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Anurans from an Atlantic Forest-Caatinga ecotone in Rio Grande do Norte State, Brazil

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Abstract. Brazil harbours the highest richness of anuran amphibians, and such diversity may be explained by the extensive and heterogeneous biomes and habitats occurring in this country. Still, the knowledge about anuran diversity and distribution in Brazil is marked by large gaps, and such data paucity hampers scientifically based decisions for species management and conservation, especially in north-eastern Brazil. This fact is clearly exemplified by Rio Grande do Norte State, where no species survey publication exists. Given this large gap, we surveyed an Atlantic Forest-Caatinga transition zone for thirteen months, in the municipality of Macaíba, Rio Grande do Norte State. We identified 34 amphibian anuran species at the locality, several of which are presented herein as the first published record for the State.

Keywords. Amphibians, Frogs, distribution, Escola Agrícola de Jundiaí, Macaíba.

Introduction

The Neotropical region harbours the highest diversity of anuran amphibians, with about 2000 species or approximately one third of the world's known species (Duellman, 1999). The Brazilian territory hosts the highest richness of amphibians, with 946 known species (Segalla et al., 2012). This high diversity may be explained by the extensive landscape domains, each formed by collections of fairly heterogeneous and unique ecosystems in terms of their ecological features (Ab'Saber, 1977).

The Atlantic Forest in north-eastern Brazil comprises an eastern narrow zone of coastal forests adjacent to the Caatinga, a mosaic of xerophytic, deciduous, and semiarid thorn scrub vegetation (Ab'Saber, 1977). Most faunal diversity studies in the region have focused on sites under the influence of one of these biomes, while seasonal deciduous forests (characteristics of narrow transition zones between these two biomes), have received less attention.

Studies on transition zones are relevant because of the ecological uniqueness, and hence conservation importance of these areas (Remanamanjato et al., 2002). Because transition zones may exhibit physical and biological characteristics of both adjacent regions (Willians, 1996), they may present a unique composition including species sets derived from both domains, and such sets can often be richer than either biome alone (Remanamanjato et al., 2002).

The knowledge about amphibian distributions, ranges, and community composition in north-eastern of Brazil is marked by large gaps and incomplete inventories (Rodrigues, 2003; Tabarelli and Silva, 2003). Such data paucity severely hampers conservation initiatives in highly diverse and threatened biome, such as the Atlantic Forest (Mittermeier et al., 1999). Basic data on distribution and community composition are crucial to define priority areas for biodiversity conservation, as well to manage and monitor species in the long-term (Camardelli and Napoli, 2012). This situation is so critical that not a single species list has been published for large areas in Brazil, such as Rio Grande do Norte State (with an area of 52.000 km^2, larger than the Netherlands, for example). Even with recent research conducted in the region (Garda et al., 2010; Magalhães et al., 2012; Santana et al., 2011; São-Pedro et al., 2011), the assessment on anuran community composition in specific sites remains incipient.

This information gap in Rio Grande do Norte (RN) State persists despite the old colonization of the region, the extensive fragmentation and habitat loss (only 10%

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Table 1. Amphibian species recorded in Escola Agrícola de Jundiaí (EAJ), Macaíba Municipality, Rio Grande do Norte State, Brazil.

Brachycephalidae	*Ischnocnema ramagii* (Boulenger, 1888)
Bufonidae	*Rhinella granulosa* (Spix, 1824)
	Rhinella jimi (Stevaux, 2002)
Cycloramphidae	*Proceratophrys cristiceps* (Müller, 1883)
Hylidae	*Corythomantis greeningi* Boulenger, 1896
	Dendropsophus branneri (Cochran, 1948)
	Dendropsophus minutus (Peters, 1872)
	Dendropsophus nanus (Boulenger, 1889)
	Dendropsophus oliveirai (Bokermann, 1963)
	Dendropsophus soaresi (Caramaschi & Jim, 1983)
	Hypsiboas albomarginatus (Spix, 1824)
	Hypsiboas raniceps (Cope, 1862)
	Phyllomedusa nordestina Caramaschi, 2006
	Scinax cretatus Nunes & Pombal, 2011
	Scinax fuscomarginatus (A. Lutz, 1925)
	Scinax cf. *nebulosus* (Spix, 1824)
	Scinax pachychrus (Miranda-Ribeiro, 1937)
	Scinax x-signatus (Spix, 1824)
Leptodactylidae	*Leptodactylus caatingae* Heyer & Juncá, 2003
	Leptodactylus fuscus (Schneider, 1799)
	Leptodactylus macrosternum Miranda-Ribeiro, 1926
	Leptodactylus mystaceus (Spix, 1824)
	Leptodactylus natalensis A. Lutz, 1930
	Leptodactylus troglodytes A. Lutz, 1926
	Leptodactylus vastus A. Lutz, 1930
	Leptodactylus sp. (gr. *marmoratus*)
	Physalaemus albifrons (Spix, 1824)
	Physalaemus cuvieri Fitzinger, 1826
	Pleurodema diplolister (Peters, 1870)
	Pseudopaludicola cf. *falcipes*
	Pseudopaludicola sp.
Microhylidae	*Elachistocleis cesarii* (Miranda-Ribeiro, 1920)
	Dermatonotus muelleri (Boettger, 1885)
Ranidae	*Lithobates palmipes* (Spix, 1824)

