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New records and distribution extensions of centrolenid frogs for Venezuela

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ABSTRACT: We report the first record of *Centrolene notostictum* for Venezuela, the first records of *Centrolene venezuelense* and *Hyalinobatrachium pallidum* for Zulia state, and extend the distribution of *Hyalinobatrachium tatayoi* and *Espadarana andina* based on specimens coming from the eastern versant of the Sierra de Perijá in northwestern Venezuela. The altitudinal ranges of all species are extended, and comments and notes on natural history provided.

The family Centrolenidae Taylor, 1951, also commonly known as glassfrogs, is among the most specious families of Neotropical anurans, with about 150 currently recognized species arranged in 12 genera (Guayasamin *et al*. 2009; Castroviejo-Fisher *et al*. 2009; 2011). The family is distributed from southern Mexico through Central and South America to Bolivia, with an isolated group of species occurring in southeastern Brazil and northeastern Argentina (Guayasamin *et al*. 2009; Frost 2011). The highest species diversity is in Colombia, with about 70 species (Rada *et al*. 2007), and Ecuador with 44 species (Cisneros-Heredia and McDiarmid 2007) mainly in the Andean Region of these countries. Twenty five species are currently recognized for Venezuela (Barrio-Amorós *et al*. 2009; Rojas-Runjaic *et al*. 2010; Castroviejo-Fisher *et al*. 2011) and curiously, only eight of them are from the Venezuelan Andes (Macizo de Tamá, Cordillera de Mérida and Sierra de Perijá).

The Sierra de Perijá is the northernmost spur of the Andean range and forms a natural boundary between northwestern Venezuela and northeastern Colombia. This region has been explored only superficially and its anuran fauna is still poorly known (Barrio-Amorós *et al*. 2010; Rojas-Runjaic *et al*. 2011). To date, only three glassfrogs have been recorded from the Venezuelan versant of Perijá: *Espadarana andina*, *Hyalinobatrachium tatayoi*, and more recently *Centrolene daidaleum* (La Marca 1994; Castroviejo-Fisher *et al*. 2007; and Rojas-Runjaic *et al*. 2010, respectively).

Recent expeditions to the Venezuelan Sierra de Perijá (Estado Zulia; Figure 1) by the Museo de Historia Natural La Salle (MHNLS) and the Museo de Biología de la Universidad del Zulia (MBLUZ) resulted in the finding of three unreported species of glassfrogs. We report the first record of *Centrolene notostictum* for Venezuela, the first records of *C. venezuelense* and *Hyalinobatrachium pallidum* for the Zulia state, and extend the distribution of *E. andina* and *H. tatayoi* in the Sierra de Perijá. Collecting permits 01-03-03-3649 (period 2006–2007), 4100 (period 2007–2008), and 4750 (period 2008–2009) were issued to Fernando J. M. Rojas-Runjaic (FR) by Ministerio del Poder Popular para el Ambiente of Venezuela. Expeditions to Río Negro and Río Tokuko in the Parque Nacional (PN) Sierra de Perijá were undertaken with permit of the Venezuelan Instituto Nacional de Parques (PAA-215-2008) issued to FR. Specimens were identified by comparison with museum specimens (MHNLS) and descriptions (Rivero 1985, Ruiz-Carranza and Lynch 1991; Señaris and Ayarzagüena 2005; Castroviejo-Fisher *et al*. 2007). All specimens are housed in the MHNLS and the MBLUZ.

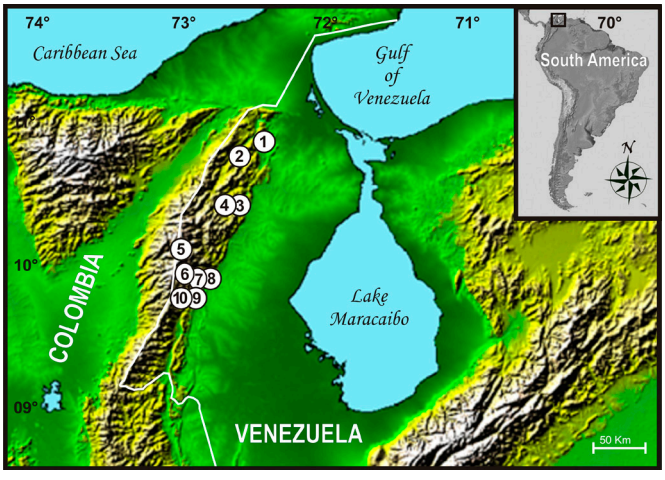

FIGURE 1. Map of NE Colombia and NW Venezuela showing major physiographic elements, from west to east: Sierra de Santa Marta, Sierra de Perijá, Maracaibo Lake, and Cordillera de Mérida. Circles numbered represent the known localities of centrolenids in the Sierra de Perijá: 1. Fundo La Orchila, Riecito Maché, Río Cachirí basin; 2. Fundo El Progreso, upper basin of the Río Socuy; 3. Creek near base camp of the Cerro Las Antenas, Río Lajas basin; 4. Creek near last antenna, Cerro Las Antenas, Río Lajas basin; 5. Base camp of the Cerro Tétari, Páramo del Tétari; 6. Campamento Guacharaca, Caño Tétari Kopejoacha, Río Negro basin; 7. Manastara, Río Negro basin; 8. Toromo, Río Negro basin; 9. El Tokuko, Río Tokuko basin; 10. Ipika, Río Tokuko basin.

