



## A new species of *Noblella* (Anura: Craugastoridae) from the Amazonian Slopes of the Ecuadorian Andes with Comments on *Noblella lochites* (Lynch)

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### Abstract

We describe a new species of *Noblella* from wet, montane forest at the Sardinayacu Lake Complex between 1600–1920 m elevation in Morona Santiago, Ecuador. The new species differs from congeners in having three phalanges in the fourth finger, finely tuberculate skin on the dorsal body, pointed digital tips with marginal grooves on the fingers, a yellow to pale yellow venter, and a reduced facial mask not extending beyond the arm. The new species also lacks the pair of inguinal spots on the dorsal flanks of most congeners. Since its discovery in 1976, *N. lochites* has remained poorly known. We describe variation, color in life, and basic ecology of *N. lochites* based on a large series from the Cordillera del Condor.

**Key words:** Cordillera del Condor, Morona Santiago, *Noblella personina* new species, Sardinayacu Lake Complex, vocalizations

### Resumen

Se describe una especie nueva de *Noblella* del bosque montano del Complejo Lacustre Sardinayacu, entre 1600-1920 m de altitud, de Morona Santiago, Ecuador. La nueva especie difiere de sus congéneres por tener tres falanges en el cuarto dedo manual, dorsalmente la piel es finamente tuberculada, los dedos manuales presentan papilas digitales puntiagudas y leves rebordes cutáneos, vientre de color amarillo a amarillo pálido y una máscara facial reducida que no se extiende más allá de la parte proximal del brazo. La nueva especie carece del par de manchas suprainguinales, presentes en la mayoría de sus congéneres. Desde el descubrimiento de *N. lochites* en 1976, se conoce muy poco sobre esta especie. Describimos la variación de color en vida y datos ecológicos básicos fundamentados en una serie grande proveniente de la Cordillera del Cóndor.

### Introduction

Frogs of the genus *Noblella* are some of the smallest Neotropical vertebrates. These frogs were referred to *Phyllonastes* Heyer (1977) until De la Riva *et al.* (2008) revalidated *Noblella* Barbour (1930) and transferred *Phyllonastes* to its synonymy. Hedges *et al.* (2008) recently placed *Noblella* in the terraranan frog family Strabomantidae, however, Pyron and Wiens (2011) synonymized Strabomantidae with Craugastoridae.

Currently, *Noblella* contains 11 described species. *Noblella carrascoicola* (De la Riva & Köhler 1998), *N. duellmani* (Lehr *et al.* 2004), *N. lynchi* (Duellman 1991), *N. peruviana* (Noble 1921), *N. pygmaea* Lehr and Catenazzi (2009), and *N. ritarasquinae* (Köhler 2000) have been reported only from Peru or Bolivia. Four species inhabit Ecuador: *N. coloma* Guayasamin and Terán (2009) and *N. heyeri* (Lynch 1986) on the western slopes of the Andes; *N. lochites* (Lynch 1976) above 900 m in humid forests of the eastern Andes, Cordillera del Cóndor, and Cordillera de Cutucú; and the widespread species *N. myrmecoides* (Lynch 1976) in the Amazonian lowlands and humid forests of the eastern Andean below 1200 m.

When originally described, *Noblella lochites* was known from a single specimen (Lynch 1976). Although additional specimens were later reported, this species's variation and natural history remains virtually unknown, its coloration in life has not been described, and several morphological characters used to diagnose species of *Noblella* remain unreported for *N. lochites* (Lynch 1976; Duellman & Lynch 1988; Almendáriz 1997; Reynolds & Icochea 1997; Cisneros-Heredia & Reynolds 2007; Duellman & Lehr 2009). In recent years, A. Almendáriz and field parties from the EPN secured a relatively large series of *N. lochites* as part of a long-term survey of reptiles and amphibians of the Cordillera del Condor (Almendáriz 1997; Almendáriz *et al.* 2012). While reviewing this material and some additional specimens of *Noblella* from the eastern slopes of the Andes, we identified a new species of *Noblella* among frogs from montane forest in Morona Santiago. In this paper, we describe this new species and provide new morphological and natural history data for *N. lochites*.

## Material and methods

Ana Almendáriz and field parties from the EPN surveyed reptiles and amphibians at various localities between La Via a Pindal (3° 44' 55.4" S, 78° 33' 11.7" W, 1335 msnm; all latitude and longitude based on datum WGS 84, recorded with Garmin eTrex Summit® HC) and La Loma Paquisha (3° 53' 25.9" S, 78° 30' 30.1", 1850 msnm) in sector La Zarza, Cantones Paquisha and Yantzatza, Cordillera del Condor, Province Zamora Chinchipe, Ecuador. Jorge Brito and Diego Batallas surveyed reptiles and amphibians at the Sardinayacu Lake Complex (2° 03–04' S, 78° 11–14' W), Parque Nacional Sangay, Morona Santiago, Ecuador from 20–29 December 2010, 18–28 February 2011, and 25–30 October 2011. We fixed specimens in 10% formalin, preserved them in 70% ethanol, and followed specimen preservation protocols of Chen and Combs (1999) and Simmons (2002). We deposited all specimens in the Museo de Historia Natural Gustavo Orcés of the Escuela Politécnica Nacional (EPN).

We compared specimens collected in this study to *Noblella heyeri*, *N. myrmecoides*, and the holotype of *N. lochites* (Appendix). With dial calipers to the nearest 0.1 mm we measured snout-vent length (SVL), head length (from the rictus to the anterior tip of the snout), head width (at the rictus), eye diameter, eye-nostril distance (from the anterior ocular angle to the posterior border of the nostril), length of tympanum (i.e., its smallest diameter), minimum interorbital distance, minimum width of the eyelid, length of the hand (from the posterior border of the palmar tubercle to the tip of Finger III), length of the shank, and length of the foot (from the posterior border of the outer metatarsal tubercle to the tip of Toe IV). To test for interspecific differences in mensural characters among the new species, *N. lochites*, and *N. myrmecoides*, we used Analysis of Covariance (ANCOVA), treating SVL as a covariate. An *F*-test for equality of the regression slopes was used to test the assumption of parallelism. To test assumptions of homoscedasticity and normality before the ANCOVA, we used Levene's test and the Shapiro-Wilk test. We used the PAST (Hammer *et al.*, 2001) software program for statistical analyses.

Sexual maturity was determined by presence of vocal slits and extended vocal sacs in males and by presence of eggs or convoluted oviducts in females. Many features such as marginal grooves, supernumerary tubercles, and vomerine teeth are easily overlooked in minute craugastorid frogs. We routinely used the reversible stain methylene blue in 70% ethanol to examine these structures.