of the original cover remains) caused by pastures and sugar cane cultivation, and the intensive knowledge on amphibian communities in neighbouring states (Borges-Nojosa and Cascon, 2005; Borges-Nojosa et al., 2010; Moura, 2010; Santana, 2010; Santana et al., 2008). Fragmentation and habitat loss can lead to dramatic reductions in species diversity (Cushman, 2006), but the lack of information on species compositions precludes an evaluation of their impacts in RN. More importantly, the lack of information impedes scientifically based decisions for the local fauna management and conservation. Thus, as part of a larger effort to fill the information gap on anurans in RN, we surveyed for thirteen months an anuran community within an Atlantic Forest—Caatinga transition area in RN. We discuss species distribution extensions and contextualize the results in face of the richness reported for other areas in north-eastern Brazil.

Material and Methods

The study was conducted at Escola Agrícola de Jundiaí (EAJ), municipality of Macaíba, Rio Grande do Norte State (5º 53' 06.68''S 35º 22' 01.28''W, Figure 1). The local climate is transitional between As' and BSh' types, according to Köppen classification (Cestaro and Soares, 2004). Deciduous lowland

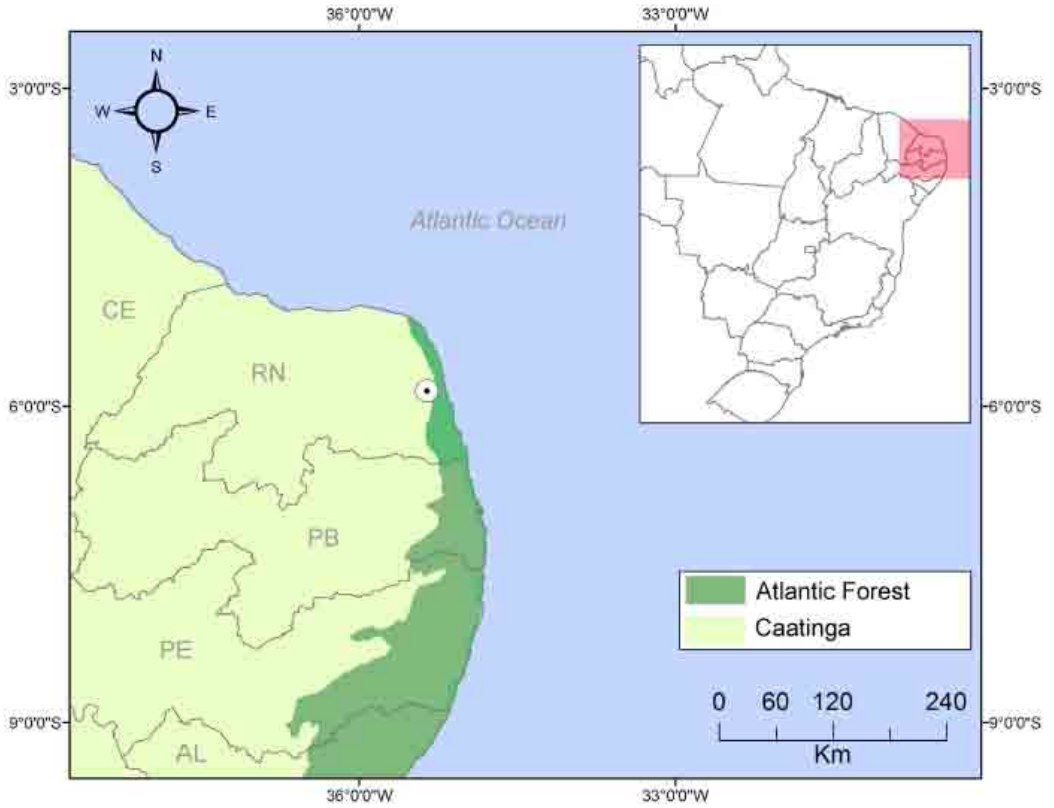

Figure 1. The study site, Escola Agrícola de Jundiaí (black dot), located in the transition zone of the Atlantic Forest and Caatinga domains in Rio Grande do Norte State, north-eastern Brazil.

forests with both Caatinga and Atlantic forest domain characterize the region. Several temporary ponds form in the area during the rainy season, which also contains a permanent lake and a shallow permanent river (Jundiaí River) with sandy bottom. Human activity is intense in the region with the presence of cattle and pastures surrounding the study area.