Centrolene notostictum (Figure 2A) is known from at least nine localities on the western and eastern versants of the Cordillera Oriental of the Colombian Andes, in the Departments of Norte de Santander, Santander, Cundinamarca, and Boyacá (Ruiz-Carranza and Lynch 1991). The Venezuelan specimens (MHNLS 19182–19184, 19226–19231) come from Campamento Guacharaca (10°04'22" N, 72°51'17" W; 1,661 m; Figures 1 and 2B), Caño Tétari Kopejoacha, PN Sierra de Perijá, Río Negro basin, Municipio Machiques de Perijá. These specimens represent the first record of the species for Venezuela and extend the species' distribution by ca. 250 km NNE (linear) from near Chinacota (Departamento Norte de Santander, Colombia), the northernmost locality previously reported (Ruiz-Carranza and Lynch 1991). The lower limit of the species' altitudinal range is also extended to 1,661 m (previously known from 1,730 to 2,440 m). These specimens were previously mentioned as *Centrolene* sp. by Rojas-Runjaic *et al*. (2010).

Figure 2. A: Adult male *Centrolene nostostictum* from the Sierra de Perijá, Venezuela; B: habitat of *C. notostictum* at Campamento Guacharaca, Río Tétari Kopejoacha, Sierra de Perijá, Venezuela (Photos: F.J.M. Rojas-Runjaic).

Centrolene notostictum was common at Campamento Guacharaca (in May 2009). Almost all males were found calling between 19:00 and 22:00 h, on the upper surface of the leaves of ferns and Heliconeaceae plants, at the sides of a small fast-flowing creek. An amplectant pair was found on the upper side of a leaf, but egg masses were not observed.

Centrolene venezuelense (Figures 3A-B) is endemic to the Venezuelan Andes, known from at least six localities in the Cordillera de Mérida (states Mérida, Táchira and Trujillo), between 2,100 and 3,050 m (La Marca and Lynch 2004; Señaris and Ayarzagüena 2005). The four specimens reported herein (MHNLS 19212–19215) come from the base camp of the Cerro Tétari (10°07'20.40" N, 72°52'40.30" W; 3,000 m; Figures 1 and 4A), Páramo del Tétari, PN Sierra de Perijá, Municipio Machiques de Perijá. These specimens constitute the first record for Zulia state and extend the distribution ca. 240 km NNW from Betania (Táchira), the westernmost locality previously reported (Señaris and Ayarzagüena 2005).

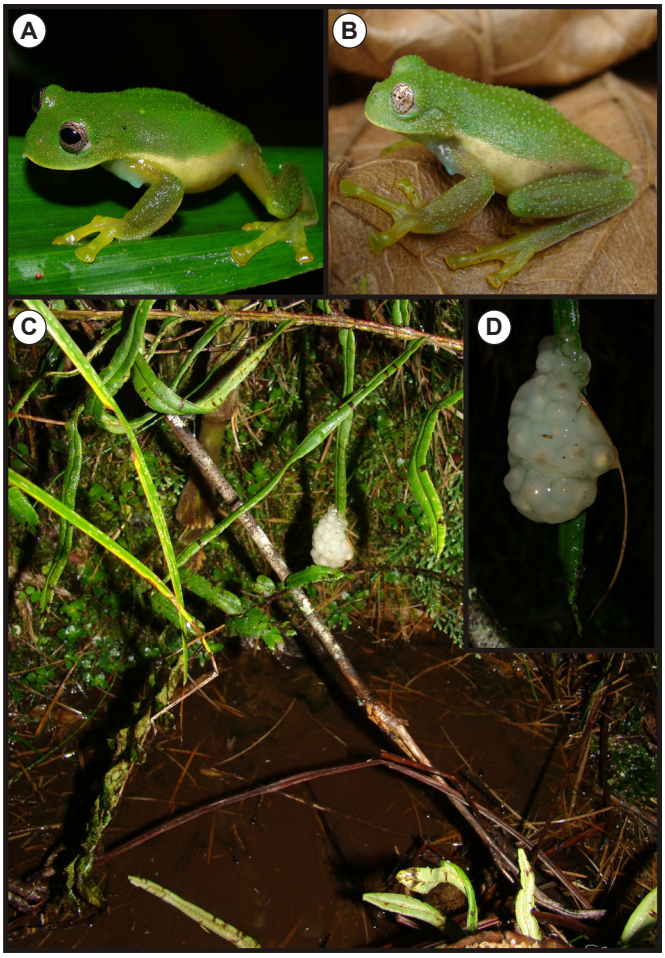

Figure 3. A-B: Males of *Centrolene venezuelense* from the Sierra de Perijá, Venezuela, showing variation in dorsal skin texture; C-D: egg mass of *C. venezuelense* found above a pond in peatland in a bamboo forest patch (Photos: F.J.M. Rojas-Runjaic).

