferus* (Dos Bocas de Río Indio); F. *Incilius melanochlorus* (Intersection of Río Sarapiquí with Río San Juan).

chingopetaca, *C. ranoides, Dendropsophus ebraccatus*, *Ecnomiohyla miliaria,* and *Gastrophryne pictiventris*. *Craugastor polyptychus* was also described based on material collected in the same general area (Cope 1886; Savage 1973), but no additional specimens have been collected in Nicaragua since (Sunyer and Köhler *in press*). Further study is needed to evaluate the status of this taxon (Savage 2002). Other type specimens of amphibians from the Río San Juan area that are currently considered synonyms of other taxa are *Dendrobates ignitus* Cope, 1874 (a junior synonym of *Oophaga pumilio*) and *Hyla quinquevittata* Cope, 1886 (a junior synonym of *Scinax elaeochroa*). Also, the type locality of *Pristimantis ridens* is "St. Juan River, Nicaragua" (Cope 1866).

The purpose of this paper is to inform on a collection of 469 specimens of 44 amphibian species collected during seven field trips to 13 localities in the Río San Juan area; including several at elevations greater than 200 m, which are very scarce in extreme southeastern Nicaragua (see Fig. 2). We also provide selected morphometric data for all species taken from 195 specimens. Finally, we

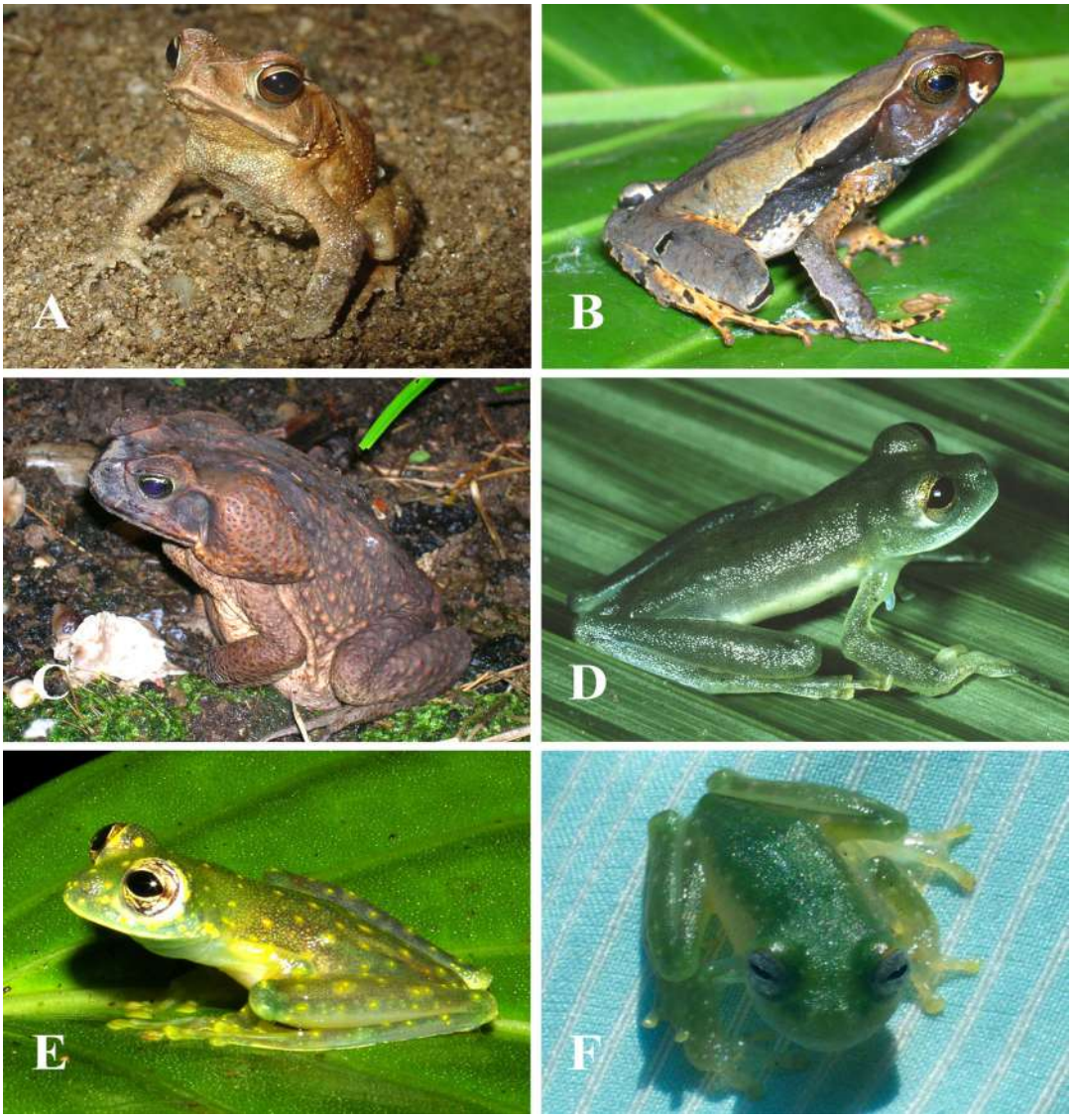

Figure 4. A. *Incilius valliceps* (Bartola), photo: M. Salazar-Saavedra; B. *Rhaebo haematiticus* (Dos Bocas de Bartola); C. *Rhinella marina* (Dos Bocas de Río Indio); D. *Espadarana prosoblepon* (Cerro El Gigante); E. *Sachatamia albomaculata* (Dos Bocas de Bartola), photo: S. Lotzkat; F. *Teratohyla pulverata* (Gran Reserva Indio-Maíz).

discuss zoogeographic and conservation considerations of the amphibians known to occur in the Río San Juan area.

Material and methods

Abbreviations used for collectors are GP (Guillermo Páiz), GK (Gunther Köhler), JS (Javier Sunyer), and MD (Matthias Dehling). This study is based exclusively on specimens we collected during seven expeditions to thirteen localities in the Río San Juan area (see assigned numbers for each locality in Fig. 2): 14–17.VI.2000 GK to Bartola (Locality 1, 10.97° N, 84.34° W, 70 m elev.; also known as Boca de Bartola), Río Sarnoso (2, 10.92° N, 84.29° W, 25 m), and Boca de San Carlos (4, 10.79° N, 84.20° W, 20 m); 25.IV–09.V.2001 and 23.IX–01.X.2001 GK to Bartola (1); 18.IV–03.V.2004 GP to Río Las Cruces (a tributary of Caño Negro; 5, 10.90° N, 84.18° W, 415 m) and Cerro El Bolívar (6, 10.87° N, 84.17° W, 280 m); 18.IV–03.V.2004 MD to Lomas de Tambor (8, 10.78° N, 83.99° W, 210 m) and Cerro El Gigante (11, 10.77° N, 83.88° W, 415 m); 17–22.VII.2004 GK to the intersection of Río Sarapiquí with Río San Juan (9, 10.71° N, 83.93° W, 20 m), Chingo Petaca (12, 10.75° N, 83.84° W, 40 m), Río Chimurria (10, 10.73° N, 83.91° W, 25 m), and Río El Chancho (7, 10.82° N, 84.02° W, 60 m); 08–21.VI.2006 JS, Andreas Hertz, Sebastian Lotzkat, Lenin Obando, and Darwin