We conducted field expeditions from April 2009 to May 2010. Most of the field effort occurred during the raining season (March to July). Rainfall data were obtained from EMPARN (Empresa de Pesquisa Agropecuária do Rio Grande do Norte), and local average is around 1200 mm. We actively searched for adults and tadpoles following a 2 km transect that crossed several temporary and semi-permanent ponds. Voucher specimens, photographs, and advertisement calls for at least one individual per species were collected. Because only tadpoles of *Lithobates palmipes* and *Corythomantis greeningi* were collected, we used photographs from other localities: Parnamirim municipality, Rio Grande do Norte state, Brazil and Barbalha municipality, Ceará, Brazil, respectively. Adult specimens were preserved in 10% formalin and later stored in 70% alcohol, while tadpoles were preserved and stored in 10% formalin. We used the available literature to confirm the identity of tadpoles collected, when necessary. All specimens collected were deposited at Coleção do Laboratório de Anfíbios e Répteis (CLAR), Universidade Federal do Rio Grande do Norte (collecting permit 19828-4-ICMBio). Calls were deposited at the "Arquivos Sonoros da Universidade Federal do Rio Grande do Norte" (ASUFRN, the sound archives of Rio Grande do Norte University) collection. Voucher numbers and specimens for loans are available at request.

Results and Discussion

We recorded 34 species from 15 genera belonging to seven families: Brachycephalidae (1), Bufonidae (2), Cycloramphidae (1), Hylidae (14), Leptodactylidae (13), Microhylidae (2), and Ranidae (1) (Table 1). Several species are reported for the first time in Rio Grande do Norte State (we considered as new record if the species occurrences for the State is not formally published): *Dendropsophus nanus*, *D. soaresi*, *Hypsiboas albomarginatus*, *Ischnocnema ramagii*, *Leptodactylus caatingae*, *L. mystaceus*, *Physalaemus albifrons*, *Scinax cretatus*, *S. fuscomarginatus*, *S.* cf. *nebulosus* and *S. pachycrus*.