Specimens of *Centrolene venezuelense* (all males) were found calling between 22:00 and 23:00 h, on upper surface of fern leaves above small ponds, in a bamboo forest patch surrounded by peatland (Figure 4B). Calls were not recorded, but these consisted of one or two notes emitted every few seconds, and could be described onomatopoeically as "preeep" (similar to those described by Rivero [1968] and, Señaris and Ayarzagüena [2005]). Two egg masses were found near calling males, both on the upper sides of fern leaves and ca. 30 cm above small ponds (Figures 3C-D). Almost all species of centrolenids deposit their egg clutches next to, or above lotic waters, but a few species have been reported to place their egg masses above ponds (*Nymphargus grandisonae* [Cochran and Goin, 1970], *Centrolene buckleyi* [Boulenger, 1882], and *Cochranella granulosa* [Taylor, 1949]; Duellman and Burrowes 1989; Cisneros-Heredia and McDiarmid 2007; Kubicki 2007).

Espadarana andina (Figures 5A-C) is distributed in the Andes of Venezuela (Cordillera de Mérida and Sierra

de Perijá) and Colombia (eastern versant of the Cordillera Oriental), between 840 and 2,200 m (La Marca 1994; Ruiz-Carranza and Lynch 1995; Señaris and Ayarzagüena 2005; Rada and Guayasamin 2008; Rojas-Runjaic *et al*. 2010). From the Venezuelan versant of Perijá only three localities have been reported, all from the southern part, in the Río Negro basin, Municipio Machiques de Perijá: 1) track between La Escalera and La Cascada, 1,400 m (La Marca 1994); 2) Campamento El Desastre, 2,050 m (La Marca 1994); and 3) Manastara valley, 1,130 m (Rojas-Runjaic *et al*. 2010). Two new localities are reported herein (Figure 1): headwaters of the Cascada Kusare (09°52'44.10" N, 72°50'46.60" W; 505 m; Figure 5D), near Ipika, Río Tokuko basin, PN Sierra de Perijá, Municipio Machiques de Perijá (MHNLS 18507–18511), and Fundo El Progreso (10°43'13.30" N, 72°29'16.60" W; ± 845 m), upper basin of the Río Socuy, Sierra de Perijá, Municipio Jesús Enrique Lossada (MBLUZ 351). The new localities extend the range of this species in Perijá about 19 km SSW (headwaters of Cascada Kusare) and 83 km NNE (Fundo El Progreso) from the three localities previously known in Río Negro (La Marca 1994; Señaris and Ayarzagüena 2005; Rojas-Runjaic *et al*. 2010). The lower limit of altitudinal distribution for this species is extended to 505 m (previously 840 m).

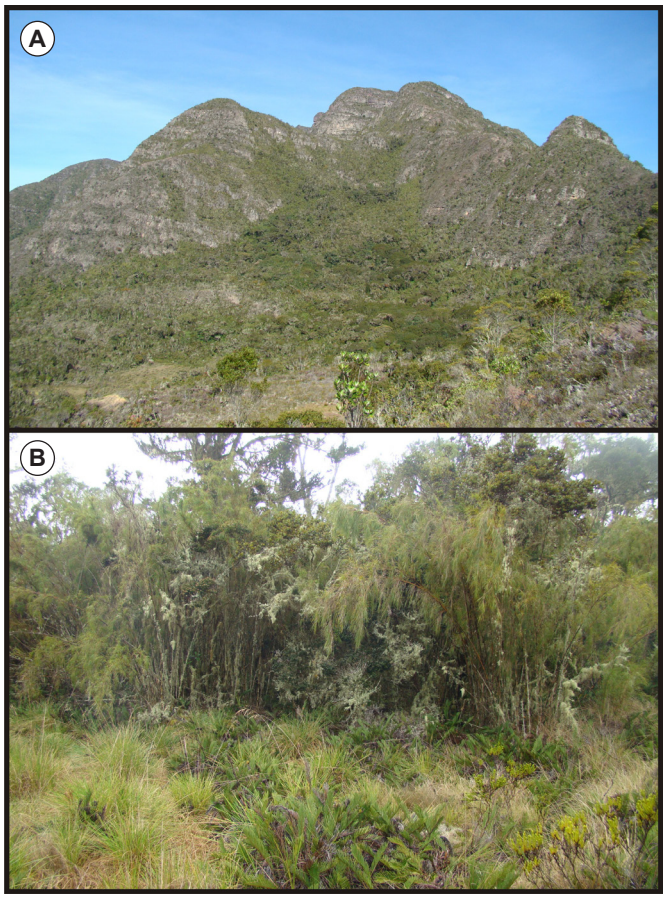

Figure 4. General view of the Páramo del Tétari, Sierra de Perijá, Venezuela; B: patch of bamboo forest surrounded by peatland where *Centrolene venezuelense* was found (Photos: F.J.M. Rojas-Runjaic).