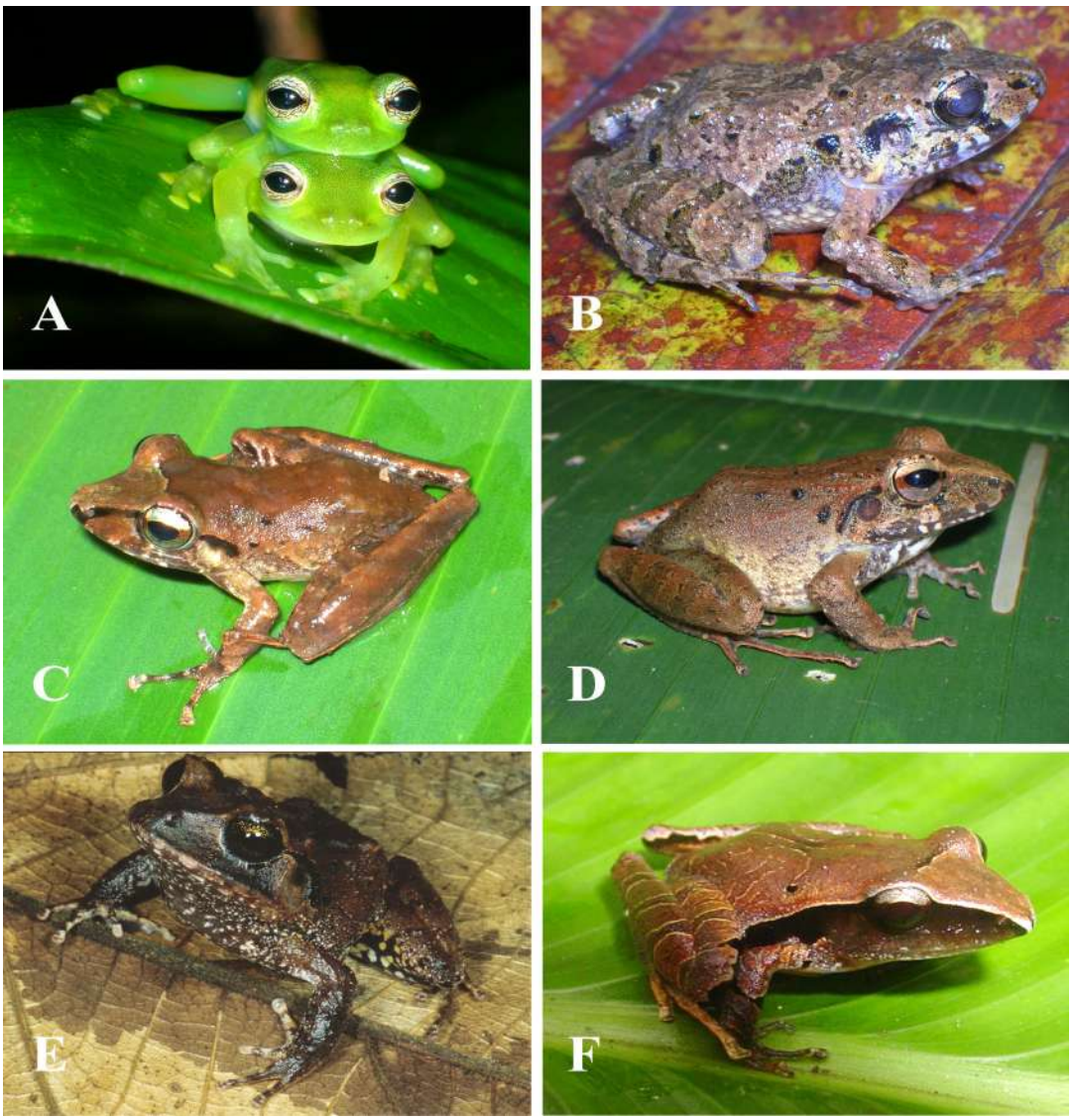

Figure 5. A. *Teratohyla spinosa* (Dos Bocas de Bartola); B. *Craugastor bransfordii* (Dos Bocas de Río Indio); C. *Craugastor chingopetaca* (Boca de San Carlos); D. *Craugastor fitzingeri* (Dos Bocas de Río Indio); E. *Craugastor megacephalus* (Cerro El Gigante); F. *Craugastor mimus* (Bartola, not collected), photo: M. Salazar-Saavedra.

Manzanarez to El Almendro (3, 11.00° N, 84.28° W, 70 m; also known as Dos Bocas de Bartola), Bartola (1), Boca de San Carlos (4), and Dos Bocas de Río Indio (13, 11.05° N, 83.88° W, 20 m).

We examined all specimens collected during the expeditions (App. 1) and took morphometric data from selected specimens. Measurements were taken using dial calipers under a dissecting microscope (Leica MZ 12) rounded to the nearest 0.1 mm, and with the dissecting microscope's ocular micrometer rounded to the nearest 0.01 mm. Terminology for the examined characters follows that of Savage (2002). Specimens labelled with SMF numbers were deposited in the collections of the Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt a.M., Germany. Specimens labelled with CRB were deposited in the herpetological collection of the Colección Refugio Bartola, Río San Juan, Nicaragua. Specimens labelled with GK field numbers were deposited in the Ministerio del Ambiente y los Recursos Naturales (MARENA), Managua, Nicaragua. Specimens labelled with GP, JS, and MD field numbers will be deposited in a yet undetermined Nicaraguan herpetological collection: Universidad Nacional Autónoma de Nicaragua-León (UNAN-León), León; Universidad Centroamericana (UCA), Managua; or Fundación Amigos del Río San Juan (FUNDAR), Managua.