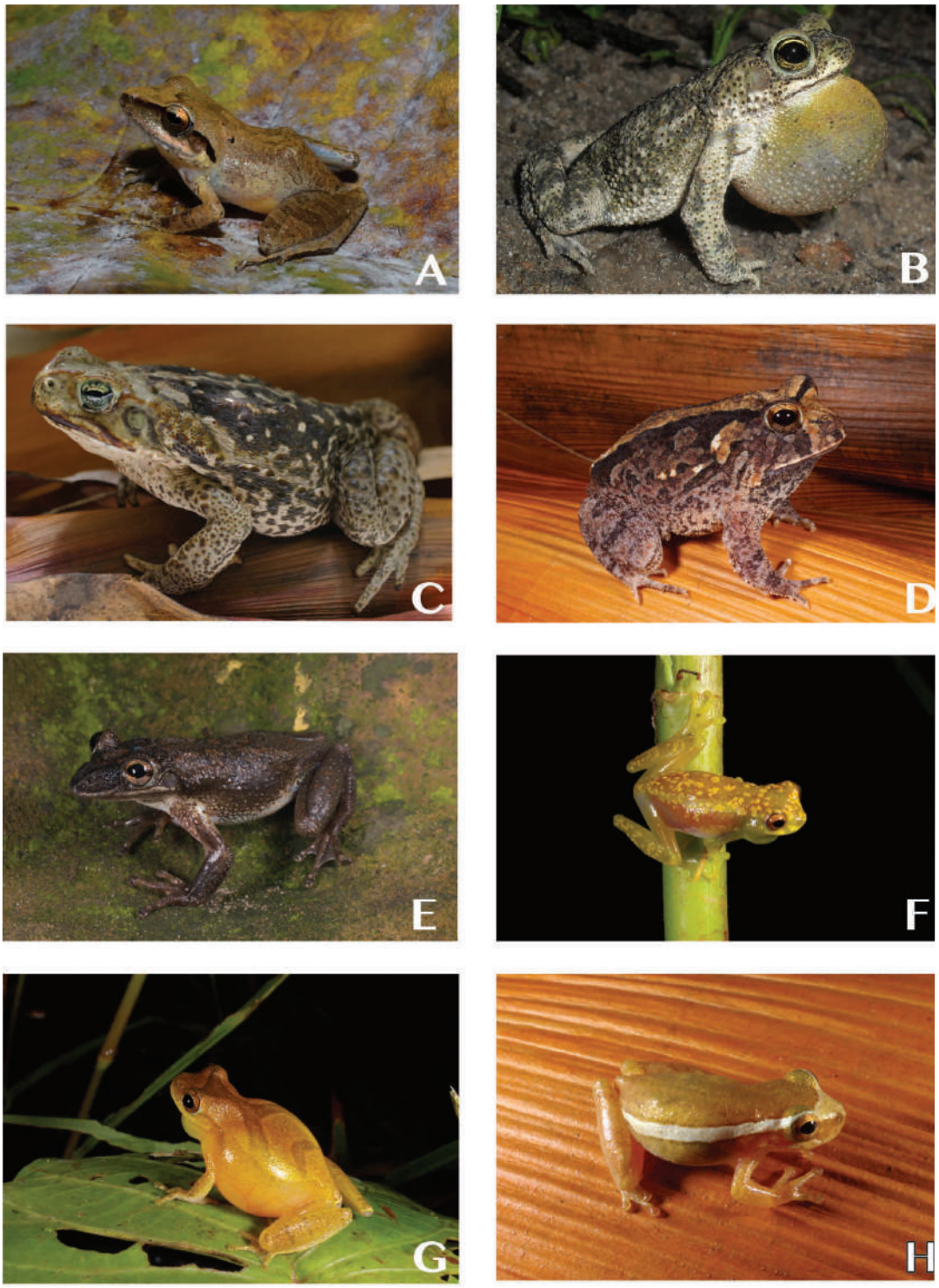

Figure 2. Anuran amphibians from Escola Agrícola de Jundiaí, Macaíba municipality, Rio Grande do Norte State, Brazil. A) *Ischnocnema ramagii*, B) *Rhinella granulosa*, C) *R. jimi*, D) *Proceratophrys cristiceps*, E) *Corythomantis greeningi*, F) *Dendropsophus branneri*, G) *D. minutus*, H) *D. oliveirai*.