Hyalinobatrachium pallidum (Figures 6A-B) is known only from its type locality at Guacharaquita, between La Grita and the Páramo de la Negra, Estado Táchira, Venezuela, 1,768 m (Rivero 1985; Señaris and Ayarzagüena 2005). The 34 specimens reported herein come from four localities in the Sierra de Perijá (Figure 1): 1) creek near base camp in Cerro Las Antenas (10°20'37" N, 72°33'41" W; 1,430 m; Figure 6C; MHNLS 18830–18834, 18854, 1886 and, 18970), Río Lajas basin, Municipio Rosario de Perijá; 2) creek near the second antenna, near the summit of the Cerro Las Antenas (10°19'40" N, 72°35'27" W; 1,832 m; MHNLS 18880–18887 and, 18984–18986); 3) the indigenous community of Manastara (10°02'52" N, 72°48'43" W; 1,132 m; MHNLS 19135–19137), PN Sierra de Perijá, Río Negro basin, Municipio Machiques de Perijá; 4) Campamento Guacharaca (10°04'22" N, 72°51'17" W; 1,661 m; MHNLS 19178–19181, 19185–19186 and, 19217–19222), Caño Tétari Kopejoacha, PN Sierra de Perijá, Río Negro basin, Municipio Machiques de Perijá.

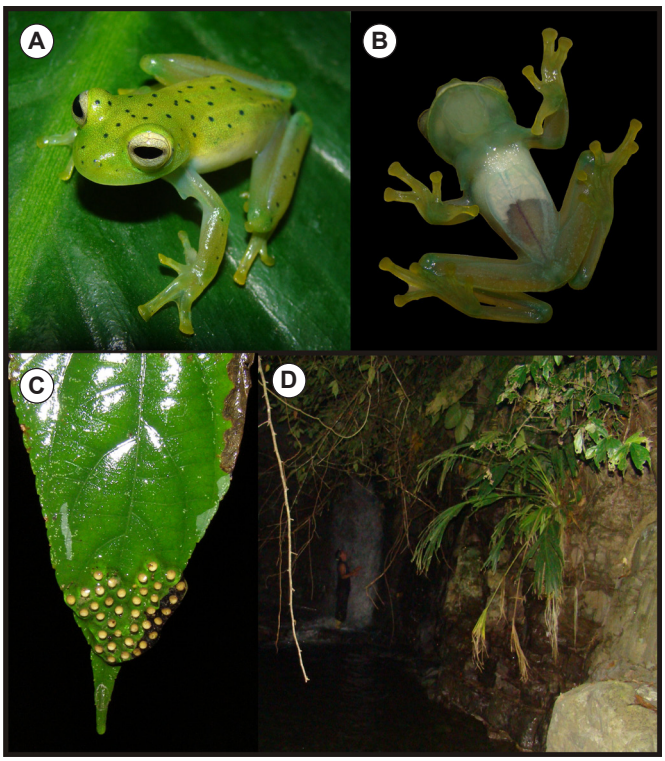

Figure 5. Adult male *Espadarana andina* (A-B), and egg mass (C), from the Sierra de Perijá, Venezuela (Photos: F.J.M. Rojas-Runjaic); D: headwaters of Cascada Kusare, near Ipika, new locality record for *E. andina* (Photo: E. Infante-Rivero).

Specimens referred to as *Hyalinobatrachium tatayoi* by Barrio-Amorós *et al*. (2010) from the Cerro Las Antenas are misidentifications of *H. pallidum*. Also, all specimens referred as *Hyalinobatrachium* sp. in Rojas-Runjaic *et al*. (2010) correspond to *H. pallidum*.

These new state records extend the distribution of *Hyalinobatrachium pallidum* by ca. 250 km NNW (linear) from the type locality (Rivero 1985) to the northernmost locality in the Sierra de Perijá (base camp of the Cerro Las Antenas). The species' altitudinal range is also expanded to 1132–1832 m.