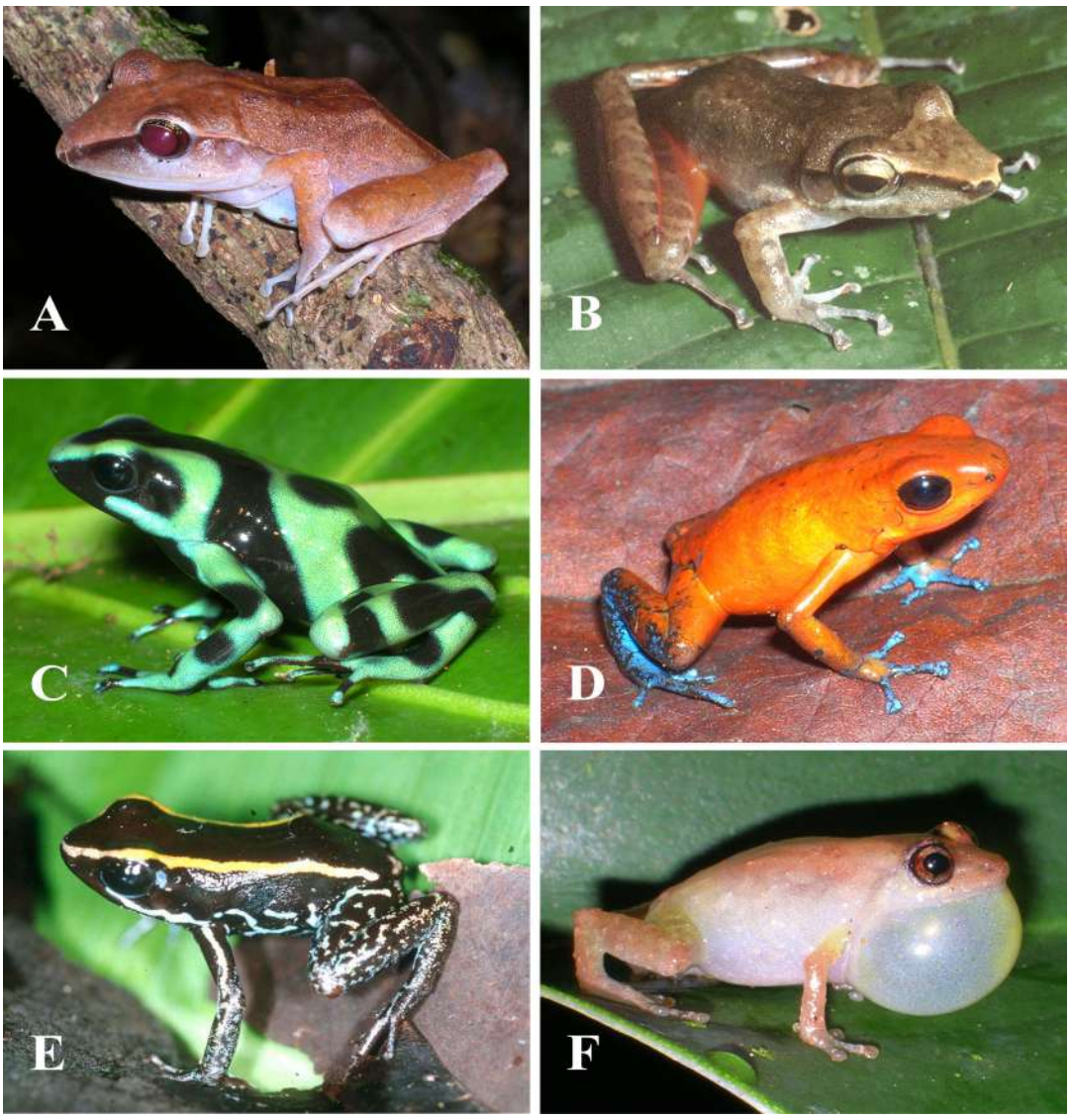

Figure 6. A. *Craugastor noblei* (Boca de San Carlos); B. *Craugastor talamancae* (Lomas de Tambor); C. *Dendrobates auratus* (Dos Bocas de Bartola); D. *Oophaga pumilio* (Dos Bocas de Río Indio); E. *Phyllobates lugubris* (Bartola); F. *Diasporus diastema* (Dos Bocas de Río Indio).

Results

We recorded a total of 44 amphibian species (Figs. 3–10) during our own field trips to the Río San Juan area, but there are voucher specimens of a total of 49 species (67% of all recognized Nicaraguan amphibian species) representing 25 genera and 13 families known from the area (Table 1). The five additional species not collected by us are: *Sachatamia ilex, Craugastor ranoides, Ecnomiohyla miliaria, Gastrophryne pictiventris,* and *Lithobates taylori* (see Savage 1973 and Köhler 2001). Morphometric data, ecological characterizations, and the conservation status of all amphibian species known to occur in the Río San Juan area are provided in Table 1. Localities of all examined specimens are listed in App. 1.

Discussion

Comparison of the examined specimens with data provided by Savage (2002)

Craugastor bransfordii: Savage (2002) states that in

Table 1. Morphometric data, ecological characterization, and conservation status of the amphibians of the Río San Juan area.

GYMNOPHIONA	n	SVL	Primary annulli	Secondary annuli	HW/HL	Distance tentacle-nostril/HL	Distance tentacle-snout/HL	ABUND	HIST UNIT	REPR	IUCN	VULN
Caeciliidae												
Gymnopis multiplicata	3	322.0–378.0 (341.0±23.25)	114–118 (118±1.89)	89–100 (97±4.64)	0.74–0.78 (0.76±0.02)	0.30–0.33 (0.32±0.01)	0.43–0.45 (0.43±0.01)	+++	MA	e	LC	medium

CAUDATA	n	♂	♀	SVL ♂	SVL ♀	TL/SVL	HW/SVL	HL/SVL	AGD/SVL	Hind limb/ SVL	Forelimb/ SVL	Hind foot width/SVL	TEETH MAX	TEETH VOM	TEETH PRE	ABUND	HIST UNIT	REPR	IUCN	VULN
Plethodontidae																				
Bolitoglossa indio [R]	1		1		46.8	0.74	0.17	0.24	0.52	0.23	0.22	0.11	48	38	7	+	ON	e	DD	high
Bolitoglossa striatula	2	1	1	51.0	58.5	0.94–1.04 (0.99±0.05)	0.14	0.21–0.23 (0.22±0.01)	0.55–0.57 (0.56±0.01)	0.20	0.19	0.09–0.10	36–55	23–27	6–7	+++	ON	e	LC	medium

