A New Species of Minute *Noblella* (Anura: Strabomantidae) from Southern Peru: The Smallest Frog of the Andes

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We describe a new species of *Noblella* from the upper Cosñipata Valley in southern Peru (Cusco Region). Specimens were found in the leaf litter of a cloud forest between 3025 and 3190 m elevation. The most distinctive character of the new species is its diminutive size (maximum SVL female 12.4 mm, male 11.1 mm). With an average snout–vent length of 11.4 mm ($n = 7$) in adult specimens, the new species is the smallest Andean frog, and one of the smallest anurans in the world. The new frog is rare (between 30 and 75 frogs/ ha) and found only in montane scrub and forest habitats near the ecotone with the high-Andean puna grasslands. Although the amphibian fungal infection (*Batrachochytrium dendrobatidis*) has been recorded in southern Peru, no infections were detected in the new species.

Describimos una nueva especie de *Noblella* de la parte alta del Valle Cosñipata en el sur de Perú (Región Cusco). Los especímenes fueron encontrados en la hojarasca del bosque nublado a elevaciones entre 3025 y 3190 m. La característica más destacada de la nueva especie es su tamaño diminuto (longitud hocico–cloaca máxima 12.4 mm en hembras y 11.1 mm en machos). Con una longitud promedio de 11.4 mm ($n = 7$) en individuos adultos, esta especie es la ranita más pequeña de los Andes, y entre los anuros más pequeños del mundo. Esta nueva ranita es rara (densidad entre 30 y 75 individuos/ha) y habita los matorrales y bosques nublados cerca del ecotono con los pajonales altoandinos (puna). La infección causada por el hongo *Batrachochytrium dendrobatidis* ha sido reportada en anuros del sur de Perú; sin embargo no detectamos la presencia de este hongo en individuos de la nueva especie.

RECENT genetic studies of neotropical frogs indicate that amphibian diversity may be highly underestimated (Fouquet et al., 2007). Many of the newly described species belong either to *Pristimantis* or *Phrynopus*, which are major components of the Andean anuran faunas. Intensive fieldwork in Peru and revision of museum specimens collected in Peru within the last decade resulted in the discovery of 37 new species of *Pristimantis* (Duellman and Pramuk, 1999; Lehr et al., 2006; Duellman and Lehr, 2007) and 17 new species of *Phrynopus* (Duellman, 2000; Lehr et al., 2000; Lehr, 2001; Lehr et al., 2002a; Lehr and Aguilar, 2002, 2003; Lehr et al., 2005; Lehr, 2006, 2007; Chaparro et al., 2007; Duellman and Hedges, 2008).

Based on molecular genetic data, Hedges et al. (2008) allocated species of *Phrynopus* to five genera: *Bryophryne*, *Lynchius*, *Niceforonia*, *Noblella*, *Phrynopus*, and *Psychrophynella*. De la Riva et al. (2008a) resurrected *Noblella* and recognized *Phyllonastes* as its junior synonym. All species in the above mentioned genera have limited distributions often not exceeding the type locality and belong to the family Strabomantidae (Hedges et al., 2008), which contains direct developing frogs with snout–vent lengths up to 56.4 mm (Lehr et al., 2002b). Partly because of their restricted distributions, most species are classified as critically endangered, endangered, or unknown due to data deficiency (IUCN et al., 2006).

Long-term fieldwork in the Cosñipata Valley (Cusco Region) in southern Peru was conducted by the junior author between 1996 and 1999 to study amphibian diversity and population density of terrestrial and leaf-litter frogs along an elevational transect between 600 and 3600 m (Catenazzi and Rodríguez, 2001). During July and August 2007, and February 2008, some localities along the transect were resampled to assess the current condition and trends of frog populations, in view of the recent declines of montane neotropical amphibians (Young et al., 2001; Lips et al., 2005). Among the specimens obtained during fieldwork is a new species of leaf-litter *Noblella* which is distinguished from all known Andean anurans by its minute size. The purpose of this paper is to describe the new species and to assess its population density and conservation status. The relationship between miniaturization in frogs and cloud forest leaf-litter as a potential habitat is discussed.