The morphology of the specimens of *Hyalinobatrachium pallidum* from Perijá agrees with the original description (Rivero 1985), except for the color of the pericardium and the relative length of fingers I and II. Rivero (1985) defines the pericardium as "*no blanco*" (not white) in the diagnosis and description; subsequently, in the same paper (p. 360) comments that "*el corazón del animal vivo se ve rojo y pulsante*" (the heart of the live animal looks red

and pulsating). However, in the redescription provided by Señaris and Ayarzagüena (2005), based on the type series and an additional topotype, the color of the pericardium was described as light golden in life. All specimens from Perijá have light golden pericardium in life (Figure 6B), and nacreous in preservative. Rivero (1985) states that fingers I and II are similar in length; nevertheless in the section of variation Rivero mentions that the specimen UPR-M 5561 (now MHNLS 15117), a topotype tentatively assigned to *H. pallidum*, has finger I slightly larger than II. Señaris and Ayarzagüena (2005), redefine this character as: finger I = II, or slightly longer than II. Specimens from Perijá have finger I slightly longer than finger II. Señaris and Ayarzagüena (2005) refer to *H. pallidum* as a medium-sized frog, with snout-vent length (SVL) in adult males 21.9–22.4 mm (females unknown). The specimens of Perijá reach slightly greater sizes: males 21.2–25.0 mm (23.0 ± 0.9; n = 26) and females 23.0–24.8 mm (23.8 ± 0.7; n = 4). Finally, in addition to the typical densely punctuated dorsal pattern of *H. pallidum* (Rivero 1985; Señaris and Ayarzagüena 2005), most of the specimens from Perijá also exhibit irregular black flecks (dark purple in preservative) on the dorsum, head, and dorsal surfaces of the limbs. This condition is very variable, ranging from numerous flecks (*e.g.* MHNLS 18832 and 18881) to no flecks (*e.g.* MHNLS 19219, 19221). Also, MHNLS 18880 shows an atypical color pattern, with some dark flecks and several light blotches on the dorsum (seen under magnification to correspond to areas without melanophores). The descriptions of Rivero (1985) and Señaris and Ayarzagüena (2005) do not mention the presence of dark flecks and/or dorsal light blotches in the specimens examined but they are present in the photograph of a topotype provided in Guayasamin *et al*. (2009). We consider that this color variation is due to intraspecific variation. It is evident that morphological variation in *H. pallidum* is greater than previously described, and therefore this species will require a new redescription.

The two localities in the Cerro Las Antenas (Figure 6C) and Campamento Guacharaca (Figure 2B) are small fast-flowing creeks surrounded by primary cloud forest, with abundant stream-side vegetation (ferns, Heliconiaceae, Araceae and Cyclanthaceae). In these localities *Hyalinobatrachium pallidum* was abundant, and besides the specimens collected numerous males were calling from the underside and upper side of leaves, and guarding their egg masses on the undersides of the leaves of Heliconiaceae, Araceae and Cyclanthaceae plants. The locality of Manastara is a small creek in secondary forest with shaded coffee plantations. In this locality, *H. pallidum* was scarce while other syntopic centrolenids (*Centrolene daidaleum* and *Espadarana andina*) were abundant.

Hyalinobatrachium pallidum is classified as Endangered in the IUCN Red List of Threatened Species (La Marca and Manzanilla 2004), because its extent of occurrence was less than 5,000 km^2 (previously known from a single locality), and there is continuing decline in the extent and quality of its habitat at the type locality (La Marca and Manzanilla 2004). However, the new localities in the Venezuelan Sierra de Perijá significantly increase its distribution. Furthermore, Guayasamin *et al*. (2008) mention a specimen (as *H.* cf. *pallidum;* MHNLS 17881) coming from

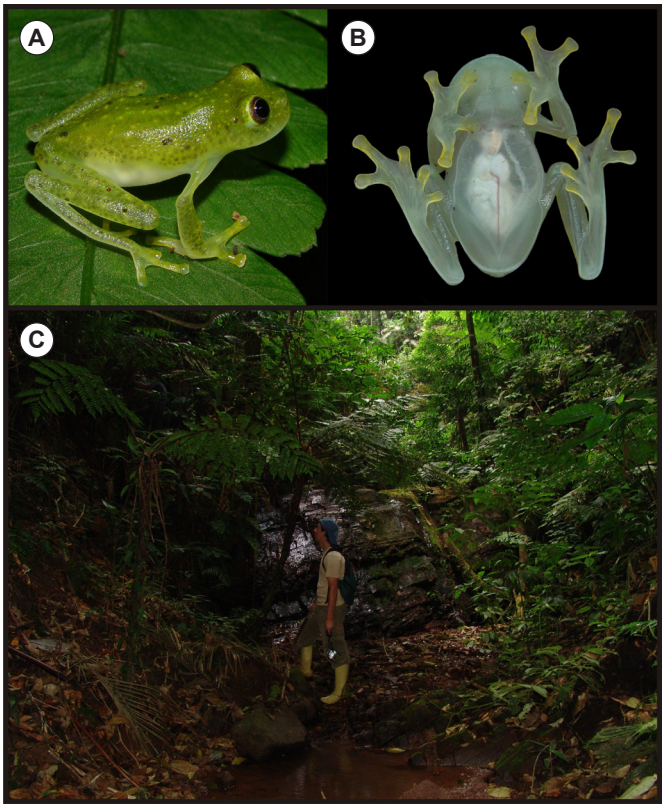

Figure 6. A-B: Adult male *Hyalinobatrachium pallidum* from Sierra de Perijá, Venezuela; C: creek near base camp in the Cerro Las Antenas, Sierra de Perijá, hábitat of *H. pallidum* (Photos: A: F.J.M. Rojas-Runjaic; B-C: P. Velozo).