ANURA	n	♂	♀	♂ SVL	♀ SVL	SHL/SVL	FL/SVL	HW/SVL	HL/SVL	TM/EL	EN/HL	IOD/HW	IN/HW	ABUND	HIST UNIT	REPR	IUCN	VULN
Aromobatidae																		
Allobates talamancae [R]	2			18.2–21.1 (19.65±1.45)		0.41–0.49 (0.45±0.04)	0.33–0.37 (0.35±0.02)	0.33–0.36 (0.34±0.01)	0.36–0.38 (0.37±0.01)	0.21–0.21 (0.21±0.00)	0.19–0.20 (0.29±0.01)	0.37–0.37 (0.37±0.00)	0.35–0.36 (0.36±0.00)	++	SA	d	LC	high
Bufonidae																		
Incilius coniferus	3	1	2	53.8	79.2–84.5 (81.85±2.65)	0.43	0.40–0.44 (0.42±0.02)	0.36–0.38 (0.36±0.01)	0.32–0.34 (0.34±0.01)	0.38–0.43 (0.39±0.02)	0.14–0.15	0.32–0.34 (0.33±0.01)	0.10–0.13 (0.12±0.01)	+++	MA	a	LC	low
Incilius melanochlorus [R]	1		1		110.4	0.48	0.4	0.41	0.38	0.31	0.16	0.29	0.12	+	MA	a	LC	medium
Incilius valliceps *	1		1		50.5	0.41	0.37	0.37	0.35	0.39	0.16	0.36	0.12	+++	MA	a	LC	low
Rhaebo haematiticus	2	1	1	60.2	67.6	0.44–0.49 (0.47±0.02)	0.38–0.40 (0.39±0.01)	0.33	0.30–0.32 (0.31±0.01)	0.28–0.30 (0.29±0.01)	0.16	0.38–0.39 (0.39±0.01)	0.20–0.21 (0.20±0.01)	+++	SA	a	LC	low
Rhinella marina *	1	1		65.8		0.4	0.38	0.39	0.34	0.38	0.18	0.36	0.2	+++	SA	a	LC	low
Centrolenidae																		
Espadarana prosoblepon	4	3	1	24.8–26.2 (25.2±0.59)	27.2	0.53–0.60 (0.58±0.02)	0.38–0.42 (0.39±0.01)	0.34–0.36 (0.35±0.01)	0.32–0.35 (0.33±0.01)	0.15–0.21 (0.17±0.02)	0.19–0.21 (0.20±0.01)	0.30–0.34 (0.31±0.02)	0.17–0.18 (0.18±0.01)	+++	SA	c	LC	medium
Sachatamia albomaculata	1	1		24.3		0.65	0.43	0.34	0.33	0.21	0.16	0.31	0.2	++	SA	c	LC	medium
Sachatamia ilex [R]														+	SA	c	LC	high
Teratohyla pulverata	1	1		24.1		0.59	0.46	0.34	0.33	0.19	0.21	0.36	0.23	+	SA	c	LC	medium
Teratohyla spinosa	13	12	1	18.8–21.3 (20.05±0.87)	21.6	0.56–0.63 (0.60±0.02)	0.40–0.44 (0.41±0.01)	0.33–0.37 (0.35±0.01)	0.28–0.36 (0.34±0.02)	0.13–0.21 (0.17±0.02)	0.18–0.25 (0.20±0.02)	0.27–0.38 (0.37±0.03)	0.16–0.22 (0.19±0.02)	++++	SA	c	LC	medium
Craugastoridae																		
Craugastor bransfordii	29	13	16	15.4–23.4 (20.5±2.85)	14.0–26.2 (21.5±2.75)	0.49–0.60 (0.54±0.02)	0.45–0.55 (0.48±0.02)	0.35–0.41 (0.37±0.01)	0.37–0.45 (0.40±0.02)	0.22–0.55 (0.39±0.10)	0.17–0.23 (0.20±0.02)	0.25–0.35 (0.30±0.02)	0.19–0.24 (0.22±0.01)	++++	MA	e	LC	medium
Craugastor chingopetaca [R]	1	1		30.7		0.68	0.55	0.36	0.39	0.38	0.28	0.28	0.23	++	MA	e	DD	high
Craugastor fitzingeri	17	8	9	27.3–31.6 (30.5±1.26)	43.0–48.5 (46.2±1.55)	0.56–0.63 (0.59±0.02)	0.47–0.55 (0.51±0.02)	0.32–0.38 (0.35±0.02)	0.37–0.42 (0.40±0.02)	0.35–0.56 (0.40±0.07)	0.24–0.33 (0.30±0.03)	0.28–0.32 (0.30±0.01)	0.23–0.30 (0.25±0.02)	++++	MA	e	LC	medium
Craugastor megacephalus	2	1	1	40.3	78.1	0.49–0.50 (0.50±0.01)	0.44	0.46–0.50 (0.48±0.02)	0.40–0.44 (0.42±0.02)	0.34–0.58 (0.46±0.12)	0.21–0.23 (0.22±0.01)	0.24–0.26 (0.25±0.01)	0.14–0.15 (0.14±0.01)	+++	MA	e	LC	medium
Craugastor mimus *	1	1		14.4		0.59	0.5	0.35	0.42	0.44	0.21	0.36	0.28	++	MA	e	LC	medium
Craugastor noblei *	6	3	3	16.0–20.1 (17.4±1.7)	16.0–18.7 (16.9±1.12)	0.50–0.56 (0.52±0.02)	0.36–0.39 (0.37±0.01)	0.32–0.37 (0.35±0.02)	0.41–0.44 (0.43±0.01)	0.19–0.28 (0.22±0.03)	0.23–0.27 (0.25±0.01)	0.32–0.39 (0.33±0.02)	0.25–0.27 (0.27±0.01)	+++	MA	e	LC	medium
Craugastor ranoides														+	MA	e	CR	high
Craugastor talamancae	1	1		28.2		0.62	0.54	0.33	0.41	0.53	0.32	0.34	0.32	+	MA	e	LC	high
Dendrobatidae																		
Dendrobates auratus	9			27.6–36.9 (33.00±2.90)		0.43–0.47 (0.45±0.01)	0.37–0.42 (0.39±0.01)	0.27–0.31 (0.28±0.01)	0.30–0.35 (0.31±0.01)	0.28–0.33 (0.31±0.01)	0.19–0.21 (0.20±0.01)	0.40–0.46 (0.44±0.02)	0.33–0.39 (0.37±0.02)	+++	SA	d	LC	medium
Oophaga pumilio	15			17.5–21.3 (19.20±1.05)		0.39–0.47 (0.44±0.02)	0.32–0.39 (0.36±0.02)	0.30–0.33 (0.31±0.01)	0.33–0.37 (0.35±0.01)	0.18–0.30 (0.23±0.04)	0.15–0.20 (0.18±0.01)	0.35–0.44 (0.39±0.02)	0.33–0.39 (0.36±0.02)	++++	SA	d	LC	medium
Phyllobates lugubris [R]	6			19.5–22.0 (19.95±0.86)		0.47–0.51 (0.50±0.02)	0.38–0.45 (0.39±0.03)	0.31–0.34 (0.33±0.01)	0.35–0.38 (0.38±0.01)	0.25–0.31 (0.28±0.02)	0.17–0.19 (0.18±0.01)	0.36–0.40 (0.37±0.01)	0.34–0.37 (0.36±0.01)	++	SA	d	LC	high
Eleutherodactylidae																		
Diasporus diastema	8	4	4	16.1–19.0 (17.0±1.10)	19.3–21.5 (20.0±0.88)	0.42–0.49 (0.45±0.02)	0.34–0.37 (0.35±0.01)	0.32–0.37 (0.34±0.02)	0.36–0.40 (0.38±0.02)	0.13–0.22 (0.18±0.03)	0.17–0.22 (0.19±0.02)	0.33–0.37 (0.35±0.01)	0.25–0.27 (0.26±0.01)	++++	MA	e	LC	low
Hylidae																		
Agalychnis callidryas	2	2		51.8–55.3 (53.55±1.75)		0.51–0.55 (0.53±0.02)	0.34–0.35 (0.35±0.01)	0.34–0.35 (0.34±0.01)	0.33–0.34 (0.34±0.01)	0.31–0.34 (0.33±0.01)	0.22–0.23 (0.23±0.01)	0.34	0.18–0.22 (0.20±0.02)	++	MA	c	LC	low
Cruziohyla calcarifer [R]	1		1		73.5	0.53	0.39	0.37	0.3	0.57	0.29	0.28	0.24	++	MA	c	LC	medium

Costa Rican *Craugastor bransfordii* the thenar tubercle is equal to, or slightly smaller than, the palmar tubercle as indicated in his Fig. 7.53a. In our material a few specimens had the thenar tubercle much smaller than the palmar tubercle, similar to the condition as shown in Fig. 7.53b in Savage (2002). Also, the maximum recorded SVL for Costa Rican males and females is 23.0 mm and 26.0 mm, respectively (Savage 2002). In our material, GP 121 (♂) reaches 23.4 mm and SMF 83382 (♀) 26.2 mm.