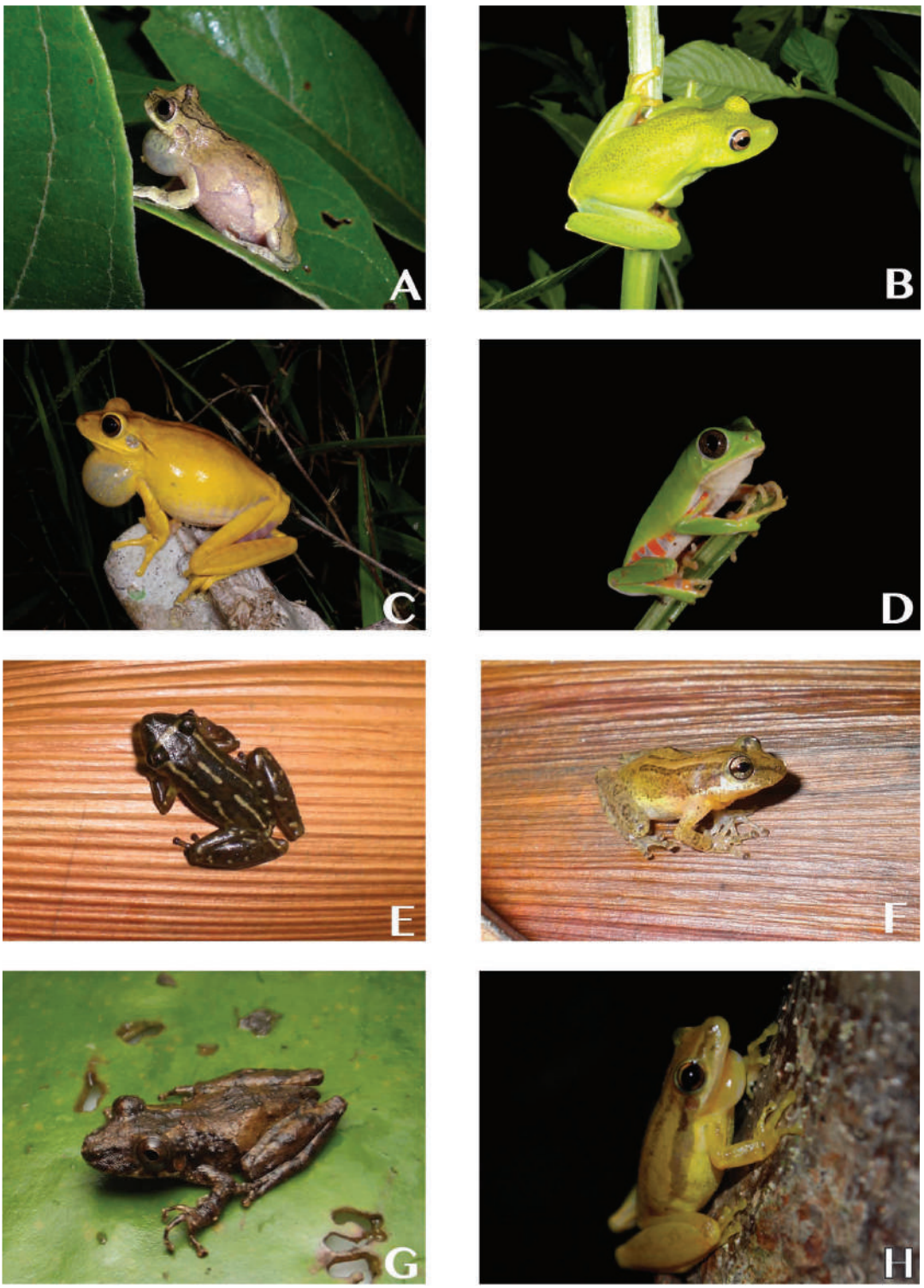

Figure 3. Anuran amphibians from Escola Agrícola de Jundiaí, Macaíba municipality, Rio Grande do Norte State, Brazil. A) *Dendropsophus soaresi*, B) *Hypsiboas albomarginatus*, C) *H. raniceps*, D) *Phyllomedusa nordestina*, E) *Scinax cretatus*, F) *S. fuscomarginatus*, G) *S.* cf. *nebulosus*, H) *S. pachycrus*.