To facilitate comparisons, our numbered diagnoses mostly follow the sequence of Guayasamin and Terán-Valdez (2009). However, we add information regarding presence/absence of a papilla extending from the digital pad to character 10. Lynch (1976) originally noted this difference between *Noblella lochites* and *N. myrmecoides*. Nonetheless, the character has not been mentioned in some recent descriptions of congeners.

We recorded 92 vocalizations from three different specimens with an Olympus WS-750 digital recorder and a Sennheiser K6-C unidirectional microphone. During these recordings, we measured ambient temperature with a Springfield thermometer. We analyzed vocalization structure with the Adobe Audition 3.0 software package (Adobe Systems Incorporated, San José, CA) at a frequency of 44.1 KHz and 16 bit resolution, and we diagrammed vocalizations with the Raven 1.4 software package (Cornell Lab of Ornithology, Ithaca, NY). Herein, we report dominant frequency (frequency of maximum energy, determined with a Fourier calculation), number of notes per call, duration of the call, duration of the notes, intervals between notes, and interval between calls (Bernal *et al.*, 2004; Crocroft & Ryan, 1995).

## Systematics

### *Noblella personina* Harvey, Almendáriz, Brito & Batallas new species

(Fig. 1)

**Holotype.** An adult male (EPN 14324, bearing field tag DBR 177) collected by Jorge Brito from forest at the Sardinayacu Lake Complex (Cantón Morona, Parroquia Sinaí), Morona Santiago, Ecuador, 2° 03' 48.4" S, 78° 14' 11.3" W, 1916 m, 27 December 2010.

**Paratypes (6).** Two adult males (EPN 14326 and 14327) collected by Diego Batallas on 23 December 2010 at 2° 04' 47.8" S, 78° 11' 51" W, 1647 m, two adult females (EPN 14325 and 14328) collected by Jorge Brito at 2° 03' 48.4" S, 78° 14' 11.3" W, 1916 m, 25 February 2011, and an adult male (EPN 14330) and adult female (EPN 14329) collected by J. Brito on 28 October 2011 at 2° 04' 27.4" S, 78° 12' 46.1" W, 1776 m in the Sardinayacu Lake Complex.

**Diagnosis.** A species of *Noblella* as defined by Hedges *et al.* (2008) reaching 17.9 mm SVL in females and 16.3 mm in males and distinguished from all congeners by (1) skin on dorsal body mostly smooth with few low pustules most dense on posterior half of body; dorsal head, dorsal limbs, and flanks smooth; (2) tympanic annulus and membrane clearly visible, its dorso-posterior edge covered by indistinct supratympanic fold; (3) snout rounded in dorsal view, subtruncate in profile (eye-nostril distance 28–36% of head length); (4) dentigerous process of vomer and teeth absent; (5) fingers not expanded distally; finger tips acuminate; Finger I shorter than Finger II; nuptial pad not visible; fingers with indistinct marginal grooves, at least on Fingers III and IV; (6) distal phalanges T-shaped; phalangeal formula of hands 2, 2, 3, 3; (7) supernumerary palmar tubercles present at base of Fingers II–IV; subarticular tubercles rounded; antebrachial ornamentation absent; (8) one elongate tarsal tubercle; two prominent metatarsal tubercles; supernumerary plantar tubercles absent; toes slightly expanded and acuminate distally; (9) Toe V shorter than Toe III; (10) palmar and pedal digital pads and unguis folds pointed (i.e., papilla of digital pad not projecting distally beyond unguis fold), separated by marginal grooves; (11) in preservative, adults with distinctive charcoal chin contrasting with mostly immaculate white ventral body; charcoal band on side of body not extending onto flanks; dorsum with two poorly defined, smudge-like chevrons; short charcoal stripe above inguinal region parasagittal, one on each side.

**Comparisons.** The new species superficially resembles frogs in *Adelophryne* and *Phyzelaphryne*. Although not yet reported from the Andes (Fouquet *et al.* 2012), these two genera are widely distributed in Amazonia and the Atlantic Forest Biome. We assign the new species to *Noblella* as defined by Duellman (1991), De la Riva *et al.* (2008), Hedges *et al.* (2008), and Heyer (1977) rather than one of these genera, because it has a tarsal tubercle and marginal grooves completely encircling the digital pads, whereas both *Adelophryne* and *Phyzelaphryne* have tarsal folds, and grooves are present only on the sides of the digital pads of *Adelophryne*. Frogs of the genus *Noblella* are morphologically similar and closely related to *Barycholos* (Heinicke *et al.* 2007; Hedges *et al.* 2008). We assign the new species to *Noblella* rather than *Barycholos* (characters in parentheses), because it lacks dentigerous processes of the vomers (present), has a short first finger (Finger I longer than Finger II), and has low, rounded subarticular tubercles (subarticular tubercles projecting).

The new species is noticeably more gracile than Ecuadorian congeners (Fig. 1). Unlike *Noblella carrascoicola*, *N. lochites*, *N. myrmecoides*, and *N. ritarasquinae*, the new species has three phalanges in Finger IV. In *Noblella personina*, the charcoal mask fades abruptly at the level of the scapula, leaving the flanks lightly pigmented. Circular suprainguinal spots are absent, although a charcoal stripe running parasagittally is poorly defined. Except in rare patternless specimens, the mask extends to the inguinal region and suprainguinal spots are present in all other congeners except *N. duellmani* and *N. pygmaea*. However, *N. pygmaea* has tubercular skin and occurs above 3000 m in Cusco, Peru, and *N. duellmani* lacks a tympanum and marginal grooves on the toes (Lehr & Catenazzi, 2009; Lehr *et al.*, 2004).

*Noblella coloma* and *N. heyeri* are the only other species of *Noblella* in Ecuador with three phalanges in the fourth finger. Unlike the new species, both *N. coloma* and *N. heyeri* have suprainguinal spots and an extensive facial mask extending to the inguinal region. Unlike the new species (characters in parentheses), *N. coloma* also has a finely shagreened dorsum (dorsum with few low tubercles, most dense posteriorly), smooth finger tips lacking marginal grooves (grooves present on Fingers III and IV), and an orange venter (pale yellow or yellow). *Noblella heyeri* is a smaller species with males reaching 12.9–14.1 mm SVL ( $n = 5$ ) and females 13.1–15.9 mm SVL ( $n = 4$ ;

Lynch 1986; vs. males 14.7–16.3 mm and females 15.6–17.9 mm; Table 1). The fingers of *N. heyeri* lacks marginal grooves (present on Fingers III and IV) and have rounded digital tips (pointed).

*Noblella myrmecoides* occurs on the eastern slopes of the Andes in Ecuador and might be confused with *N. personina*. Unlike the new species (characters of *N. personina* in parentheses), *N. myrmecoides* has two phalanges in Finger IV (three), papillae extending distally from its digital pads (papillae absent), and usually suprainguinal spots and an extensive facial mask extending to the inguinal region (spots absent, facial mask fading at arm).