Craugastor megacephalus: The maximum recorded SVL for Costa Rican females is 70.0 mm (Savage

Table 1. (continued)

ANURA	n	♂	♀	♂ SVL	♀	SHL/SVL	FL/SVL	HW/SVL	HL/SVL	TM/EL	EN/HL	IOD/HW	IN/HW	ABUND	HIST UNIT	REPR	IUCN	VULN
Dendropsophus ebraccatus	3	2	1	25.6–27.3 (26.5±0.85)	36.5	0.48–0.58 (0.53±0.04)	0.41–0.48 (0.45±0.03)	0.29–0.34 (0.32±0.02)	0.28–0.34 (0.31±0.02)	0.21–0.28 (0.28±0.03)	0.18–0.21 (0.20±0.01)	0.36–0.39 (0.38±0.01)	0.22–0.24 (0.23±0.01)	++	SA	c	LC	medium
Dendropsophus microcephalus	1	1		23.9		0.41	0.38	0.29	0.29	0.23	0.23	0.3	0.27	++	SA	a	LC	low
Dendropsophus phlebodes	4	3	1	22.3–23.0 (22.6±0.29)	27.6	0.50–0.54 (0.51±0.01)	0.39–0.43 (0.40±0.02)	0.30–0.33 (0.33±0.01)	0.30–0.33 (0.32±0.01)	0.18–0.25 (0.21±0.02)	0.18–0.19 (0.19±0.01)	0.34–0.37 (0.34±0.01)	0.21–0.24 (0.22±0.01)	+++	SA	a	LC	medium
Ecnomiohyla miliaria R														+	SA	f	VU	high
Hypsiboas rufitelus	6	4	2	40.7–43.3 (41.7±1.08)	53.2–54.8 (54.0±0.80)	0.50–0.56 (0.55±0.02)	0.36–0.41 (0.39±0.02)	0.33–0.35 (0.33±0.01)	0.35–0.37 (0.36±0.01)	0.31–0.40 (0.36±0.03)	0.23–0.26 (0.24±0.01)	0.35–0.37 (0.36±0.01)	0.15–0.18 (0.16±0.01)	+++	SA	a	LC	medium
Scinax boulengeri	1		1		49.8	0.57	0.44	0.33	0.36	0.41	0.29	0.34	0.18	++	SA	a	LC	medium
Scinax elaeochroa	4	4		32.3–34.7 (32.8±0.93)		0.50–0.53 (0.52±0.01)	0.40–0.43 (0.42±0.01)	0.31–0.33 (0.33±0.01)	0.32–0.35 (0.34±0.01)	0.28–0.36 (0.33±0.03)	0.21–0.29 (0.25±0.03)	0.34–0.39 (0.37±0.02)	0.20–0.21 (0.20±0.01)	+++	SA	a	LC	medium
Scinax staufferi	1	1		22.9		0.48	0.4	0.31	0.33	0.3	0.29	0.34	0.23	++	SA	a	LC	low
Smilisca baudinii	1		1		60.9	0.54	0.44	0.39	0.37	0.54	0.21	0.32	0.22	++	MA	a	LC	low
Smilisca phaeota	1	1		50.7		0.54	0.4	0.36	0.34	0.51	0.24	0.3	0.22	++	MA	a	LC	low
Smilisca puma	1	1		39.9		0.51	0.39	0.37	0.36	0.53	0.2	0.33	0.2	++	MA	a	LC	medium
Smilisca sordida	4	3	1	38.8–43.7 (39.1±2.24)		0.55–0.61 (0.58±0.03)	0.42–0.46 (0.43±0.02)	0.34–0.36 (0.34±0.01)	0.35	0.31–0.34 (0.32±0.01)	0.19–0.21 (0.20±0.01)	0.34–0.38 (0.35±0.02)	0.20–0.23 (0.22±0.01)	++	MA	a	LC	medium
Leptodactylidae																		
Leptodactylus fragilis	2	1	1	38.4		0.47–0.50 (0.48±0.01)	0.47–0.48 (0.47±0.01)	0.32	0.36–0.37 (0.37±0.01)	0.37–0.41 (0.39±0.02)	0.19	0.25	0.23	++	SA	b	LC	low
Leptodactylus melanonotus *	1		1		21.7	0.4	0.53	0.37	0.43	0.45	0.22	0.27	0.25	++	SA	b	LC	low
Leptodactylus savagei	1	1		151.1		0.44	0.45	0.38	0.38	0.42	0.21	0.24	0.21	+++	SA	b	LC	medium
Microhylidae																		
Gastrophryne pictiventris														+	MA	a	LC	medium
Ranidae																		
Lithobates taylori														+	ON	a	LC	medium
Lithobates vaillanti *	2	1	1	57.3	73.1	0.52–0.55 (0.54±0.01)	0.53–0.54 (0.54±0.01)	0.34–0.37 (0.35±0.01)	0.41–0.43 (0.42±0.01)	0.49–0.51 (0.50±0.01)	0.18–0.19 (0.18±0.01)	0.23–0.24 (0.23±0.01)	0.23–0.25 (0.24±0.01)	+++	ON	a	LC	low
Lithobates warszewitschii	5	1	4	51.1	57.3–65.1 (62.9±2.94)	0.47–0.52 (0.50±0.02)	0.41–0.48 (0.42±0.02)	0.31–0.33 (0.32±0.01)	0.40–0.41 (0.41±0.01)	0.40–0.56 (0.45±0.06)	0.17–0.19 (0.19±0.01)	0.26–0.30 (0.28±0.01)	0.26–0.31 (0.29±0.02)	+++	ON	a	LC	medium
Strabomantidae																		
Pristimantis cerasinus	8	3	5	23.6–25.6 (23.8±0.90)	20.9–33.4 (32.6±4.77)	0.56–0.64 (0.57±0.03)	0.42–0.47 (0.45±0.01)	0.33–0.39 (0.37±0.01)	0.39–0.44 (0.40±0.01)	0.18–0.30 (0.24±0.03)	0.24–0.31 (0.29±0.02)	0.27–0.37 (0.29±0.03)	0.18–0.23 (0.20±0.02)	+++	SA	e	LC	medium
Pristimantis ridens	16	3	13	17.4–19.0 (18.3±0.65)	22.9–26.9 (24.5±1.39)	0.48–0.59 (0.55±0.03)	0.38–0.47 (0.43±0.03)	0.32–0.38 (0.37±0.02)	0.37–0.42 (0.38±0.02)	0.12–0.29 (0.17±0.04)	0.20–0.29 (0.24±0.02)	0.28–0.38 (0.33±0.02)	0.20–0.24 (0.22±0.01)	++++	SA	e	LC	low

n: number of specimens we took morphometic data from. Specimens were not sexed in Caecilidae, Aromobatidae and Dendrobatidae. Morphometrics: range (mean ± one standard deviation). *: morphometrics based on juvenile specimens; R: in Nicaragua, species is restricted to the Río San Juan area; ABUND: Abundance (based on voucher specimens and observations: + = rare; ++ = relatively rare; +++ = relatively abundant; and ++++ = abundant); AGD: Axilla-groin distance; EL: eye length; EN: eye-nostril distance; FL: foot length; HIST UNIT: historical unit (ON: Old Northern element; MA: Middle American element; SA: South American element); HL: head length (tip of snout to angle of jaw); HW: greatest width of head; IN: internasal distance; IOD: interorbital distance; IUCN: IUCN categorization (LC: least concern; VU: vulnerable; CR: critically endangered; DD: data deficient); REPR: reproductive strategies (a: both eggs and tadpoles in large or small bodies of lentic or lotic water; b: eggs in foam nests, tadpoles in small bodies of lentic or lotic water; c: tadpoles occur in small bodies of lentic or lotic water, eggs elsewhere; d: tadpoles carried to water by parents on their back; e: eggs laid in moist situations on land or moist arboreal situations, direct development; f: eggs and tadpoles in water-filled tree cavities); SHL: shank length; SVL: snout-vent length; TL: tail length; TEETH (MAX: maxillary; VOM: vomerine; PRE: premaxillary); TM: tympanum length; VULN: vulnerability risk in Nicaragua (calculated from the Environmental Vulnerability Scores; see text).

