Description of a small tree frog, genus *Hyla* (Anura: Hylidae), from humid Andean slopes of Bolivia

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Abstract

A new species in the frog genus *Hyla* is described from humid Andean forests of the Departamento Cochabamba, Bolivia. It is a small species mainly characterised by a small tympanum lacking an annulus, an axillary membrane, a long cloacal sheath, a white supra-cloacal stripe, a white transverse line on the heel, a bifid distal subarticular tubercle under the fourth finger and its call. Morphologically, the new species is probably related to *Hyla minuta*, but actual phylogenetic relationships remain unsolved.

Key words: Amphibia: Anura: Hylidae; *Hyla*, new species, Bolivia.

Zusammenfassung

Beschreibung einer kleinen Baumfroschart, Gattung Hyla *(Anura: Hylidae), von den humiden Andenabhängen Boliviens.*

Eine neue Froschart der Gattung *Hyla* wird von den humiden Andenwäldern des Departamentos Cochabamba, Bolivien, beschrieben. Es handelt sich um eine kleine Art, die hauptsächlich durch ein kleines Tympanum ohne Annulus, eine Axillarmembran, einen langen Kloakalsaum, einen weißen Supra-Kloakal-Streifen, einen weißen Querstreifen an der Ferse, einen bifiden distalen Subartikulartuberkel am vierten Finger und seinen Ruf charakterisiert ist. Sie ist morphologisch der *Hyla minuta*-Gruppe am ähnlichsten, unterscheidet sich jedoch durch ein undeutlicheres Tympanum, größere und stärker vorstehende Augen und den Anzeigeruf. Der Ruf der neuen Art weist drei Lauttypen auf, die in unterschiedlicher Weise kombiniert werden können. Die Pulsrate innerhalb langer gepulster Laute beträgt im Mittel 95,7 Pulse/Sekunde, die dominante Frequenz liegt bei 3699 Hz. Im Vergleich dazu ergeben publizierte Rufparameter und eigene Rufanalysen von *H. minuta* wesentlich höhere Pulsraten (144 bis 300 Pulse/Sekunde). Während sich bei der neuen Art nur die subgulare Schallblase entfaltet, blähen *H. minuta*-Männchen zudem ihren Körper bei Rufaktivität auf. Die Reproduktion erfolgt wahrscheinlich in langsamen Fließgewässern, denn stehende Gewässer sind im Verbreitungsgebiet auf Grund extrem starker Hangneigungen praktisch nicht vorhanden. Obwohl die Morphologie der neuen Art auf eine Verwandtschaft mit *Hyla minuta* schließen lässt, bleibt die tätsächliche phylogenetische Stellung offen.

Schlagwörter: Amphibia: Anura: Hylidae; *Hyla*, neue Art, Bolivien.

1 Introduction

The humid north-eastern versants of the Andes of Bolivia, known as the Yungas, are inhabited by a diverse anuran fauna with an extremely high level of endemism. According to KÖHLER et al. (1998), approximately 68 % of the species known from this area are Bolivian endemics and several of these species have been described in recent years (e.g. DE LA RIVA 1995, DE LA RIVA & KÖHLER 1998, DE LA RIVA & LYNCH 1997, KÖHLER 2000a, KÖHLER & LÖTTERS 1999). By far most of the frog species occurring in the Yungas region belong to the family Leptodactylidae. Hylid frogs, including species in the genus *Hyla*, are less diverse in this area (KÖHLER 2000b). Most Andean *Hyla* known from Bolivia are members of the *Hyla pulchella* group which contains moderately large robust species with males having projecting prepollex and hypertrophied forearms (DUELLMAN et al. 1997). With the exception of *Hyla minuta* and *H. rhodopepla*, no small species of the genus are known to occur at higher elevations in the Bolivian

Andes (DE LA RIVA 1990, KÖHLER et al. 1995). During herpetological surveys in 1998 and 1999 in the Yungas de Cochabamba, we discovered a new small species of *Hyla*. Some characters of this species were already mentioned by KÖHLER (2000b) under *Hyla* sp. A and these are partly repeated herein to provide all the information available within the formal species description.