Most morphometric ratios broadly overlap among *Noblella lochites*, *N. myrmecoides*, and *N. personina* (Table 1). *Noblella myrmecoides* appears to have a shorter shank than *N. personina*, however we could not show this statistically ( $F_{11,7} = 3.283$ ,  $P = 0.09$ ), perhaps because of small sample sizes.

**TABLE 1.** Mensural characters of three species of *Noblella* from the Amazonian slopes of the Ecuadorian Andes. In parentheses, mean  $\pm$  standard deviation follows each range.

Character	<i>N. personina</i>		<i>N. lochites</i>		<i>N. myrmecoides</i>	
	Males ( <i>n</i> = 4)	Females ( <i>n</i> = 3)	Males ( <i>n</i> = 6)	Females ( <i>n</i> = 13)	Males ( <i>n</i> = 7)	Females ( <i>n</i> = 4)
Snout-vent Length (mm, SVL)	14.7–16.3 (15.5 $\pm$ 0.7)	15.6–17.9 (17.0 $\pm$ 1.2)	13.4–15.3 (14.2 $\pm$ 0.7)	12.9–19.4 (17.2 $\pm$ 1.8)	10.1–11.9 (11.1 $\pm$ 0.7)	13.0–14.7 (13.6 $\pm$ 0.8)
Head Length/SVL	26–32% (30 $\pm$ 3)	28–30% (29 $\pm$ 1)	28–35% (31 $\pm$ 2)	26–32% (29 $\pm$ 2)	26–34% (30 $\pm$ 2)	22–32% (29 $\pm$ 4)
Head Width/Head Length	98–124% (108 $\pm$ 12)	101–117% (107 $\pm$ 9)	104–123% (112 $\pm$ 7)	99–133% (115 $\pm$ 10)	104–127% (117 $\pm$ 9)	110–149% (123 $\pm$ 18)
Eye Diameter/Head Length	31–43% (35 $\pm$ 5)	38–41% (39 $\pm$ 1)	34–40% (36 $\pm$ 2)	24–41% (33 $\pm$ 5)	32–39% (35 $\pm$ 3)	34–42% (37 $\pm$ 4)
Eye-Nostril Length/Head Length	28–31% (29 $\pm$ 2)	28–36% (32 $\pm$ 4)	23–31% (27 $\pm$ 3)	24–45% (32 $\pm$ 8)	25–34% (30 $\pm$ 3)	24–43% (33 $\pm$ 8)
Tympanum Diameter/Eye Diameter	46–67% (53 $\pm$ 10)	46–60% (54 $\pm$ 7)	47–67% (57 $\pm$ 8)	52–97% (67 $\pm$ 13)	51–80% (60 $\pm$ 10)	44–64% (56 $\pm$ 9)
Eyelid Width/Interorbital Distance	54–67% (58 $\pm$ 6)	48–60% (54 $\pm$ 6)	52–79% (62 $\pm$ 10)	48–79% (60 $\pm$ 9)	47–64% (54 $\pm$ 6)	52–58% (54 $\pm$ 3)
Hand Length/Foot Length	33–40% (37 $\pm$ 3)	38–42% (41 $\pm$ 2)	37–47% (42 $\pm$ 3)	35–48% (42 $\pm$ 4)	35–46% (41 $\pm$ 3)	35–41% (38 $\pm$ 2)
Foot Length/Length of Shank	89–97% (93 $\pm$ 3)	88–95% (91 $\pm$ 3)	86–98% (93 $\pm$ 4)	73–105% (90 $\pm$ 8)	80–90% (86 $\pm$ 3)	84–88% (86 $\pm$ 2)

**Description of holotype.** Adult male (16.3 mm SVL); head not distinct from body, its length 26% of SVL; head wider than long (head width 124% of head length, Fig. 2); dorsal surface of head (including eyelids) smooth; eye-lid width 57% of interorbital distance; region between nostrils not depressed; snout rounded in dorsal view, subtruncate in profile; nostril oval with short groove in antero-dorsal corner, directed laterally, slightly protuberant; canthus rostralis rounded; lores flat; eye large, 43% of head length, its diameter 1.36 times as large as its distance from the nostril; lips slightly flared between ventral margin of eye and antero-ventral margin of tympanum; tympanum distinct, slightly oval with its largest diameter vertical; length of tympanum 46% of eye diameter; tympanic annulus distinct; low, indistinct supratympanic fold overlapping dorso-posterior edge of tympanic annulus and extending obliquely to scapular region; elongate, tubercular ridge extending from rictus to insertion of arm, oriented obliquely at about 30° to horizontal.

Doral body mostly smooth with few low pustules denser posteriorly; skin on flanks and limbs smooth; no trace of glands in inguinal region; skin of ventral body and gular region smooth to very finely areolate.

When adpressed, Finger 3 > 4 > 2 > 1 (Fig. 2); digital tips of fingers sharply pointed; marginal grooves present on Fingers III and IV; digital formula of fingers 2, 2, 3, 3; manual subarticular tubercles rounded; distal subarticular tubercle of Finger IV absent (large, flat, oval supernumerary tubercle under penultimate phalanx of Finger IV); palm fleshy and swollen; three flat, round supernumerary tubercles, each positioned proximal to subarticular tubercle of Fingers II–IV; thenar tubercle flat and oval about half as large as round palmar tubercle; antebrachium unornamented.



**FIGURE 1.** Paratypes of *Noblella personina* (A–B, adult male, EPN 14330, SVL 15.2 mm; C, adult female, EPN 14329, SVL 17.4 mm; and D, adult male, EPN 14326, SVL 15.7 mm) from Sardinayacu Lake Complex, Morona Santiago, Ecuador.