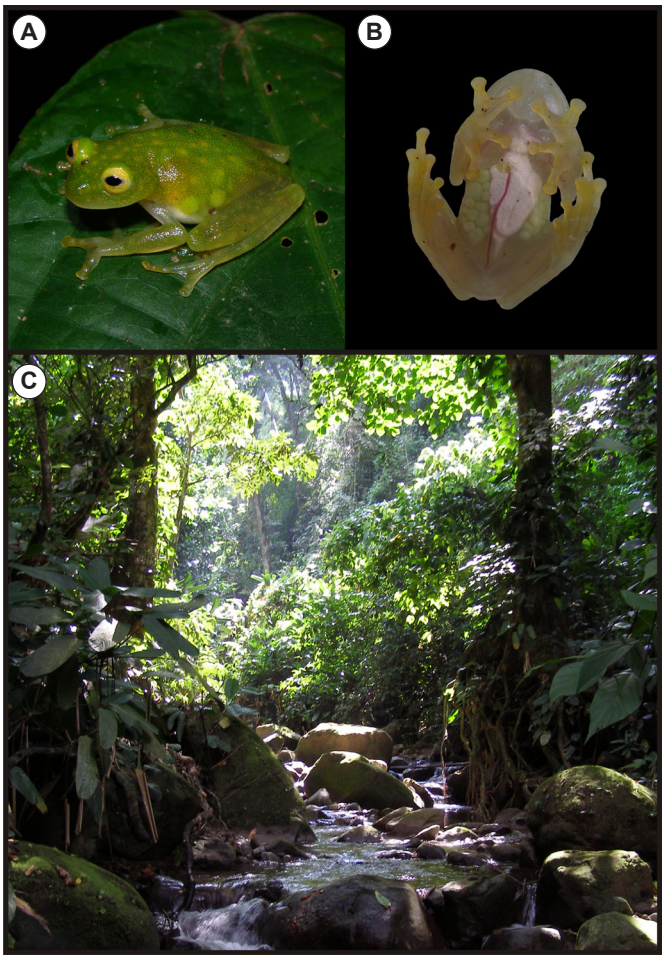

Figure 7. Adult male of *Hyalinobatrachium tatayoi* from Sierra de Perijá, Venezuela (Photos: F.J.M. Rojas-Runjaic); C: headwaters of Cascada Kusare, near Ipika, habitat where *H. tatayoi* was recorded (Photo: E. Infante-Rivero).

San Isidro (08°50'05" N, 70°34'41" W; 1,500 m), Estado Barinas, Venezuela. The specimen could not be examined but if it is *H. pallidum*, this would indicate that the species is also present on the eastern versant of the Cordillera de Mérida, and its range is much greater than previously known. Additionally, two populations (Manastara and Campamento Guacharaca) occur inside the PN Sierra de Perijá, so a reassessment of the conservation status of this species is required.

Hyalinobatrachium tatayoi (Figures 7A-B) is only known from its type locality, a stream near El Tokuko, Municipio Machiques de Perijá, 301 m (Castroviejo-Fisher *et al*. 2007), and from near Toromo in Río Negro, PN Sierra de Perijá (Municipio Machiques de Perijá; 10°02'50" N, 72°43'00" W; 450 m). This last locality was reported by Infante *et al*. (2008) based on visual records. We add two new localities (Figure 1): near Ipika (09°52'53" N, 72°51'03" W; 512 m; Figure 7C; MHNLS 18484, 18500–18506), Río Tokuko basin, PN Sierra de Perijá, Municipio Machiques de Perijá; and Fundo La Orchila (10°48'44" N, 72°21'13" W; 230 m; MHNLS 20389), Riecito Maché, Río Cachirí basin, Municipio Mara, in the northern piedmont of Perijá. This last record extends the distribution of *H. tatayoi* ca. 93 km NNE from Toromo (northernmost locality previously known). Evidently, *H. tatayoi* is a lowland species occurring throughout the eastern (Venezuelan) piedmont of Perijá. Its known altitudinal distribution is extended from 230 to 512 m.

During our expeditions to Ipika in November and December 2006, and April 2007, *H. tatayoi* was very abundant in stream-side vegetation of two fast-flowing creeks, particularly in areas dominated by Heliconieaceae. Castroviejo-Fisher *et al*. (2007) also comment on the abundance of the species at the type locality (several km downstream on the same river) during July 2005. At Ipika, in September 2008, two months after a heavy rainy season that caused major flooding and landslides, which devastated almost all stream-side vegetation and modified the physiography of the river, only three specimens of *H. tatayoi* were detected during nocturnal surveys. These natural disasters have increased in frequency and intensity as consequence of the deforestation of watersheds in the piedmont of Perijá and can severely affect the population dynamic of this riparian species, perhaps even causing local extirpations.