2 Material and Methods

Notes on colour in life were taken in the field, as were colour slides of specimens and habitat. Measurements of specimens are in millimetres (mm) and were taken to the nearest 0.1 with dial callipers. Geografic position was obtained using a Magellan 3000 XL GPS receiver. Calls were recorded using a Sony WM-D6C tape recorder, a Sennheiser Me-80 directional microphone, and a TDK MA60 cassette. Recordings were sampled at a rate of 22.05 kHz and 16-bit resolution and analysed with the sound analysis software Cool Edit 96 (Syntrillium Software Corporation) on IBM compatible computers. Frequency information was obtained through fast Fourier transformation (FFT, width 1024 points). Pulse repetition rates were calculated within notes. Webbing formulae follow MYERS & DUELLMAN (1982). Morphometric abbreviations used throughout the text are: E-N, eye to nostril distance; FL, foot length; HL, head length; HW, greatest head width; IOD, interorbital distance; SVL, snout-vent length; TL, tibia length. Institutional abbreviations are those listed in Leviton et al. (1985) with the following addition: CBF, Colección Boliviana de Fauna (La Paz).

3 Results

Hyla delarivai sp. nov.
Hyla species A: KÖHLER (2000b)

Holotype: CBF 3332, an adult male, from approximately 15 km south of Paractito on the road to El Palmar (17° 06' 06" S, 65° 30' 36" W), 700-800 m above sea level, Provincia Chapare, Departamento Cochabamba, Bolivia, collected on 6 February 1998 by J. KÖHLER & S. LÖTTERS.

Paratypes: ZFMK 67139, adult female, ZFMK 67140-42, adult males, same data as holotype; MNCN 23694–95, adult male and female, same locality, collected on 20 December 1998 by J. KÖHLER & G. SUÁREZ; CBF 3331, KU 224700, ZFMK 68658 (cleared and stained), adult females, from approximately 24 km south of Paractito on the road via El Palmar to Cochabamba (17° 06' 28" S, 65° 33' 52" W), 900-1000 m a.s.l., collected on 4 February 1998 by J. KÖHLER & S. LÖTTERS; CBF 3336-37, MNCN 23696, ZSM 1/1999, adult females, MNCN 23697, ZSM 2/1999, adult males, same locality, collected on 19 December 1998 by J. KÖHLER & G. SUÁREZ; ZFMK 70317, adult male, from approximately 32 km south of Paractito on the road via El Palmar to Cochabamba (17° 07' 01" S, 65° 34' 30" W), 1500 m a.s.l., collected on 3 January 1999 by J. KÖHLER & S. LÖTTERS; ZSM 3/1999, adult male, from approximately 6.7 km south of Paractito on the road to El Palmar (17° 03' 54" S, 65° 28' 34" W), 500 m a.s.l., collected on 13 December 1998 by J. KÖHLER & G. SUÁREZ. All localities in Provincia Chapare, Departamento Cochabamba, Bolivia.

Diagnosis: A small species of *Hyla* characterised by: sexual dimorphism in size, maximum snout-vent length (SVL) 19.4 mm in males, 26.6 mm in females; large

protruding eyes; small tympanum lacking an annulus; extensive axillary membrane; bifid distal subarticular tubercle under fourth finger; long cloacal sheath extending to midlevel of thigh; outer edges of venter transparent in life; white supra-cloacal stripe; white transversal line on heel.