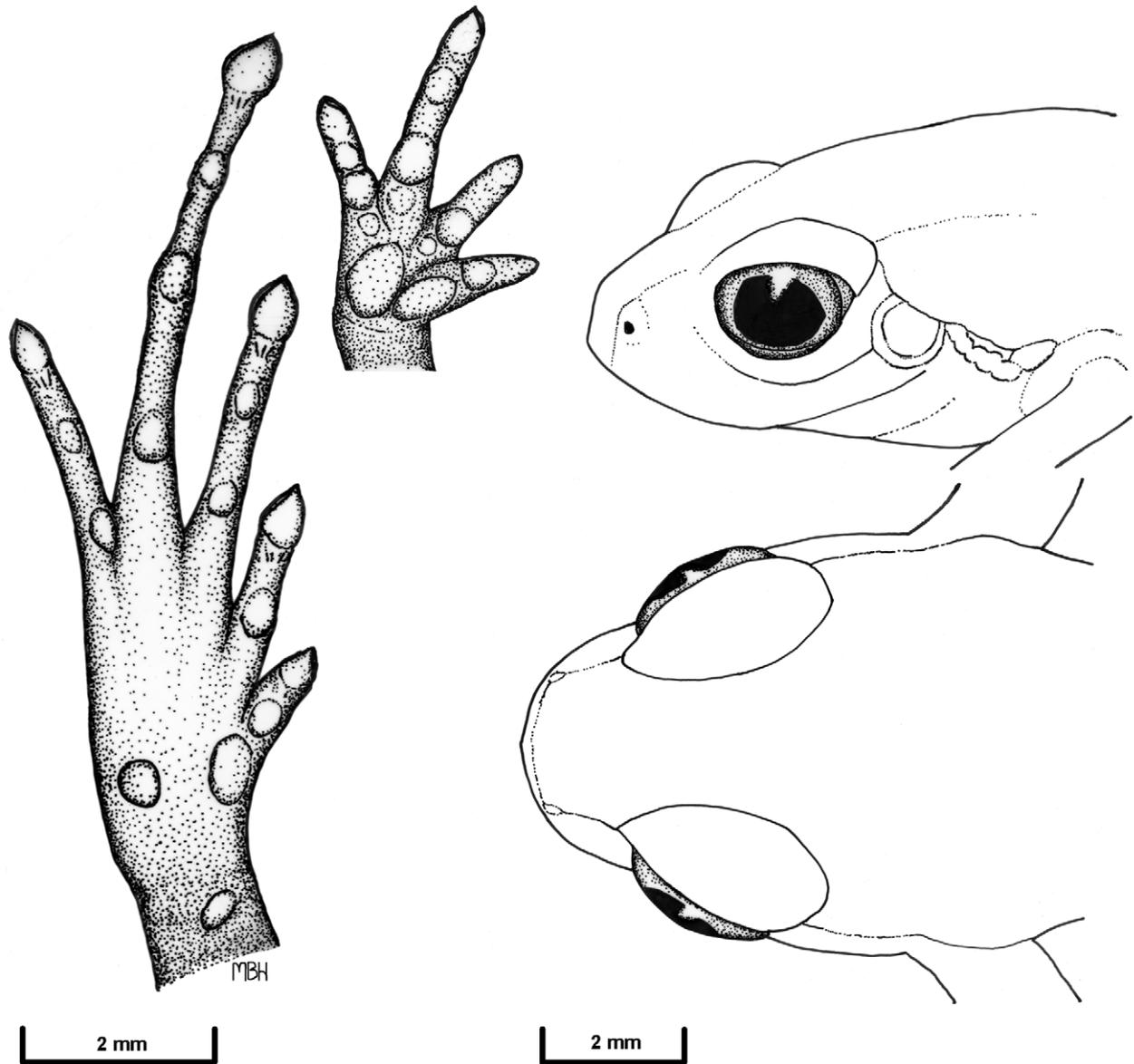
When adpressed, Toe 4 > 3 > 5 > 2 > 1; unguis fold and digital pads of toes sharply pointed, separated by marginal grooves (i.e., papilla of pad not projecting beyond distal margin of each toe); digital tip of Toe V noticeably reduced relative to Toes III–IV; pedal subarticular tubercles oval, low and rounded in profile; pedal supernumerary tubercles absent; inner metatarsal tubercle oval, rounded and low in profile; outer metatarsal tubercle round, rounded in profile but of noticeably higher relief than inner tubercle; tarsal tubercle oval, rounded in profile, positioned near preaxial edge on ventral surface of tarsus.

Choanae small and circular, positioned far anterior and laterally, widely separated from one another and almost vertical in roof of mouth; dentigerous processes of vomer and vomerine teeth absent; tongue relatively small, subcircular, lacking posterior notch and medial process, free for one-fourth its length; vocal slits paired, elongate (each about half as long as tongue), positioned laterally in floor of mouth; extending from level of middle of eye to level of posterior edge of tympanum; vocal sac distended, single.

Coloration in preservative: Dorsum gray with diffuse charcoal mottling; charcoal interorbital bar slightly arched medially; dorsum with two poorly defined markings, large irregular blotch immediately behind interorbital bar, another large blotch overlapping anterior end of sacrum; parasagittal charcoal band just above flanks from leg to about level of anterior end of sacrum; charcoal pigmentation on limbs in poorly defined bands; wide dark charcoal mask from tip of snout rapidly fading on flank behind arm, covering entire side of head; tympanic membrane brown, distinctly contrasting with charcoal skin surrounding it; flanks and sides of limbs like dorsum but lighter (no charcoal band on flanks); large triangular cloacal blotch darkest along its lateral and dorsal margins; except for cloacal blotch, postaxial skin of thighs brown, densely and uniformly speckled with cream; venter white, diffusely flecked with melanophores; gular region mottled, darkest under mandible and in mental region; palms

and soles charcoal, completely lacking cream spots; dorsal pigmentation extending to ventral surfaces of arms although leaving midventral white patches; melanophores forming diffuse reticulum on ventral surfaces of legs; free edge of palpebrum distinctly charcoal; rest of palpebrum uniformly and only slightly opaque (likely transparent in life).

*Measurements (mm) of holotype:* snout-vent length 16.3; head length 4.2; head width 5.2; eye diameter 1.8; eye-nostril distance 1.3; diameter of tympanum 0.8; eyelid width 1.2; interorbital distance 2.1; hand length 3.1; length of foot 7.8; length of shank 8.2.



**FIGURE 2.** Cephalic, palmar, and plantar morphology of *Noblella personina* (holotype, EPN 14324).

**Variation.** In preservative, coloration of the paratypes resemble that of the holotype. All lack a charcoal band on the flanks. They all have white bellies and dark gular areas (even the females) with noticeably darker pigment below the mandible. In each, there is at least a trace of a charcoal band above the inguinal region and a triangular cloacal blotch. EPN 14325 has bolder markings overall. In this specimen and EPN 14326 3/3 transverse bands can be counted on each tibia and, as in most frogs, the bands extend across the shank and foot when the legs are folded into a sitting position. No sexual dichromatism is evident in this species.

In life, *Noblella personina* ranges from charcoal to brown with scattered darker marking and tiny cream spots (Fig. 3). In some species, light tan areas edge dark charcoal to black markings on the dorsal body and head. The

rictal gland is white contrasting with the charcoal supratympanic fold. The skin covering the tympanum is flesh-colored. When present, light markings on the limbs are tan to yellow. The venter is pale to bright yellow with brown reticulation. The iris is dark brown with red marbling noticeably denser above the pupil. The ciliary ring is mostly black ventral to the pupil and red dorsal to the pupil.

Adult females lack vocal slits.