MATERIALS AND METHODS

Institutional abbreviations follow Leviton et al. (1985) with the addition of MUSM for Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Peru, and MTD for Museum für Naturkunde Dresden, Dresden, Germany. We captured frogs in 10×10 m^2 leaf-litter quadrat plots (Jaeger and Inger, 1994) at the Wayqecha Research Center and within the Manu National Park in southeastern Peru, at the ecotone between the high-Andean puna grasslands and the cloud forest. A team of four (2008), five (in 2007), and two persons (in 1998 and 1999) searched intensively for frogs within the quadrat plots by removing leaf-litter and moss, lifting rocks and fallen logs, and examining other favorable microhabitats (e.g., water-filled epiphytic bromeliads) during the day. We sampled four quadrat plots for every 100 m of elevation between 2800 and 3400 m, for a total of 24 quadrat plots in 1998 and 1999 (wet season: 8–19 January 1998 and 29 January–6 March 1999), 24 plots in 2007 (dry season: 25 July–4 August) and 24 plots in 2008 (wet season: 19–26 February). The total sampling effort was 90 person-hours during 1998 and 1999, 266 person-hours during 2007, and 114 person-hours during 2008. We collected skin swabs from each frog captured in

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quadrat plots in 2007. Skins swabs were analyzed using PCR for the presence of *Batrachochytrium dendrobatidis*.

Taxonomy follows Hedges et al. (2008) and the format for the description follows that of Lynch and Duellman (1997), except that the term dentigerous processes of vomers is used instead of vomerine odontophores (Duellman et al., 2006). Conditions of the tympanum follow Lynch and Duellman (1997). Specimens were preserved in 10% formalin and stored in 70% ethanol. Specimens were dissected to determine the sex and maturity, and the otic region was dissected in order to determine the condition of the tympanic annulus. The following measurements were taken with digital calipers under a microscope and rounded to the nearest 0.1 mm: snout–vent length (SVL), tibia length (TL), foot length (FL, distance from proximal margin of inner metatarsal tubercle to tip of Toe IV), head length (HL, from angle of jaw to tip of snout), head width (HW, at level of angle of jaw), eye diameter (ED), tympanum diameter (TY), interorbital distance (IOD), upper eyelid width (EW), internarial distance (IND), eye–nostril distance (E–N, straight line distance between anterior corner of orbit and posterior margin of external nares). Comparative lengths of Toes III and V were determined by adpressing both toes against Toe IV; relative lengths of Fingers I and II were determined by adpressing the fingers against each other. Skin of Finger IV was removed to count number of phalanges. Drawings were made by the senior author using a stereomicroscope with drawing tube attachment. Photographs taken by A. Catenazzi were used for descriptions of coloration in life. Photographs of all types have been deposited at the Calphoto online database (http://calphotos.berkeley.edu). Spelling of locality names follow standards of the U.S. Board on Geographic Names (http://earth-info.nga.mil/gns/html/index.html) and for localities not listed in this database, according to Carta Nacional ''Calca,'' Hoja 27-s, Instituto Geográfico Nacional, Lima. The elevation profile was generated using SRTM 90 m digital elevation data.

Noblella pygmaea, new species

Figures 1, 2; Tables 1, 2

Holotype.—MUSM 26320, Peru, Cusco Region, Province of Paucartambo, District of Cosñipata, Wayqecha Research Center, Quebraba Toqoryuoc, gravid female, 13°11′31.92″S, 71°35′28.97″W, 3100 m above sea level, 3 August 2007, A. Catenazzi, I. Chinipa, A. Machaca, W. Qertehuari, and R. Santa Cruz.