Comparisons: *Hyla minuta* shares with *H. delarivai* the white supra-cloacal stripe, the white transverse line on heel, a long cloacal sheath and extensive axillary membrane. But *H. minuta* (including its current synonyms *H. velata*, *H. bivittata*, *H. pallens*, *H. suturata*, *H. emrichi*, some of which may be valid species) has a distinct tympanic annulus, smaller less protruding eyes, and a different advertisement call (see below). Additionally, there is an obvious difference in calling behaviour of the two species. Males of the new species do not inflate the body while calling as do males of *H. minuta*. *Hyla xapuriensis*, a species assigned to the *H. minuta* group from the Amazon Basin, Acre, Brazil, differs by slightly smaller size, a more rounded snout, less protruding eyes and advertisement call (see below). Frogs of the *Hyla parviceps* group also have a poorly developed tympanum, but differ from *H. delarivai* in lacking an extensive axillary membrane, a supra-cloacal white stripe and a white transverse line on the heel. The presence of an axillary membrane in *H. delarivai* is shared with frogs of the *Hyla leucophyllata* group, from which it is distinguished by its smaller size, the white supra-cloacal stripe and the white transverse line on the heel. *Hyla aperomea*, a small species from Andean Peru not assigned to any group, is superficially similar to *H. delarivai* but differs in having a single distal subarticular tubercle under the fourth finger and lacking an axillary membrane. *Hyla rhodopepla* is distinctly different in having a white upper lip and a broad reddish brown lateral stripe; it lacks a white supra-cloacal stripe. *Hyla chlorostea*, another Bolivian species occurring in the same general area, is larger and has a distinct preorbital ridge, lateral folds and green bones in life. Other small species of *Hyla* known to occur in the tropical lowlands of Bolivia include *H. leali*, *H. nana*, *H. riveroi*, *H. rubicundula*, *H. tritaeniata*, and *Hyla* sp. (a species related to *H. leali*, description by KÖHLER & LÖTTERS in press). All of these are distinguished from *H. delarivai* by lacking a white supra-cloacal stripe and a transverse white line on the heel.

Description of holotype: SVL 18.6 mm; body slender; HW 7.0 mm; head wider than body, wider than long, widest below eyes; HL 6.5 mm; snout bluntly rounded to truncate in dorsal view, truncate in profile; snout shorter than diameter of eye; eye length 3.4 mm; canthus rostralis rounded; loreal region slightly convex; lips nearly vertical, not flared; internarial area slightly depressed; nostrils slightly protuberant, directed dorsolaterally; E-N 1.7 mm; interorbital area flat, about 147 % of eyelid width; IOD 2.8 mm; eye large, protuberant, its diameter about four to five times depth of lip below eye, its length (3.4 mm) 53.1 % of HL; upper eyelid width 1.9 mm; tympanum small, barely evident, separated from eye by a distance about equal to its diameter; tympanum diameter 0.8 mm; tympanic annulus absent; supratympanic fold prominent, obscuring upper part of tympanum.

Arm slender, not hypertrophied, with extensive axillary membrane; ulnar folds and tubercles absent; fingers short, bearing moderately large, round discs; second finger much shorter than fourth; subarticular tubercles small, round, distal one of fourth finger prominent and bifid; supernumerary tubercles minute, barely evident; palmar tubercle small, round; prepollical tubercle ovoid, lacking nuptial excrescences; fingers one third webbed; webbing formula I2—2II^{-}—1½III1^{+}—1IV. Legs mo-

Fig. 1. Adult male paratype of *Hyla delarivai* n. sp. in life (ZFMK 67142).
Adulter männlicher Paratypus von *Hyla delarivai* sp. nov. im Leben (ZFMK 67142).

Fig. 2. Adult female paratype of *Hyla delarivai* sp. nov. in life (KU 224700).
Adulter weiblicher Paratypus von *Hyla delarivai* sp. nov. im Leben (KU 224700).

Fig. 3. Preserved holotype of *Hyla delarivai* sp. nov. (CBF 3332) in dorsal and ventral view (SVL 18.6 mm).

Konservierter Holotypus von *Hyla delarivai* sp. nov. (CBF 3332) in dorsaler und ventraler Sicht (Kopf-Rumpf-Länge 18,6 mm).

Fig. 4. View on the valley of El Palmar with the San Mateo river, Provincia Chapare, Bolivia, approximately 900 m a.s.l.

Blick of das Tal von El Palmar mit dem Río San Mateo, Provincia Chapare, Bolivien, etwa 900 m ü.NN.

derately long and slender; TL 10.0 mm; FL 14.0 mm; TL 53.8 % of SVL; heels broadly overlapping when limbs flexed perpendicular to axis of body; tarsal fold and tubercles absent; toes moderately long, bearing round discs of about the same size as those on fingers; subarticular tubercles small, round; supernumerary tubercles not evident; outer metatarsal tubercle minute, round; inner metatarsal tubercle moderately large, elliptical; toes about four-fifth webbed; webbing formula I½⁻—1II½—1½⁻III½⁻—1IV1⁺—½⁻V.