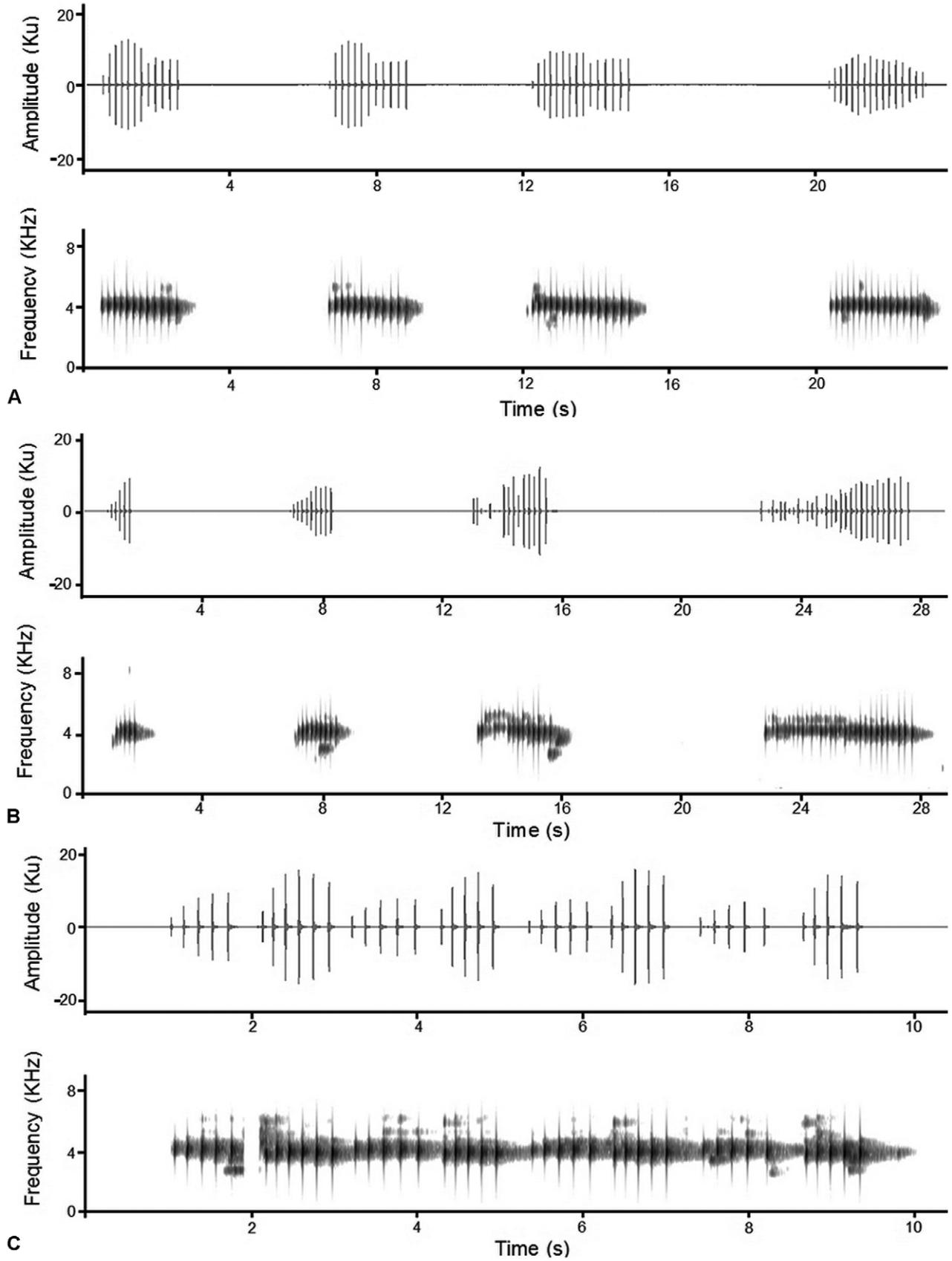


**FIGURE 3.** Dorsal and ventral morphology of *Noblella personina* (from left to right: EPN 14325 [female, SVL 15.6 mm], 14328 [female], and 14324 [male holotype]).

**Etymology.** The specific name *personina* is an adjective derived from the Latin word *persona*, meaning mask, especially as worn by an actor. A diminutive suffix calls attention to the greatly reduced mask that readily differentiates *Noblella personina* from Ecuadorian congeners.

**Vocalizations.** *Noblella personina* emits at least two different kinds of advertisement calls of modulated frequency: a simple call emitted in isolation and a more complex call emitted when conspecifics are calling nearby.

We recorded vocalizations from the holotype (EPN 14324) on 27 December 2010 at 19°C. The advertisement calls of this individual lasted 570–1524 milliseconds (ms) ( $1052 \pm 307$ ,  $n = 20$  calls) and consisted of 5–11 short notes lasting 13–20 ms ( $16 \pm 2$ ) each. Intervals of 103–166 ms ( $128 \pm 14$ ) separated the notes. This specimen's advertisement calls included notes of relatively uniform frequency and amplitude (Table 2; Fig. 4). Such calls are typical of individual males calling in isolation.



**FIGURE 4.** Oscilograms and sonograms of advertisement calls from three individuals of *Noblella personina* (A: holotype EPN 14324; B: EPN 14327; C: EPN 14326).