Paratypes.—MUSM 24536, 26318, MTD 47286 (three adult females), MUSM 24535, 26319, MTD 47287 (three adult males), all from the type locality and its surroundings. MUSM 26318, 250 m east of the type locality, 13°11′29.36″S, 71°35′21.34″W, 3025 m above sea level, 1 August 2007. MUSM 26319, type locality, 3 August 2007. MTD 47286, 200 m east of the type locality, 13°11′30.12″S, 71°35′22.56″W, 3060 m above sea level, 4 August 2007. MTD 47287, near the type locality, 13°11′31.92″S, 71°35′28.97″W, 3135 m above sea level, 3 August 2007. A. Catenazzi, I. Chinipa, A. Machaca, W. Qertehuari, and R. Santa Cruz. MUSM 24536, 90 m east of the type locality, 13°11′33.1″S, 71°35′26.1″W, 3062 m above sea level. MUSM 24535, 13°11′33.1″S, 71°35′24.1′″W, 3070 m above sea level, 20 February 2008, A. Catenazzi, I. Chinipa, J. C. Jahuanchi, and A. Machaca.

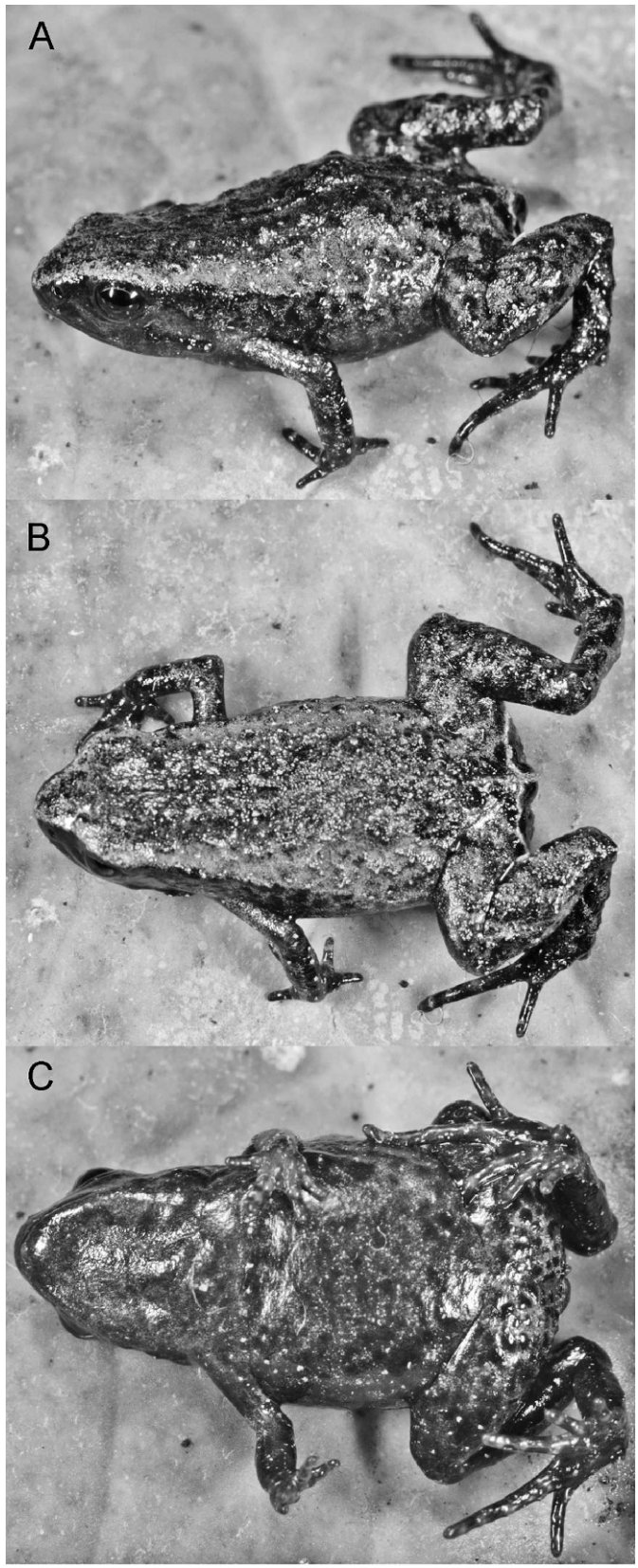

Fig. 1. *Noblella pygmaea* (MUSM 26320, holotype, SVL 12.4 mm) in lateral (A), dorsal (B), and ventral (C) views. Photos by A. Catenazzi.