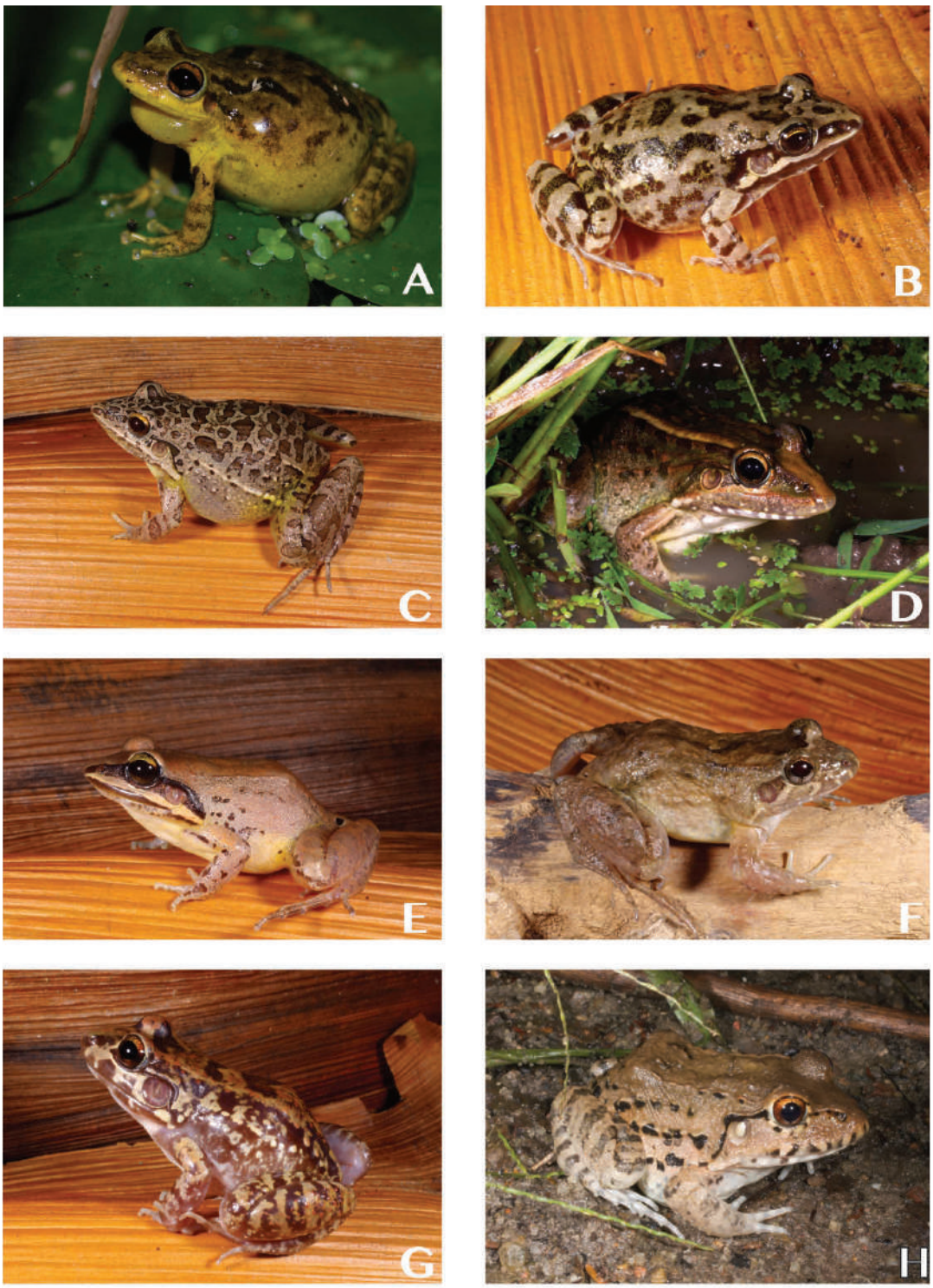

Figure 4. Anuran amphibians from Escola Agrícola de Jundiaí, Macaíba municipality, Rio Grande do Norte State, Brazil. A) *Scinax x-signatus*, B) *Leptodactylus caatingae*, C) *L. fuscus*, D) *L. macrosternum*, E) *L. mystaceus*, F) *L. natalensis*, G) *L. troglodytes*, H) *L. vastus*.