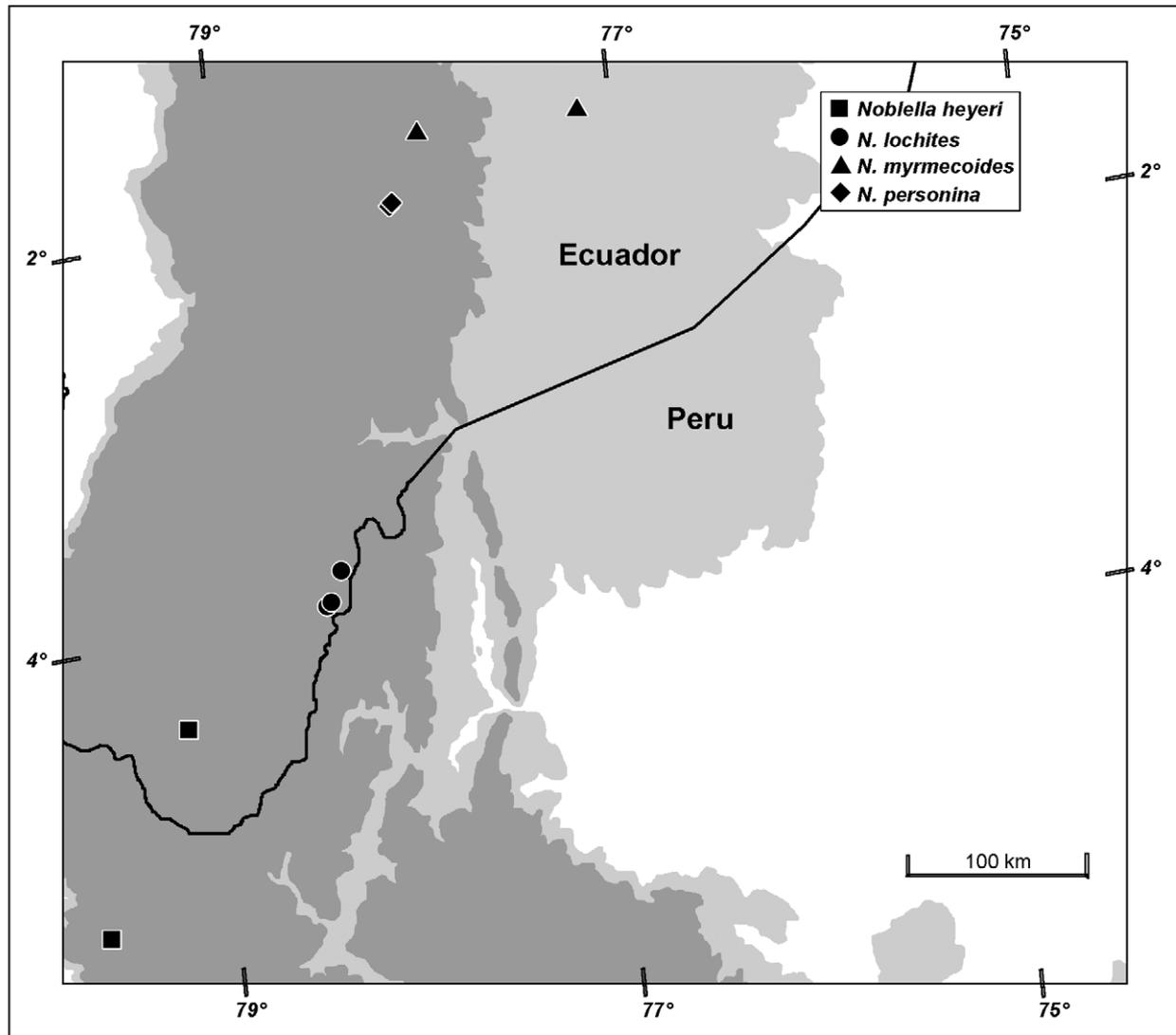


FIGURE 5. Collection localities of specimens of *Noblella* examined in this study (areas above 500 and 1000 m shaded gray).

TABLE 2. Vocalization parameters of *Noblella personina*. In parentheses, mean  $\pm$  standard deviation follows each range. All measurements of time are in milliseconds.

Parameter	EPN 14324	EPN 14326	EPN 14327
Number of Vocalizations Analyzed	20	54	18
Temperature ( $^{\circ}$ C)	19.0	19.0	19.3
Dominant Frequency (Kilohertz)	3.91–4.39 (4.10 $\pm$ 0.13)	4.17–4.56 (4.35 $\pm$ 0.10)	4–4.26 (4.14 $\pm$ 0.07)
Duration of Vocalization	570–1524 (1052 $\pm$ 307)	549–4335 (1063 $\pm$ 660)	481–4926 (1464 $\pm$ 1055)
Duration of Each Note	13–20 (16 $\pm$ 2, $n$ = 109)	7–20 (15 $\pm$ 2, $n$ = 340)	10–22 (17 $\pm$ 2, $n$ = 160)
Interval Between Vocalizations	1402–6722 (4245 $\pm$ 1526)	926–9563 (2460 $\pm$ 1786)	1807–8039 (3727 $\pm$ 2176)
Interval Between Notes	103–166 (128 $\pm$ 14)	119–230 (163 $\pm$ 19)	95–245 (150 $\pm$ 22)

More complex calls recorded from two other specimens were likely emitted in response to conspecifics nearby. The advertisement calls of EPN 14326 (recorded 28 December 2010 at 19 $^{\circ}$  C) lasted 549–4335 ms (1063  $\pm$  660,  $n$  = 54 calls) and consisted of 4–23 notes lasting 7–20 ms (15  $\pm$  2) each. Intervals of 119–230 ms (163  $\pm$  19) separated the notes. A conspecific calling nearby answered each note, suggesting that this call is an aggressive call.

Finally, calls of a third specimen (EPN 14327, recorded 24 February 2011, 19.3° C) lasted 481–4926 ms ( $1464 \pm 1055$ ,  $n = 18$ ) and consisted of 4–31 notes lasting 10–22 ms ( $17 \pm 2$ ) each. Intervals of 95–245 ms ( $150 \pm 22$ ) separated the notes. Unlike the holotype, calls of this individual included short and long notes with considerably more structural variation.

**Distribution and Natural History.** *Noblella personina* occurs in primary forest and in vegetation along the edge of lakes at the type locality (Fig. 5). The area of the type locality is part of the “Herbazal Lacustre Montano Bajo” formation (Cerón, 2001). We found individuals of the type series in leaf litter of swampy, densely vegetated areas adjacent to the lakes during the day. This species takes refuge under exposed tree roots and decomposing logs.

During our surveys, male *Noblella personina* called throughout the day from at least 5:15–20:10 hrs. Calling was most intense after rains.

Other terraranan frogs occurring in sympatry with *Noblella personina* include *Pristimantis bicantus*, *P. diadematus*, *P. eriphus*, *P. nigrogriseus*, *P. galdi*, *P. prolatus*, *P. quaquaversus* and *P. incomptus*.

### *Noblella lochites* Lynch 1976

**Diagnosis.** A species of *Noblella* as defined by Heyer (1977) and Hedges *et al.* (2008) reaching 19.4 mm SVL in females and 15.3 mm in males and distinguished from all congeners by (1) skin on dorsal body mostly finely shagreened; circular white epidermal glands raised into low pustules in many specimens; (2) tympanic annulus and membrane clearly visible, its dorso-posterior edge covered by indistinct supratympanic fold; (3) snout rounded in dorsal view, subtruncate in profile; (4) dentigerous process of vomer and teeth absent; (5) fingers not expanded distally; finger tips acuminate; Finger I slightly shorter than Finger II; nuptial pad not visible; fingers lacking marginal grooves; (6) distal phalanges T-shaped; phalangeal formula of hands 2, 2, 3, 2; (7) supernumerary palmar tubercles flat and inconspicuous, present at base of Fingers II–IV; subarticular tubercles rounded; antebrachial ornamentation absent; (8) one elongate tarsal tubercle; two prominent metatarsal tubercles; supernumerary plantar tubercles present (at least as circular white dots; see below); toes slightly expanded and acuminate distally; (9) Toe V shorter than Toe III; (10) pedal digital pads and unguis folds pointed, separated by marginal grooves; (11) in preservative, most adults (rare patternless specimens occur) with distinctive charcoal and black facial mask extending to inguinal region and narrowing on flanks; dorsum with well-defined scapular and sacral chevrons and pair of suprainguinal spots; venter diffusely pigmented in adults, mottled in juveniles.