Diagnosis.—A new species of *Noblella* as defined by Heyer (1977) and De la Riva et al. (2008a) that differs from the currently eight known species in the genus (Hedges et al., 2008) by its small size. With a SVL of 11.3–12.4 mm in adult

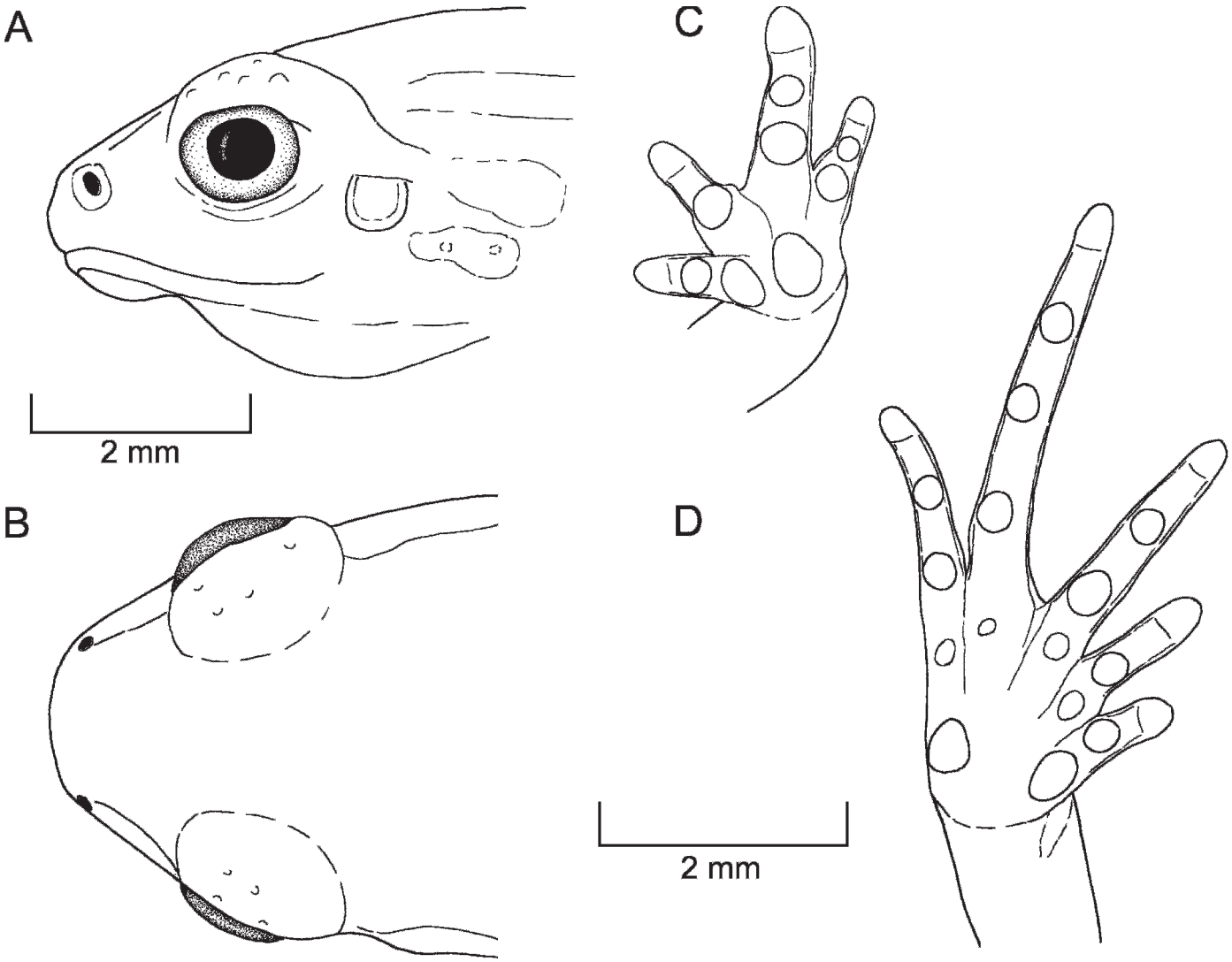

Fig. 2. Lateral (A) and dorsal (B) views of head and ventral views of hand (C) and foot (D) of *Noblella pygmaea* (MUSM 26320).