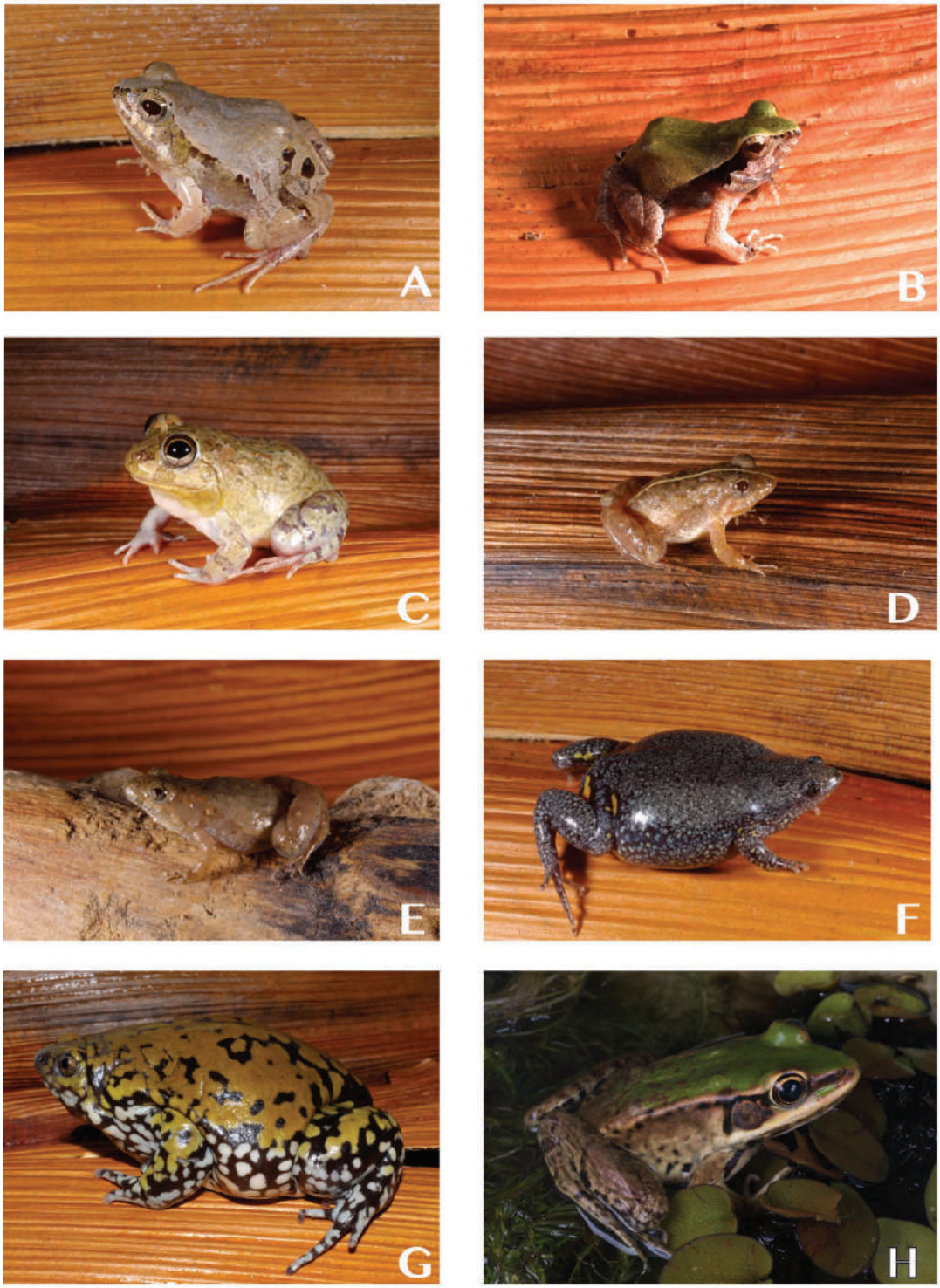

Figure 5. Anuran amphibians from Escola Agrícola de Jundiaí, Macaíba municipality, Rio Grande do Norte State, Brazil. A) *Physalaemus albifrons*, B) *P. cuvieri*, C) *Pleurodema diplolister*, D) *Pseudopaludicola* cf. *falcipes*, E) *Pseudopaludicola* sp., F) *Elachistoleis cesarii*, G) *Dermatonotus muelleri*, H) *Lithobates palmipes*.

Table 2. Number of anuran species found in areas of Atlantic forest and Caatinga domains in north-eastern Brazil (abbreviations for Brazilian states as follows: AL: Alagoas; BA: Bahia; CE: Ceará; PE: Pernambuco; PI: Piauí; SE: Sergipe).