Skin on dorsum, head, and dorsal surfaces of forearms and thighs smooth; skin on flanks finely shagreened; skin on venter coarsely granular; skin on throat granular. Anal opening directed posteriorly at upper level of thighs; anal sheath long, extending to midlevel of thighs; anal tubercles absent. Tongue broadly cordiform, shallowly notched posteriorly, barely free behind; vomerine odontophores prominent, ovoid, well-separated medially, between choanae, each bearing four vomerine teeth; choanae small, round; vocal slits long, extending from midlateral base of tongue to angle of jaws; vocal sac single, median, subgular.

In alcohol, dorsal surfaces brown with faint dark brown markings consisting of: (1) broad triangular mark on head with corners on eyelid and apex extending behind scapular region; (2) transverse bar in sacral region; (3) few small weakly defined spots in postsacral region; and (4) two transverse bars on forearm and three on shank. Upper half of flanks brown, lower half cream; throat cream, anterior half with scattered chromatophores; venter and anterior surfaces of thighs cream; dorsal, ventral and posterior surfaces of thighs cream, densely scattered with chromatophores; ventral surfaces of hands and feet cream with scattered chromatophores, discs cream; white supra-cloacal stripe; white transversal line on heel.

In life, the dorsal colour was paler; venter cream only medially; outer edges of venter, ventral surfaces of forearms and anterior half of throat flesh-colored and transparent; ventral surfaces of thighs yellowish; dorsal surfaces of toe and finger discs yellowish; iris brown with fine black speckling; bones white.

Variation: *Hyla delarivai* exhibits considerable variation in coloration. All male paratypes have (3-15) minute white spots on the dorsum, each with a diameter about that of nostril. Most specimens also have a narrow white suborbital bar. This bar is only weakly defined in ZFMK 67140-41 and ZSM 2-3/1999, but broader and well defined in ZFMK 67142 (Fig. 1) and has a width of about one third of the eye diameter. The dorsal white spotting is most extensive in the female KU 224700. This specimen has numerous spots on its dorsum, flanks, and upper surfaces of thighs and forearms; it has two narrow white bars below the eye (Fig. 2). In this specimen, the white line on the heel extends along the external border of the tarsus. MNCN 23694 has a yellow blotch approximately 1.0 mm in diameter on the tip of the snout and ZSM 2/1999 has some white mottling on the dorsum and upper surfaces of the thighs. Generally, the nocturnal coloration is pale or bright yellow; it may turn to dark brown during the day. In ZFMK 67139 and 67141, the iris was silvery grey in life.

Variation in measurements (in mm) and proportions of nine males and eight females of the type series is as follows (females in parentheses): SVL, 18.2-19.4 (21.1-26.6); HW, 6.6-7.2 (7.0-9.1); HL, 6.5-6.9 (6.7-8.9); upper eyelid width, 1.6-2.1 (1.8-2.2); IOD, 2.5-3.2 (2.6-3.5); tympanum diameter, 0.7-1.0 (0.8-1.1); eye length, 3.2-3.9 (3.3-4.3); E-N, 1.6-1.8 (1.8-2.2); TL, 9.8-10.6 (11.9-14.6); FL, 14.0-15.1 (16.6-21.0). TL/SVL, 51.9-57.1 % (52.1-60.0 %); HW/SVL, 35.4-37.6 % (33.2-36.0 %); upper eyelid width/IOD, 59.4-84.0 % (57.1-75.9 %); tympanum diameter/eye length, 19.4-31.3 % (18.6-31.4 %); E-N/eye length, 43.6-56.3 % (46.2-62.9 %).

Distribution: *Hyla delarivai* is known only from the localities listed for the type series and occurs at elevations of 500-1500 m at the slopes of the Andes.