**Color pattern and notes about external morphology.** Most specimens have two well-defined chevrons on the back, one overlapping the anterior end of the sacrum, the other between the arms (Fig. 6–7). Both chevrons point anteriorly, whereas the arched interorbital mark points posteriorly and is connected to the anterior chevron. Two (sometimes three) brown bands cross the dorsal surfaces of the thighs, shanks, and feet. The bands are indistinctly edged in light tan to cream.

Like most congeners, *Noblella lochites* has a black spot above the inguinal region on either side of the body. The spot is edged in cream and may be circular or elongate. However, when elongate, the blotch extends backward and laterally to the preaxial insertion of the thigh. Thus, shape of the supra-inguinal mark differs from that in *N. personina*, where the blotch is a parasagittal stripe above the flanks and is not edged in cream.

*Noblella lochites* has a distinctive charcoal, dark brown, or black facial mask. The mask is darkest dorsally where it sharply contrasts with thin light gray edging. Beyond the arm, the mask decreases in height as it approaches the inguinal region. A single large dark brown blotch edged in cream covers the preaxial surface of the brachium and merges with the mask at the insertion of the arm. Two similar preaxial markings are present on the antebrachium, a smaller one near the wrist and larger one in the center of the antebrachium. Some specimens have an additional blotch covering the elbow. A similar light-edged very dark blotch covers the preaxial surface of the thigh distally and overlaps the knee, and another light-edged blotch covers the distal end of the shank and wraps around the ankle onto the tarsus, extending to the tarsal tubercle.

As in other species examined by us, *Noblella lochites* has a well-defined triangular cloacal mark. The mark is edged by black dorsally and laterally and contrasts with the mostly brown and cream speckled pigmentation on the postaxial surface of the thighs.

*Noblella lochites* has small circular white dots scattered across all body surfaces. On close inspection, the dots appear to be epidermal glands. In many specimens, they are raised pustules just above the flanks at midbody and on the ventral thigh below the cloaca. The white dots are particularly noticeable on the otherwise charcoal to brown plantar surface. In some specimens, these glands have no relief in profile, whereas they are slightly elevated in others. Readers should note that these dots are the “obscure” supernumerary plantar tubercles mentioned by Lynch (1976, p. 50).



**FIGURE 6.** *Noblella lochites* (A, EPN 14255, SVL 15.83 mm; B and C, EPN 14254, SVL 17.35 mm) from Loma Paquisha, Cordillera del Condor, Ecuador.

Skin covering the mandible is charcoal flecked by tiny cream dots. The rest of the gular region and venter is cream in preservative and bright orange in life, immaculate except for uniformly distributed and very diffuse melanophores.

The palpebrum is likely transparent in live specimens. In preserved material it is slightly opaque except for a charcoal dorsal margin.

A few specimens in the series depart from the typical color pattern. EPN 11376 has a cream vertebral pinstripe, but otherwise resembles most specimens. Chevrons are very faint in EPN 11373 and absent from EPN 12814. The scapular chevron is represented by a pair of black dots and the sacral chevron is absent in EPN 11361. However, all other elements of the typical pattern are present and bold in these three specimens. A few specimens (e.g., EPN 11362, 11366, 13252) are nearly patternless (Fig. 7). These specimens completely lack the suprainguinal spots and have poorly defined facial masks. On the flanks, irregular blotches replace the well-defined charcoal and black band of most specimens.

Female *Noblella lochites* lack vocal slits. We detected no apparent sexual dichromatism. In particular the gular region of males is not more heavily pigmented than that of females. Attaining a SVL of 19.4 mm, females are larger than males (maximum SVL in our sample 15.3 mm), but we did not note any other mensural differences between the sexes (Table 1). The venter of juveniles is heavily mottled in brown and apparently lightens during ontogeny.

**Natural history.** We found most specimens of *Noblella lochites* during the day and occasionally heard males calling. A few specimens were found at night although they did not appear to be active. At the study site, this species occurs in both primary and secondary forest habitats. It primarily inhabits leaf litter or sandy areas covered in mosses and roots.

**Remarks.** The large series of *Noblella lochites* allows us to revisit earlier comments about the species’s morphology. In their key to *Noblella*, Guayasamin and Terán-Valdez (2009, couplet 5) characterize *N. lochites* as having “flanks and dorsum similarly colored,” whereas other species such as *N. myrmecoides* have “flanks with well-defined dark brown stripe that narrows as it approaches groin, contrasting with much lighter dorsal coloration.” These authors are referring to the facial mask. As we show above, most *N. lochites* have a dark brown facial mask on the flanks and would key out to *N. myrmecoides* in the key of Guayasamin and Terán-Valdez. These authors did not list any specimens of *N. lochites* in their appendix, but may have based this characterization on patternless specimens like the ones described above. However, patternless *N. lochites* are evidently quite rare.



**FIGURE 7.** Dorsal and ventral morphology of *Noblella lochites*: boldly patterned female (EPN 11361) and patternless female (EPN 11362, SVL 18.0 mm).