Locality	Species	Duration	Biome	Reference
RPPN Frei Caneca, PE	42	11 months	Atlantic Forest	(Santos and Santos, 2010)
Planalto da Ibiapaba, CE	38	24 months	Caatinga/Moist Forest	(Loebmann and Haddad, 2010)
Macaíba, RN	34	13 months	Atlantic Forest/Caatinga	**Present work**
Mata do Junco, SE	33	5 days	Atlantic Forest	(Morato et al., 2011)
Refúgio Ecológico Charles Darwin, PE	30	9 months	Atlantic Forest	(Santos, 2010)
Serra da Jibóia, BA	29	5 months	Atlantic Forest/ Caatinga	(Juncá, 2006)
Aldeia, PE	28	6 months	Atlantic Forest	(Silva and Moura, 2010)
Campo Alegre, AL	28	13 months	Atlantic Forest	(Queissada, 2009)
Reserva Sapiranga, BA	26	5 months	Atlantic Forest/Restinga	(Juncá, 2006)
Parque Nacional Serra de Itabaiana, SE	23	-	Atlantic Forest/Caatinga	(Carvalho et al., 2005)
APA Delta do Parnaíba. PI	21	18 months	Coastal Forest/Caatinga	(Loebmann and Mai, 2008)
Fazenda Maturi, CE	20	1 month	Coastal Forest/Caatinga	(Borges-Nojosa et al., 2010)
Fazenda Formosa, CE	20	1 month	Coastal Forest/Caatinga	(Borges-Nojosa et al., 2010)
Betânia e Floresta, PE	19	7 months	Caatinga	(Borges-Nojosa and Santos, 2005)
Região do Rio Proxin, SE	18	4 months	Atlantic Forest	(Oliveira and Lírio-Junior, 2000)
Floresta do Crasto, SE	17	12 months	Atlantic Forest	(Arzabe et al., 1998)
São José do Bonfim, PB	16	11 months	Caatinga	(Arzabe, 1999)
São João do Cariri, PB	16	23 months	Caatinga	(Vieira et al., 2007)
Mata do Buraquinho, PB	14	9 months	Atlantic Forest	(Santana et al., 2008)
Maturéia, PB	12	11 months	Caatinga	(Arzabe, 1999)
Boa Vista, PB	9	23 months	Caatinga	(Vieira et al., 2007)

Among these, *D. nanus*, *D. soaresi*, *L. mystaceus*, *P. albifrons*, *S. fuscomarginatus* and *S. cf. nebulosus* have been reported in the neighbouring Paraíba (Santana, 2010; Santana et al., 2008; Vieira et al., 2007) and Ceará States (Borges-Nojosa et al., 2010; Loebmann and Haddad, 2010). These new records extend species geographic distributions about 150 km to the north of João Pessoa, Paraíba, and 400 km southeast of Pacajús, Ceará. Furthermore, *H. albomarginatus*, *I. ramagii*, L. caatingae and *S. cretatus* have their northernmost record in Paraíba State (Santana, 2010; Santana et al., 2008; Vieira et al., 2007), and therefore their geographic distribution is extended approximately 150km to the north.

We only found tadpoles of *Corythomantis greeningi* and *Lithobates palmipes*, in a temporary stream with rocky bottom and a sandy bottom permanent lake, respectively, during the peak of the rainy season. This record extends the known distribution of *C. greeningi* in RN about 150 km east of Angicos, Fazenda São Miguel (Jared et al., 1999), whereas *L. palmipes* has already been reported for regions near Macaíba (Hillis and de-Sá, 1988). This reinforces the importance of tadpole sampling for anuran inventories (Silva, 2010).

The two species of *Pseudopaludicola* are tentatively identified as *P. cf. falcipes*, based on advertisement call, and *Pseudopaludicola sp*. This genus is considered taxonomically problematic and involves several cryptic species, which are somehow difficult to diagnose (Carvalho, 2012). Likewise, the *Leptodactylus marmoratus* species group complex also has a complicated taxonomy (Angulo et al., 2003) and therefore further analyses are needed to confirm the identification of this species.

We collected species typical of the Atlantic Forest morphoclimatic domain, such as *D. branneri*, *H. albomarginatus*, *I. ramagii* and *S. cretatus* (Nunes and Pombal, 2011; Santana et al., 2008) and Caatinga domain, such as *C. greeningi*, *P. albifrons*, *Pleurodema diplolister*, and *Phyllomedusa nordestina* (Arzabe, 1999; Caramaschi, 2006; Rodrigues, 2003). This reinforces the transitional nature of our study site. Accordingly, Cestaro and Soares (2004) found a similar result for plants and characterized the area as a transition region between the Caatinga and Atlantic Forest phytogeographic provinces.

Because of the lack of publications on amphibian communities from RN, it is not possible to compare EAJ species richness with other localities in the state. However, even with different methodologies (specially field effort, area size, and sampling methods), we found a high species richness in comparison to other studies conducted in the Atlantic Forest and Caatinga in north-eastern Brazil (Table 2). This supports the hypothesis

that transition areas may be especially important for biodiversity management and conservation (Remanamanjato et al., 2002). Hence, prioritization of such areas of ecological tension can help protect biodiversity of neighbouring biomes, especially in regions where human activity has devastated much of the original vegetation, as is the case of RN.

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