Natural history: This species occurs in the evergreen tropical Andean forests, known as the Yungas de Cochabamba (Fig. 4). Precipitation in this region is the highest in Bolivia and can be expected to be 2500 to 8000 mm annually (IBISCH 1996, KESSLER 1999). The steep slopes have many small streams and rivers. On the nights of 6 February and 13 December 1998, males of *Hyla delarivai* called from bushes and grasses above slow running water at the edge of the road during rain. A prolonged breeding period can be expected for *H. delarivai*, because almost all females observed in February and December were gravid. Oviductal eggs are approximately 1.4 mm in diameter and have one hemisphere darkly pigmented. Tadpoles probably develop in slow running water; ponds were not observed in the distribution area. Other species of *Hyla* sympatric with *H. delarivai* include *H. lanciformis* and *H.* cf. *callipleura* (see KÖHLER 2000b).

Etymology: The specific name is a patronym for IGNACIO DE LA RIVA (Madrid) in recognition of his substantial contributions to the knowledge of Bolivian anurans.

Vocalisation: Twenty-one calls of three individuals were analysed. Air temperature was 24.3 °C during recording. Generally, the vocalisation of *Hyla delarivai* consists of three different types of notes combined in two different call types (Fig. 5). The three types of notes are long pulsed notes, short pulsed notes and unpulsed frequency modulated whistles. One call type (type A) consists of a long pulsed note followed by a short pulsed note, whereas the other type (type B) consists of a whistle

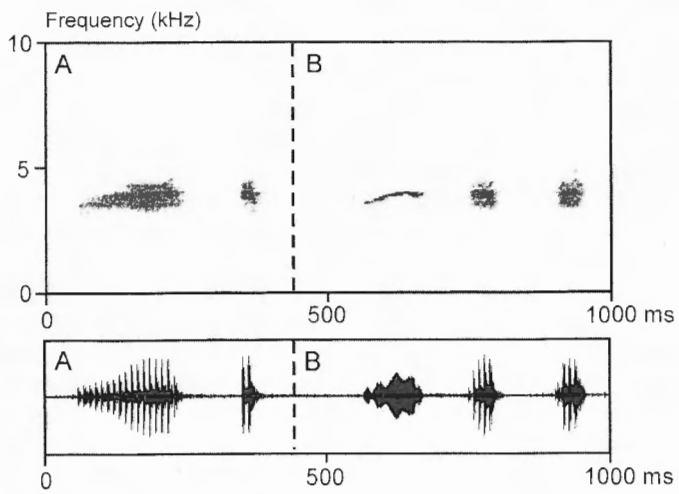

Fig. 5. Audiospectrogram and oscillogram of the two call types of *Hyla delarivai* sp. nov. (type A, left; type B, right). Recording obtained on 13 December 1998. Air temperature 24.3 °C.

Audiospektrogramm und Oszillogramm der beiden Ruftypen von *Hyla delarivai* sp. nov. (Typ A, links; Typ B, rechts). Aufnahme vom 13. Dezember 1998. Lufttemperatur 24,3 °C.

followed by one or two short pulsed notes. Calls were emitted at irregular intervals. Temporal and spectral characteristics of notes and calls were as follows (range, followed by mean ± one standard deviation in parentheses): (1) long pulsed notes: pulses per note 11-19 (16.1 ± 2.5), duration 99-195 ms (165.1 ± 26.1), pulses/s 88.4-108.1 (95.7 ± 5.9), dominant frequency range 3360-4060 Hz (3699.2 ± 111.8); (2) short pulsed notes: pulses per note 2-5 (2.8 ± 0.9), duration 27-75 ms (36.6 ± 16.0), pulses/s same as in long pulsed notes, dominant frequency range 3340-3920 Hz (3582.7 ± 109.9); (3) whistles: duration 97-164 ms (128.2 ± 21.3), without pulses, upward frequency modulation from 3390 Hz at beginning to 3910 Hz at the end of note, dominant frequency range 3710-3820 Hz (3782.5 ± 49.2); (4) call type A: duration 310-327 ms (317.2 ± 6.4), inter note interval 82-134 ms (107.2 ± 12.9); (5) call type B: duration 309–452 ms (395.4 ± 51.9), inter note interval 79-103 ms (89.4 ± 8.2).