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## References

- Almendáriz, A. (1997) Overview of the herpetofauna of the western slopes of the Cordillera del Cóndor. In: Schulenberg, T.S. & Awbrey, K. (Eds), *The Cordillera del Cóndor region of Ecuador and Peru: A Biological Assessment*. Conservation International, Washington, D.C., pp. 80–82.
- Almendáriz, A., Ron, S.R. & Britto M., J. (2012) Una especie nueva de rana venenosa de altura del género *Excidobates* (Dendrobatoidea: Dendrobatidae) de la Cordillera del Cóndor. *Papéis Avulsos de Zoología*, 52, 387–389.  
<http://dx.doi.org/10.1590/S0031-10492012021200001>
- Barbour, T. (1930) A list of Antillean reptiles and amphibians. *Zoologica*, 11, 61–116.
- Bernal, M.H., Montealegre, D.P. & Páez, C.A. (2004) Estudio de la vocalización de trece especies de anuros del municipio de Ibagué, Colombia. *Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales*, 28, 385–390.
- Cerón, C.E. (2001) Dos nuevas formaciones naturales del Ecuador. *Revista Cinchionia*, 2, 1–4.
- Chen, M.H. & Combs, C.A. (1999) An alternative anesthesia for amphibians: ventral application of benzocaine. *Herpetological Review*, 30, 34.
- Cisneros-Heredia, D.F. & Reynolds, R.P. (2007) New records of *Phyllonastes* Heyer, 1977 from Ecuador and Peru. *Herpetozoa*, 19, 184–186.
- Cocroft, R.B. & Ryan, M.J. (1995) Patterns of advertisement call evolution in toads and chorus frogs. *Animal Behaviour*, 49, 283–303.  
<http://dx.doi.org/10.1006/anbe.1995.0043>
- De la Riva, I. & Köhler, J. (1998) A new minute leptodactylid frog, genus *Phyllonastes*, from humid montane forests of Bolivia. *Journal of Herpetology*, 32, 325–329.  
<http://dx.doi.org/10.2307/1565445>
- De la Riva, I., Chaparro, J.C. & Padial, J.M. (2008) The taxonomic status of *Phyllonastes* Heyer and *Phrynopus peruvianus* (Noble) (Lissamphibia, Anura): resurrection of *Noblella* Barbour. *Zootaxa*, 1685, 67–68.
- Duellman, W.E. (1991) A new species of leptodactylid frog, genus *Phyllonastes*, from Peru. *Herpetologica*, 47, 9–13.
- Duellman, W.E. & Lehr, E. (2009) *Terrestrial-Breeding Frogs (Strabomantidae) in Peru*. Natur und Tier Verlag, Münster, Germany, 382 pp.
- Duellman, W.E. & Lynch, J.D. (1988) Anuran amphibians from the Cordillera de Cutucú, Ecuador. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 140, 125–142.
- Fouquet, A., Loebmann, D., Castroviejo-Fisher, S., Padial, J.M., Orrico, V.G.D., Lyra, M.L., Roberto, I.J., Kok, P.J.R., Haddad, C.F.B. & Rodrigues, M.T. (2012) From Amazonia to the Atlantic forest: Molecular phylogeny of Physelaphryninae frogs reveals unexpected diversity and a striking biogeographic pattern emphasizing conservation challenges. *Molecular Phylogenetics and Evolution*, 65, 547–561.  
<http://dx.doi.org/10.1016/j.ympev.2012.07.012>
- Guayasamin, J. M. & Terán-Valdez, A. (2009) A new species of *Noblella* (Amphibia: Strabomantidae) from the western slopes of the Andes of Ecuador. *Zootaxa*, 2161, 47–59.
- Hammer, Ø., Harper, D. A. T. & Ryan, P. D. (2001) PAST: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontologia Electronica*, 4, 1–9.
- Hedges, S.B., Duellman, W.E. & Heinicke, P. (2008) New world direct-developing frogs (Anura: Terrarana): molecular phylogeny, classification, biogeography, and conservation. *Zootaxa*, 1737, 1–182.
- Heinicke, M.P., Duellman, W.E. & Hedges, S.B. (2007) Major Caribbean and Central American frog faunas originated by ancient oceanic dispersal. *Proceedings of the National Academy of Sciences*, 104, 10092–10097.  
<http://dx.doi.org/10.1073/pnas.0611051104>
- Heyer, W.R. (1977) Taxonomic notes on frogs from the Madeira and Purus rivers, Brazil. *Papéis Avulsos de Zoologia, São Paulo*, 8, 141–162.
- Köhler, J. (2000) A new species of *Phyllonastes* Heyer from the Chapare region of Bolivia, with notes on *Phyllonastes carrascoicola*. *Spixiana*, 23, 47–53.
- Lehr, E. & Catenazzi, A. (2009) A new species of minute *Noblella* (Anura: Strabomantidae). *Copeia*, 2009, 148–156.  
<http://dx.doi.org/10.1643/CH-07-270>
- Lehr, E., Aguilar, C. & Lundberg, M. (2004) A new species of *Phyllonastes* from Peru (Amphibia, Anura, Leptodactylidae). *Journal of Herpetology*, 38, 214–218.  
<http://dx.doi.org/10.1670/135-03A>
- Lynch, J.D. (1976) Two new species of frogs of the genus *Euparkerella* (Amphibia: Leptodactylidae) from Ecuador and Perú. *Herpetologica*, 32, 48–53.
- Lynch, J.D. (1986) New species of minute leptodactylid frogs from the Andes of Ecuador and Peru. *Journal of Herpetology*, 20, 423–431.  
<http://dx.doi.org/10.2307/1564505>
- Noble, G.K. (1921) Five new species of Salientia from South America. *American Museum Novitates*, 29, 1–7.
- Pyron, R.A. & Wiens, J.J. (2011) A large-scale phylogeny of Amphibia including over 2800 species, and a revised classification of extant frogs, salamanders, and caecilians. *Molecular Phylogenetics and Evolution*, 61, 543–583.  
<http://dx.doi.org/10.1016/j.ympev.2011.06.012>
- Reynolds, R.P. & Icochea, M.J. (1997) Amphibians and reptiles of the upper Rio Comainas, Cordillera del Cóndor. In: Schulenberg, T.S. & Awbrey, K. (Eds), *The Cordillera del Cóndor region of Ecuador and Peru: A Biological Assessment*. Conservation International, Washington, D.C., pp. 82–86.
- Simmons, J. E. (2002) Herpetological collecting and collection management. *Herpetological Circular*, 31, 1–153.

**APPENDIX.** Specimens examined.

*Noblella heyeri*: **ECUADOR: Loja:** 13 km S Yangana, 2450 m (KU 218211). **PERU: Piura:** 33 km SW Huancabamba (KU 196530, Paratype).

*Noblella lochites*: **ECUADOR: Morona Santiago:** Río Piuntza, northern end of Cordillera del Condor, 1550 m (KU 147070, Holotype). **Zamora Chinchipe:** Yantzatza-Los Encuentros, Vía Las Peñas-Pindal, 1335 m (EPN 12814,13674); Paquisha, Río Blanco, Loma Paquisha, 1770 m (EPN 11359, 11360, 11361,11362,11363, 11364, 11366, 11367,11369,11371, 11373,11374, 11375, 11376, 11378, 11379, 13365, 13609, 14255); Yantzatza, Los Encuentros, San Antonio, 1505 m (EPN 13252).

*Noblella myrmecoides*: **ECUADOR: Napo:** Puyo, on and above flood plain of Río Bobonaza (USNM 287698–287703). **Pastaza:** Arajuno, Curaray, Kilómetro 27 del oleducto Villano-Nuevo Triunfo, sector La Independencia, 420 m (EPN 6789, 6791, 6792, 6793, 6794, 6795, 6796, 6798, 6799, 6800, 6801). **PERU: Loreto:** lower Rio Napo region, E bank Rio Yanayacu, ca 90 km N Iquitos (KU 206120); Quebrada Oran, ca 5 km N Rio Amazonas, 85 km NE Iquitos (KU 206121); Quebrada Vasquez, N side of lower Rio Tahuayo (KU 220577, 220578, 220579).