2002). In our material, GP 116 reaches 78.1 mm.

Dendropsophus ebraccatus: The maximum recorded SVL for Costa Rican males and females is 27.0 mm and 35.0 mm, respectively (Savage 2002). In our material, SMF 83210 (♂) reaches 27.3 mm, and SMF 79740 (♀) 36.5 mm.

Smilisca puma: The maximum recorded SVL for Costa Rican males is 38.0 mm (Savage 2002). In our material, SMF 79783 reaches 39.9 mm.

Leptodactylus fragilis: The maximum recorded SVL for Costa Rican males is 36.0 mm (Savage 2002). In our material, SMF 80910 reaches 38.4 mm.

Lithobates warszewitschii: The maximum recorded SVL for Costa Rican females is 63.0 mm (Savage 2002). In our material, GP 128, and MD 027, reach 65.1 and 63.7 mm respectively.

Teratohyla spinosa: The maximum recorded SVL for Costa Rican males is 20.0 mm (Savage 2002). In our material, six male specimens are larger than 20.0 mm. The two largest, SMF 79758 and SMF 82087 reach 21.3 mm. Sunyer and Köhler (2007) discussed part of this series.

Figure 7. A. *Agalychnis callidryas* (Bartola); B. *Cruziohyla calcarifer* (near Dos Bocas de Río Indio); C. *Dendropsophus ebraccatus* (Bartola); D. *Dendropsophus microcephalus* (Río Frío, 7 km S San Carlos); E. *Dendropsophus phlebodes* (Dos Bocas de Río Indio); F. *Hypsiboas rufitelus* (Bartola).

Zoogeographic and conservational comments

We assigned all amphibian species from the Río San Juan area to historical units as defined by Savage (2002) (Table 1). The majority of species (49%) belongs to the South American Element. The second largest category is the Middle American Element (41%), and the least representative is the Old Northern Element (10%; Table 1). Eight amphibian species (11% of total species from Nicaragua and 16% of total species from the Río San Juan area) are restricted to the Río San Juan area in Nicaragua. The only endemic amphibian species known from the Río San Juan area are *Bolitoglossa indio*, a poorly known salamander recently described by Sunyer et al. (2008), and *Craugastor chingopetaca*. Both species are likely to be found along the northern lowlands of the Atlantic versant of Costa Rica.

Also, the Río San Juan area is the northern distributional limit of *Allobates talamancae, Incilius melanochlorus, Sachatamia ilex, Dendrobates auratus, Phyllobates lugubris,* and *Smilisca puma. Dendrobates*

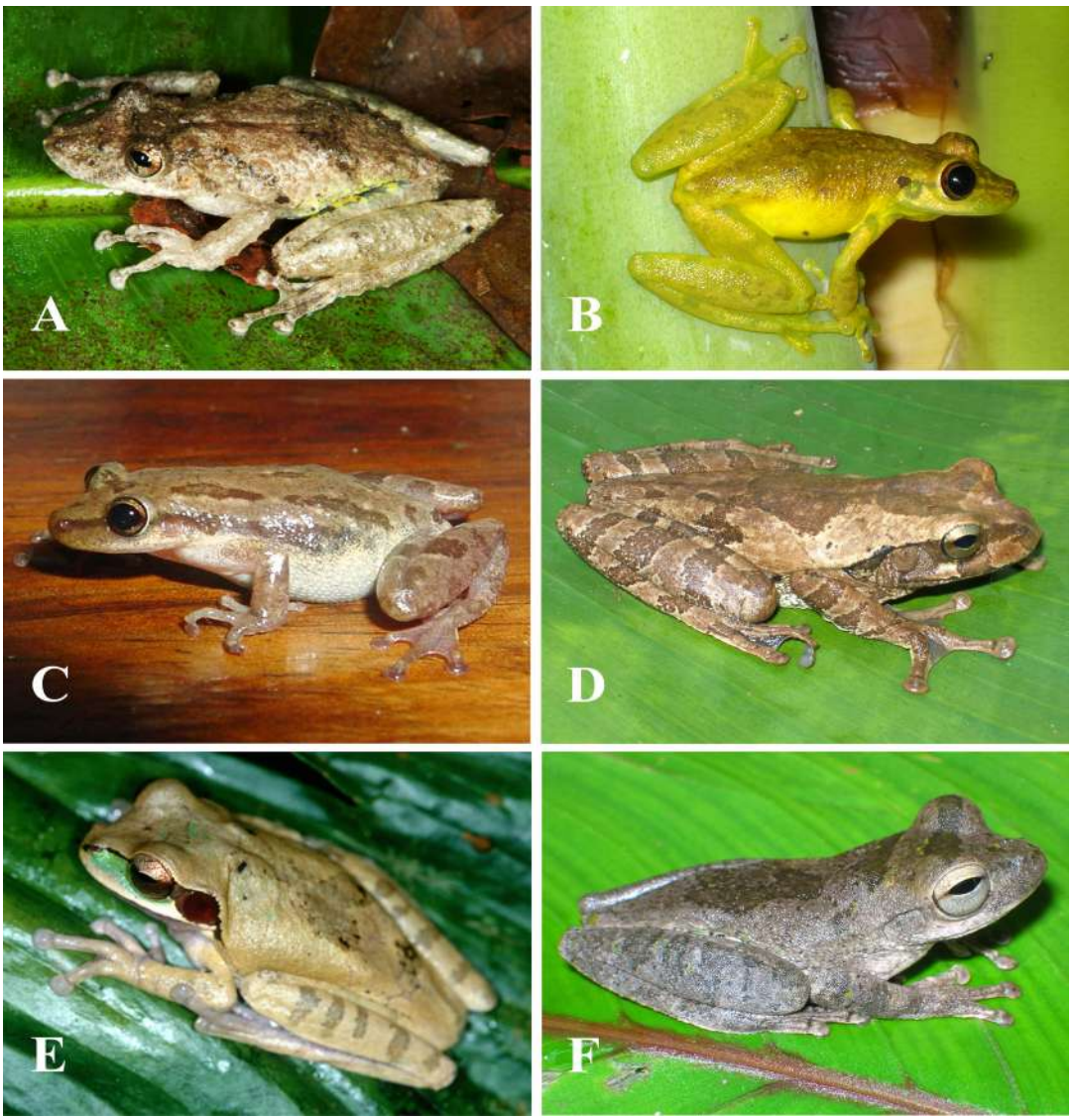

Figure 8. A. *Scinax boulengeri* (Chingo Petaca); B. *Scinax elaeochroa* (Dos Bocas de Río Indio); C. *Scinax staufferi* (Bartola), photo: M. Salazar-Saavedra; D. *Smilisca baudinii* (Boca de San Carlos); E. *Smilisca phaeota* (Bartola); F. *Smilisca puma* (Boca de San Carlos).

auratus is also known from Río Tule, approximately 25 km N of San Carlos (Köhler 2001), and *S. puma* is also known from Papaturro (Refugio de Vida Silvestre Los Guatuzos), approximately 30 km W of San Carlos (see Fig. 2). *Incilius valliceps* reaches its southernmost limit of distribution slightly south of the Río San Juan area (Köhler 2001, Savage 2002).