4 Discussion

4.1 Vocalisation

Because of morphological similarities between *Hyla delarivai* and *H. minuta*, it is appropriate to compare the call characteristics described above with those published for *H. minuta*. The pulsed calls of *H. delarivai* differ mainly from those of *H. minuta* in a significant lower pulse repetition rate within the calls (for species specific temporal differences in call characteristics, see for example PENNA 1997). Pulse rates of calls of different populations of *H. minuta* provided in the literature are: 156-193 pulses/s, Puerto Almacén, Bolivia (MÁRQUEZ et al. 1993); 284-300 pulses/s, Belém, Brazil (DUELLMAN & PYLES 1983); 160–180 pulses/s, Boracéia, Brazil (HEYER et al. 1990); about 144 pulses/s, Cerro Guaiquinima, Venezuela (DONELLY & MYERS 1991); 170–200 pulses/s, La Escalera region, Venezuela (DUELLMAN 1997). In calls of *H. minuta* from west of Río Seco, Departamento Santa Cruz, Bolivia (our recordings), the pulse rate is approximately 210 pulses/s at an air temperature of 22.3 °C. Analysis of a tape recording by C.F.B. HADDAD of calls from Ribeirão Branco, São Paulo, Brazil, revealed a mean pulse rate of 175 pulses/s (at 17.0 °C). In addition to these differences in pulse repetition rate, call energy in *H. delarivai* is distributed in a narrower frequency band compared with frequency ranges provided for *H. minuta*. Moreover, the terminal pulse in calls of *H. minuta* is usually of longer duration, whereas in *H. delarivai* all pulses within calls are equal in duration. To the human ear, calls of *H. minuta* usually sound harsh or somehow distorted, whereas calls of *H. delarivai* sound clear. MARTINS & CARDOSO (1987) figured the call of *H. xapuriensis* and in their spectrogram a pulse rate of approximately 60 pulses/s is measurable, a lower value compared to *H. delarivai*.

It has been demonstrated that aggressive interactions in male *H. minuta* were associated with different types of calls (CARDOSO & HADDAD 1984, DONELLY & MYERS 1991). The same was suggested for *H. xapuriensis* (MARTINS & CARDOSO 1987). The different types of notes recognised in *H. delarivai* also argue for different functions, but our few observations do not permit such assignments.

4.2 Relationships

Among Andean *Hyla*, only two groups have been defined containing small species: the *Hyla columbiana* group (DUELLMAN & TRUEB 1983) and the *Hyla garagoensis* group (KAPLAN & RUÍZ 1997). These groups include species distributed in northern South

America, namely Colombia and Ecuador (see also DUELLMAN et al. 1997). Members of these groups have a diploid number of 30 chromosomes which we also assume for *H. delarivai*. However, data on tadpole morphology in *H. delarivai* are missing and unfortunately we can not access the species' relationships based on larval characters. Because of the geografical distance, a relation of *H. delarivai* to one of these groups is scarcely to be expected. *Hyla delarivai* seems to be more closely related to *H. minuta*. KAPLAN (1994) discussed the taxonomy of populations presently referred to *H. minuta* and stated that they most probably comprise a complex of species. Furthermore, in describing *H. stingi* (a phenetically similar species to *H. minuta*) KAPLAN (1994) suggested that it represents a different phylogenetic lineage. With the data available, we are unable to ascertain the phylogenetic relationships of *H. delarivai*, whether it is more closely related to *H. minuta* or any other lineage represented by *H. minuta*-like frogs.

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Resumen

Se describe una especie nueva del género *Hyla* de los bosques andinos húmedos del Departamento Cochabamba, Bolivia. *Hyla delarivai* sp. nov. es una especie pequeña caracterizada por un tímpano pequeño sin anulus, una membrana axilar, una raya supra-anal blanca, una línea transversal blanca al talón, un tubérculo subarticular bífido bajo del cuarto dedo y por el canto. Las caractéristicas morfológicas parecen a *Hyla minuta,* pero las relaciones filogenéticas de *H. delarivai* son desconocidas.

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