Hyalinobatrachium tatayoi is distinguished from *H. fleischmanni* (Boettger, 1892) almost exclusively by the presence in the former, of enamelled glands in the skin covering the jaw and the lower part of the upper lip (Castroviejo-Fisher *et al*. 2007). Recent genetic analysis indicated that these two species are closely related (Guayasamin *et al*. 2008) and that *H. tatayoi* is probably a synonym of *H. fleischmanni* (Castroviejo-Fisher *et al*. 2009); however, the datasets were insufficient to resolve this problem. To this respect Castroviejo-Fisher *et al*. (2009) mentioned that the taxonomy of these species should be reevaluated using a large and geographically widely distributed sample to detect lineage divergence. *Hyalinobatrachium tatayoi* is categorized as "Least Concern" by the IUCN Red List (Castroviejo-Fisher 2008); however, its known extent of occurrence is restricted to the piedmont of the Venezuelan versant of Perijá (less than 5,000 km^2), and part of its habitat is affected by deforestation, so its conservation status could change in the near future. Clarifying the taxonomic uncertainty of *H. tatayoi* is crucial in order to properly reassess the conservation status of this species and to design management and conservation measures as required.

With the new records, the number of glassfrog species known from Perijá increases to six, making this region the most rich in centrolenids in the Venezuelan Andes. Only five glassfrogs are know from other mountain systems of the Venezuelan Andes (Cordillera de Mérida and Macizo del Tamá): *C. altitudinale* (Rivero, 1968), *C. venezuelense*, *E. andina*, *H. pallidum* and *H. duranti* (Rivero, 1985) (Señaris and Ayarzagüena 2005). Of the six species present in Perijá, only one (16.7%) is endemic (*H. tatayoi*), two (33.3%) are shared with the rest of the Venezuelan Andes (*H. pallidum* and *C. venezuelense*), two others are shared with the Cordillera Oriental of the Colombian Andes (*C. daidaleum* and *C. notostictum*), and one (16.7%) is shared with both Colombian and Venezuelan Andes (*E. andina*). Thus, the Sierra de Perijá shows affinities with both neighboring mountain systems regarding centrolenids frogs (Table 1). Curiously, Perijá does not share any glassfrog species with the nearby Serranía de Santa Marta, from which it is separated by the narrow valley of the Ranchería river.

The most centrolenid species-rich areas of Perijá are the mid-elevation zones, between 500 and 2,000 m (Figure 8), which comprise the ecological units of deciduous montane forest and cloud forest (Ataroff and Sarmiento 2004). In these zones, two glassfrog communities composed of three species each, and another three communities of two species each, were found (Figure 9). Similar patterns of diversity in glassfrogs have been previously reported by Savage (2002), Ruiz-Carranza and Lynch (1997), and Señaris and Ayarzagüena (2005).

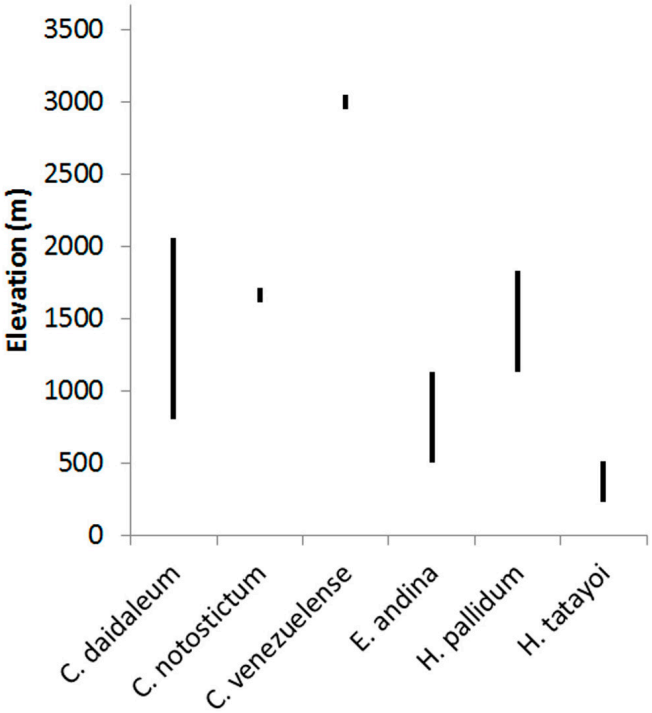

Figure 8. Altitudinal distribution of the six glassfrog species in the Sierra de Perijá.