Oedipina cyclocauda (southeastern Nicaragua to central Panama) is only known in Nicaragua from a single locality "approximately 1.5 km south of El Castillo" (Brame 1968; see Fig. 2). Sunyer and Köhler (*in press*) considered LWF to the area east of El Castillo and, therefore, included this species in this forest formation. Aside from *O. cyclocauda*, other amphibian species that are not yet reported from the Río San Juan area but are not completely unexpected to occur there are *Oedipina collaris, Cochranella granulosa, Hyalinobatrachium fleischmanni*, *Agalychnis saltator*, and *Tlalocohyla loquax*. Although *Anotheca spinosa* is not yet recorded from Nicaragua, its known distribution ranges disjunctively from Mexico to Panama (Frost 2008). In Costa Rica, *A. spinosa* is marginally found

Figure 9. A. *Smilisca sordida* (Río Las Cruces), photo: F. Buitrago; B. *Leptodactylus fragilis* (Bartola); C. *Leptodactylus melanonotus* (Bartola), photo: M. Salazar-Saavedra; D. *Leptodactylus savagei* (Boca de San Carlos); E. *Lithobates vaillanti* (Bartola); F. *Lithobates warszewitschii* (Dos Bocas de Río Indio).

in LWF (Savage 2002) and therefore it is also not completely unexpected to occur in the Río San Juan area. Villa (1972) and Ruiz and Buitrago (2003) also speculate about the possible occurrence of *Craugastor gollmeri* and *Hylomantis lemur* in Nicaragua based on the proximity of their northernmost distribution to the Costa Rica-Nicaragua Atlantic border. Other amphibian species whose northernmost distribution ends more or less close to the homogeneous Río San Juan area-Costa Rica border are (Savage 2002, IUCN 2007): *Bolitoglossa alvaradoi*, *B. colonnea, Oedipina gracilis, Hyalinobatrachium colymbiphyllum*, *H. valerioi*, *Silverstoneia flotator*, *Leptodactylus poecilochilus*, *Pristimantis altae*, *P. caryophyllaceus,* and *P. cruentus*.

Sunyer and Köhler (*in press*) gauged the vulnerability of the herpetofauna within Nicaragua with the use of Environmental Vulnerability Scores (EVS). The EVS for amphibians are calculated based upon three components (Wilson and McCranie 2003): the total geographic range of each species, the extent of ecological distribution within Nicaragua, and the degree of specialization of reproductive mode of each

Figure 10. A. *Pristimantis cerasinus* (Boca de San Carlos); B. *Pristimantis ridens* (Boca de San Carlos).

amphibian species. Under a Nicaraguan perspective, 16% of the amphibian species from the Río San Juan area are considered high vulnerability species (most of them have relatively small geographic distributions, are only known from the Río San Juan area in Nicaragua, and need well preserved forests to breed), 55% are considered medium vulnerability species, and 29% low vulnerability species (Table 1).

Only two amphibian species known from the Río San Juan area are not considered as of least concern or data deficient under the IUCN categorizations (IUCN 2007): *Craugastor ranoides* and *Ecnomiohyla miliaria* (Table 1). *Craugastor ranoides* is considered critically endangered because of a drastic population decline, probably due to chytridiomycosis, a matter not taken into account when calculating the EVS. We are not aware of any investigation dealing with the presence of the pathogenic fungus *Batrachochytrium dendrobatidis* in the amphibians of the Río San Juan area, although amphibian declines are less pronounced in lowlands than in mid and high elevation areas (Lips et al. 2008). *Ecnomiohyla miliaria* is considered as vulnerable because of the loss of its primary forest habitat. The decline in the extent and quality of the forests due to human pressure probably constitutes the greatest threat to most of the amphibians in the Río San Juan area. Although Río San Juan area is the type locality of *C. ranoides* and *E. miliaria*, we are not aware of any specimens of the former collected around (El Castillo, see Fig. 2) since 1967, and the latter is only know in the area from the holotype, collected in 1885.

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Appendix 1. Specimens examined. Morphometric data were taken from specimens marked with an asterisk (*). Sites in parentheses: (1) Bartola (10.97° N, 84.34° W), (2) Río Sarnoso (10.92° N, 84.29° W), (3) Dos Bocas de Bartola, El Almendro (11.00° N, 84.28° W), (4) Boca de San Carlos (10.79° N, 84.20° W), (5) Río Las Cruces (10.90° N, 84.18° W), (6) Cerro El Bolívar (10.87° N, 84.17° W), (7) Río El Chancho (10.82° N, 84.02° W), (8) Lomas de Tambor (10.78° N, 83.99° W), (9) Intersection of Río Sarapiquí with Río San Juan (10.71° N, 83.93° W), (10) Río Chimurria (10.73° N, 83.91° W), (11) Cerro El Gigante (10.77° N, 83.88° W), (12) Chingo Petaca (10.75° N, 83.84° W), and (13) Dos Bocas de Río Indio (11.05° N, 83.88° W). Aditional mentioned sites: (14) Gran Reserva Indio-Maíz (10.97° N, 84.08° W), (15) San Juan del Norte, Greytown (10.95° N, 83.74° W), and (16) Boca de Sábalos (11.03° N, 84.47° W).

GYMNOPHIONA

Caeciliidae

Gymnopis multiplicata: (1) CRB 018, SMF 81003*, 82125–26, 82127*; (5) SMF 84814*.

CAUDATA

Plethodontidae

Bolitoglossa indio: (13) SMF 85867*.

Bolitoglossa striatula: (1) SMF 82095*; (3) SMF 87177; (9) SMF 83191*; (13) JS 633, SMF 87178.

ANURA

Aromobatidae

Allobates talamancae: (6) GP 143*; (11) SMF 83372*.

Bufonidae

Incilius coniferus: (1) SMF 80206*, 80918, 80919*, 80920, 82206, 83238*; (3) SMF 87957; (4) JS 486; (5) SMF 83364; (11) MD 056; (13) SMF 87958.

Incilius melanochlorus: (9) GK 740; (14) SMF 81836*.

Incilius valliceps: (1) CRB 072, JS 453, SMF 79833*, 80922; (2) SMF 80921; (3) SMF 87251; (4) SMF 87980; (13) SMF 86776.