females ($n = 4$) and a SVL of 10.3–11.1 mm in adult males ($n = 3$), *Noblella pygmaea* is currently the smallest frog within the genus and the smallest frog known to occur in the Andes. *Noblella pygmaea* has three phalanges on Finger IV and differs from *N. carrascoicola*, *N. lochites*, *N. myrmecoides*, and *N. ritarasquinae*, which have two phalanges on Finger IV. *Noblella pygmaea* differs from central Peruvian *N. duellmani* by having a tympanum (absent in *N. duellmani*),

Table 1. Selected Characters (+ = Character Present; – = Character Absent; ? = Character Status Unknown) and Character Conditions among Peruvian Species of *Bryophryne*, *Noblella*, and *Psychrophrynella* Compared to *N. pygmaea*. Modified after Lehr (2006).

Characters and source	*N. pygmaea*, this paper	*N. peruviana*, Noble, 1921; De la Riva et al., 2008a	*P. bagrecito*, Lynch, 1986	*P. boettgeri*, Lehr, 2006	*B. bustamantei*, Chaparro et al., 2007	*B. cophites*, Lynch, 1975	*B. nubilosus*, Lehr and Catenazzi, 2008
Maximum SVL (mm)	12.4	16	18.6	18.4	23.4	29.3	21.9
Tympanum	+	+	+	+	Not apparent	–	–
Dentigerous processes of vomers	–	–	–	–	–	–	–
Dorsolateral folds	+	–	–	+	+	–	+
Vocal sac	+	+	+	–	+	–	+
Vocal slits	+	+	+	–	+	–	–
Nuptial pads	–	–	–	–	–	+	–
Finger I < II	+	–	+	+	+	+	+
Tarsal tubercle	–	+	+	–	–	–	–

Table 2. Ranges (in mm) and Proportions of *Noblella pygmaea*; Ranges Followed by Means and One Standard Deviation in Parentheses.

Characters	Females ($n = 4$)	Males ($n = 3$)
SVL	11.3–12.4 (11.9 ± 0.5)	10.3–11.1 (10.7 ± 0.3)
TL	4.7–5.1 (4.9 ± 0.1)	4.5–4.6 (4.6 ± 0.0)
FL	4.8–5.0 (4.9 ± 0.1)	4.3–4.6 (4.5 ± 0.1)
HL	3.7–4.1 (3.9 ± 0.2)	3.6–3.8 (3.9 ± 0.1)
HW	3.6–3.9 (3.7 ± 0.1)	3.5–3.7 (3.6 ± 0.1)
ED	1.1–1.2 (1.1 ± 0.1)	1.2 (1.2 ± 0.0)
TY	0.4–0.7 (0.5 ± 0.1)	0.5–0.6 (0.6 ± 0.0)
IOD	1.5–1.9 (1.7 ± 0.2)	1.5–1.8 (1.5 ± 0.2)
EW	0.8–1.0 (0.9 ± 0.1)	0.8–0.9 (0.8 ± 0.0)
IND	1.1–1.5 (1.3 ± 0.2)	1.1–1.2 (1.1 ± 0.0)
E–N	0.8–1.2 (1.0 ± 0.2)	0.7–0.9 (0.8 ± 0.1)
TL/SVL	0.40–0.42	0.41–0.45
FL/SVL	0.39–0.42	0.41–0.45
HL/SVL	0.32–0.33	0.34–0.37
HW/SVL	0.30–0.32	0.33–0.34
HW/HL	0.30–0.32	0.33–0.34
E–N/ED	0.67–1.09	0.58–0.75
EW/IOD	0.53–0.56	0.44–0.75
TY/ED	0.33–0.64	0.42–0.50