Table 1. Distribution patterns of the six glassfrog species present in the Sierra de Perijá. CO: Cordillera Oriental de los Andes; SSM: Serranía de Santa Marta; SP: Venezuelan versant of the Sierra de Perijá; MT-CM: Macizo del Tamá and Cordillera de Mérida.

Species	CO (Colombia)	SSM (Colombia)	SP (Venezuela)	MT-CM (Venezuela)
Centrolene daidaleum	X		X	
Centrolene notostictum	X		X	
Centrolene venezuelense			X	X
Espadarana andina	X		X	X
Hyalinobatrachium pallidum			X	X
Hyalinobatrachium tatayoi			X	

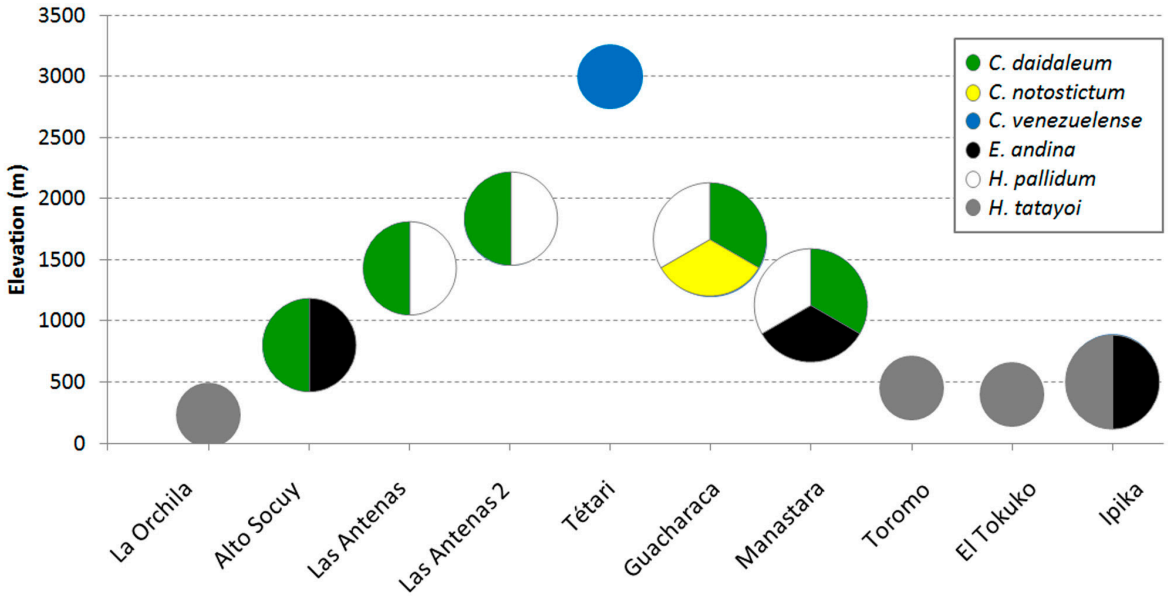

Figure 9. Richness, composition and altitudinal distribution of the glassfrog communities at ten localities in the Sierra de Perijá, ordered from north (left) to south (right).

In Venezuela, communities with more than two glassfrog species are uncommon. Señaris and Ayarzagüena (2005) mentioned only one locality (Quebrada de Jaspe, Bolívar state) where four species (*Hyalinobatrachium cappellei* [Van Lidth de Jeude, 1904], *H. iaspidiense* [Ayarzagüena, 1992], *H. taylori* [Goin, 1968], and *Vitreorana helenae* [Ayarzagüena, 1992]) can be found in sympatry. Only four communities of three species are known from Venezuela: Karuay river, Estado Bolívar (*H. capellei*, *H. taylori* and *V. oyampiensis* [Lescure, 1975]), Auyán-tepui, Estado Bolívar (*H. capellei*, *H. taylori* and *V. gorzulae* [Ayarzagüena, 1992]), Cerro Humo, Estado Sucre (*Celsiella vozmedianoi* [Ayarzagüena and Señaris, 1997], *H. orientale* [Rivero,1968] and *V. castroviejoi* [Ayarzagüena and Señaris, 1997]), and Imataca, Estado Delta Amacuro (*H. iaspidiense*, *H. mondolfii* Señaris and Ayarzagüena, 2001, and *H. taylori*) (Señaris and Ayarzagüena 2005; Rojas-Runjaic *pers. obs.*). Known communities of glassfrogs in the Venezuelan Andes consist of only two species (Señaris and Ayarzagüena 2005).

The Sierra de Perijá remains poorly explored; however, our discoveries and others (Barrio-Amorós *et al*. 2007; 2010; Infante-Rivero *et al*. 2008; Rojas-Runjaic *et al*. 2010; 2011) document the diverse amphibian fauna in this region. New expeditions undoubtedly will result in the discovery of new species, and consequently, in a better understanding of the diversity of the Sierra de Perijá, and its biogeographical affinities with neighboring bioregions.

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