Rhaebo haematiticus: (1) CRB 061, 068, GK 792, SMF 80915–17, 87965; (2) SMF 79782; (3) JS 414; (5) GP 109, 110*; (6) GP 152*; (7) GK 786; (13) SMF 87966.

Rhinella marina: (1) CRB 051, 059, SMF 79781, 80913–14; (4) SMF 87980; (9) GK 739; (13) SMF 87979; (15) SMF 87275*.

Centrolenidae

Espadarana prosoblepon: (1) SMF 80996*; (4) SMF 79779*; (11) SMF 83369–70^{both}*.

Sachatamia albomaculata: (3) SMF 87945; (6) SMF 83371*.

Teratohyla pulverata: (14) SMF 81835*.

Teratohyla spinosa: (1) CRB 040, JS 465, 467–68, SMF 80997, 82087–90^{all}*, 87807, 87809; (2) SMF 79756–58^{all}*; (3) JS 411, 417, SMF 87805, 87810–11; (4) JS 509, SMF 79753–55^{all}*, 87805; (6) GP 165*, SMF 83367–68^{both}*; (8) MD 019; (10) GK 760.

Craugastoridae

Craugastor bransfordii: (1) CRB 027, 038–39, SMF 79765–66, 79767*, 79768–69, 80983–85[all]*, 80986, 82104–07, 88113; (2) SMF 79763–64; (3) JS 397, 412, 429, SMF 88101–02; (4) SMF 88103; (5) GP 106*, 112*, 121*, 124*, 134*; (7) SMF 83130–35[all]*, 83137*; (8) SMF 83376–77[both]*; (9) GK 743; (10) GK 745, 752–53; (11) SMF 83378–83[all]*; (12) GK 771, SMF 83125–29[all]*; (13) JS 559, 591–93, 611, 613, 618, SMF 87932, 88104–12.

Craugastor chingopetaca: (4) JS 494, SMF 87947; (6) SMF 83393*; (12) SMF 83214.

Craugastor fitzingeri: (1) CRB 028, 035, JS 463, 471, SMF 79792, 80966–73[all]*, 82146*, 88009–11; (2) SMF 79789–90[both]*, 79791; (3) JS 433–34, SMF 87990; (4) SMF 79787–88, 87995; (5) GP 107–08[both]*, 117*, SMF 83392*; (7) GK 779–80, 788; (8) SMF 83394; (9) GK 735–36; (10) GK 751; (11) SMF 83395*, 84797*; (13) JS 558, 575–76, 578, 626, SMF 88003–08.

Craugastor megacephalus: (1) CRB 041, SMF 80975–76; (5) GP 116*; (11) MD 042*, 066.

Craugastor mimus: (11) SMF 84801*.

Craugastor noblei: (1) SMF 80974*; (4) JS 488, SMF 87927; (5) GP 136–37[both]*; (6) SMF 84802*; (11) SMF 84803–04[both]*.

Craugastor talamancae: (8) SMF 83360*.

Dendrobatidae

Dendrobates auratus: (1) CRB 030, JS 446, SMF 79751*, 87292; (2) SMF 79750*; (3) SMF 87291; (4) SMF 79749*; (6) GP 159*, SMF 83373*; (9) GK 730–31, SMF 83185–86[both]*; (12) SMF 83187–88[both]*.

Oophaga pumilio: (1) CRB 029, JS 448, SMF 79746–48[all]*, 87886; (3) JS 419, SMF 87887; (4) JS 491, SMF 79745*, 87893–95; (6) GP 157*, SMF 83374*; (7) SMF 83181–84[all]*; (9) SMF 83175–76[both]*, 83177; (10) GK 744, 763–64; (11) SMF 83375; (12) SMF 83178–80[all]*; (13) JS 555, SMF 87896–97.

Phyllobates lugubris: (1) SMF 80992–95[all]*; (5) GP 115*, SMF 84832*.

Eleutherodactylidae

Diasporus diastema: (1) CRB 070, JS 450, SMF 79799*, 79800, 80977*, 80978, 80979*, 88081–82; (2) SMF 79796–97[both]*, 79798; (3) JS 399, 415, 427, SMF 88077–80; (4) JS 498, 514, SMF 79794*, 79795, 88083–85; (5) SMF 83389; (6) GP 147, 151, SMF 83390*; *; (7) GK 787; (8) SMF 83391 (9) GK 738; (13) JS 544, 561, 583, SMF 88086–89.

Hylidae

Agalychnis callidryas: (1) CRB 066, SMF 79780*, 82145*

Cruziohyla calcarifer: (13) SMF 87274*.

Dendropsophus ebraccatus: (1) CRB 064, SMF 79740–41[both]*, 83210*.

Dendropsophus microcephalus: (1) CRB 033, JS 443*, SMF 88030.

Dendropsophus phlebodes: (1) CRB 065, SMF 79778*, 82144*, 83211–12[both]*; (13) JS 571–72, SMF 88073–75.

Hypsiboas rufitelus: (1) CRB 054, JS 474–75, SMF 79742–44[all]*, 80903*, 82239*, 87884, 87887; (7) GK 785; (10) GK 759; (11) SMF 84815*, 84816; (13) JS 581, SMF 87882.

Scinax boulengeri: (1) JS 444; (12) SMF 83120*.

Scinax elaeochroa: (1) SMF 79784–86[all]*, 80940*; (7) GK 778; (13) JS 562, 631, SMF 86780–81.

Scinax staufferi: (1) CRB 025; (16) JS 391*.

Smilisca baudinii: (1) CRB 053; (4) SMF 87984*.

Smilisca phaeota: (1) CRB 067, JS 461, SMF 87792*.

Smilisca puma: (4) JS 506, SMF 79783*; (11) SMF 84838; (13) SMF 86772.

Smilisca sordida: (3) JS 410; (5) GP 127*, 149*, SMF 84839*; (6) SMF 84840*.

Leptodactylidae

Leptodactylus fragilis: (1) CRB 019, SMF 80910–11[both]*.

Leptodactylus melanonotus: (1) CRB 058; (13) JS 613, SMF 87932, 87933*.

Leptodactylus savagei: (1) CRB 032, SMF 81023*; (4) SMF 88094.

Ranidae

Lithobates vaillanti: (1) CRB 052, SMF 79773*, 80912*.

Lithobates warszewitschii: (1) CRB 031, SMF 79771*, 79772, 80904–06, 82147*; (4) SMF 79770*; (5) GP 128*; (7) GK 774; (8) MD 027*; (9) GK 767; (10) GK 757–58; (13) JS 598, SMF 87950.

Strabomantidae

Pristimantis cerasinus: (1) CRB 042, SMF 80980–82[all]*; (2) SMF 79793; (3) JS 437, SMF 87822; (4) JS 533, SMF 87823–24; (5) GP 125*, 138*, SMF 83384*; (6) GP 162; (8) SMF 83385, 83386*, 83387; (11) SMF 83388*.

Pristimantis ridens: (1) CRB 043, 071, SMF 79802*, 79803, 80987*, 80988, 80989–91all*; (2) SMF 79776–77; (3) SMF 87900; (4) JS 503, 513, SMF 87904–05; (5) GP 118*, 131*, 135*, SMF 84805–06both*; (6) GP 144*; (8) SMF 84807–10all*, 84813; (11) SMF 84811*, 84812.

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