and from northern Peruvian *N. heyeri* and *N. lynchi* and southern Peruvian *N. peruviana* by lacking tarsal tubercles or folds (inner surface of tarsus bearing one prominent tubercle in *N. heyeri*, *N. lynchi*, and *N. peruviana*; Table 1). *Noblella pygmaea* differs from *N. myrmecoides* from Amazonian lowlands in lacking circumferential grooves on digits (present in *N. myrmecoides*). Six other small species of strabomantid frogs which lack circumferential grooves are known to occur in southern Peru: *Psychrophrynella bagrecito*, *P. boettgeri*, *P. usurpator*, *Bryophryne bustamantei*, *B. cophites*, and *B. nubilosus*. *Noblella pygmaea* is readily distinguished from these species by its minute size (Table 1). Furthermore it lacks a tarsal fold which is present in both *P. bagrecito* and *P. usurpator*. *Noblella pygmaea* has a tympanum which is absent in *Bryophryne*. Both *Noblella pygmaea* and *P. boettgeri* have a tympanum and dorsolateral folds, but *Noblella pygmaea* has vocal slits which are absent in *P. boettgeri*.

Description of holotype.—Head narrower than body, slightly longer than wide; head width 31.5% of SVL; head length 33.1% of SVL; snout short, rounded in dorsal and lateral views (Figs. 2A, 2B), eye diameter slightly smaller than eye–nostril distance; nostrils not protuberant, situated close to snout; canthus rostralis slightly curved in dorsal view, rounded in profile; loreal region nearly vertical; lips rounded; upper eyelid with small tubercles; width of upper eyelid narrower than IOD (upper eyelid width 52.6% of IOD); supratympanic fold short, narrow; tympanic membrane and tympanic annulus present, upper margin concealed by supratympanic fold; tympanum diameter 63.6% of eye diameter; two enlarged, elongate postrictal ridges on each side of head, upper ridge larger than lower. Choanae small, round, widely separated from each other, slightly concealed by palatal shelf of maxilla; dentigerous processes of vomers absent; tongue long and narrow, about three times as long as wide, not notched posteriorly, posterior one-third free.

Skin on dorsum tubercular with tubercles more densely arranged on posterior half of body; short, narrow dorsolateral folds present from posterior margin of eye to mid of body; skin on flanks tuberculate; skin on chest, belly, and thighs areolate, other ventral surfaces smooth; discoidal fold not evident, pectoral fold present; cloaca protuberant; large tubercles absent in cloacal region. Outer surface of brachium each with a row of small tubercles; palmar tubercles distinct, outer palmar tubercle not bifid, approximately two times the size of elongate, inner palmar tubercle; supernumerary indistinct; subarticular tubercles prominent, ovoid in dorsal view, rounded in lateral view, largest at base of fingers; fingers with narrow lateral fringes; Finger IV has three phalanges; Finger I shorter than Finger II; tips of digits rounded, circumferential grooves absent (Fig. 2C).

Hind limbs moderate, tibia length 41.1% of SVL; foot length 40.3% of SVL; upper and posterior surfaces of hind limbs tubercular; heel with one minute, round tubercle; outer surface of tarsus without tubercles; inner metatarsal tubercle elevated, ovoid, about one and a half times conical, rounded outer metatarsal tubercle; low plantar supernumerary tubercles present; subarticular tubercles well defined, ovoid in dorsal view, rounded in lateral view; toes with narrow lateral fringes, basal webbing absent; toe tips slightly pointed, slightly smaller than those on fingers, circumferential grooves absent; relative lengths of toes: $1 < 2 < 5 < 3 < 4$ (Fig. 2D).

SVL 12.4; tibia length 5.1; foot length 5.0; head length 4.1; head width 3.9; eye diameter 1.1; tympanum diameter 0.7; interorbital distance 1.9; upper eyelid width 1.0; internarial distance 1.5; eye–nostril distance 1.2.

In ethanol, dorsum mottled dark gray and dark brown on tan background; broad pale gray dorsolateral stripe from upper eyelid to insertion of thighs; narrow, slightly elevated dark brown ridge middorsally from sacral region to cloaca; flanks slightly darker than dorsum; anterior surface of thighs colored as dorsum, posterior surface with narrow, pale gray stripe from cloaca diagonally to inside of knee; dorsal and lateral tubercles bearing pale gray tips; throat, chest, and venter chocolate brown, thighs mottled tan and chocolate brown; iris dark gray.

Color in life as above except throat, chest, belly, and thighs reddish brown with minute gray spots; iris dark brown with few gold spots, pupil with an orange ringlet.

Variation.—Males are smaller than females and have vocal slits and a vocal sac, but lack nuptial pads. Otherwise, all specimens are structurally like the holotype. Slight differences can be observed in coloration pattern (in life). One male (MUSM 26319) has a mottled reddish brown and tan dorsum with dark brown flecks and pale gray tubercles. Dark brown flecks are present on the head, and the dorsolateral band is tan. The flanks are mottled dark brown and pale gray. The shanks and tarsus are dorsally pale greenish brown with dark brown flecks. Throat, chest, and belly are mottled chocolate brown and pale gray, whereas other ventral surfaces are chocolate brown with pale gray spots. One female (MTD 47286) has a pale brown dorsum with scattered brown flecks and pale gray tubercles. The flanks are grayish brown, and the chest and belly are mottled pale gray and tan, whereas all other ventral surfaces are tan with minute gray and orange spots. All specimens have a narrow, pale gray stripe from the cloaca diagonally to inside of the knee on the posterior surfaces of the thighs. Measurements of female (MTD 47286, MUSM 26318, 24536) and male paratypes (MUSM 26319, MTD 47287, MUSM 24535,

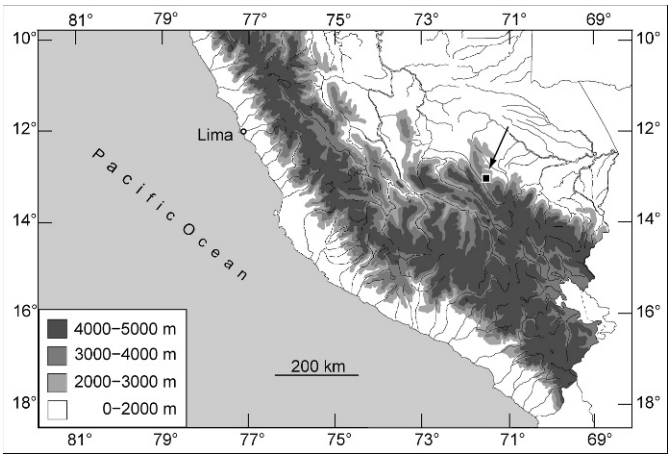

Fig. 3. Type locality (indicated by an arrow) of *Noblella pygmaea* in southern Peru.

separated by slash, respectively): SVL 12.3, 11.6, 11.3/11.1, 10.6, 10.3; tibia length 4.9, 4.8, 4.7/4.5, 4.6, 4.6; foot length 4.8, 4.8, 4.8/4.5, 4.3, 4.6; head length 4.0, 3.7, 3.7/3.8, 3.9, 3.6; head width 3.7, 3.7, 3.6/3.7, 3.5, 3.5; eye diameter 1.1, 1.2, 1.2/1.2, 1.2, 1.2; tympanum diameter 0.4, 0.4, 0.5/0.6, 0.6, 0.5; interorbital distance 1.6, 1.5, 1.6/1.8, 1.2, 1.5; upper eyelid width 0.9, 0.8, 0.9/0.8, 0.9, 0.8; internarial distance 1.1, 1.2, 1.2/1.2, 1.1, 1.1; eye–nostril distance 0.8, 1.1, 0.8/0.9, 0.9, 0.7. See Table 2 for ranges and proportions of the type series.

Distribution and ecology.—The new species is known from two localities in the upper Cosñipata Valley in southeastern Peru, at elevations of 3025–3190 m (Figs. 3, 4). Type specimens were collected from steep slopes of montane forest draining into the Quebrada Toqoryuoc, which, along with the Quebradas Toqohuayqo and Pillahuata, form the Río Cosñipata. This forest is currently preserved by the Amazon Conservation Association and is linked to the

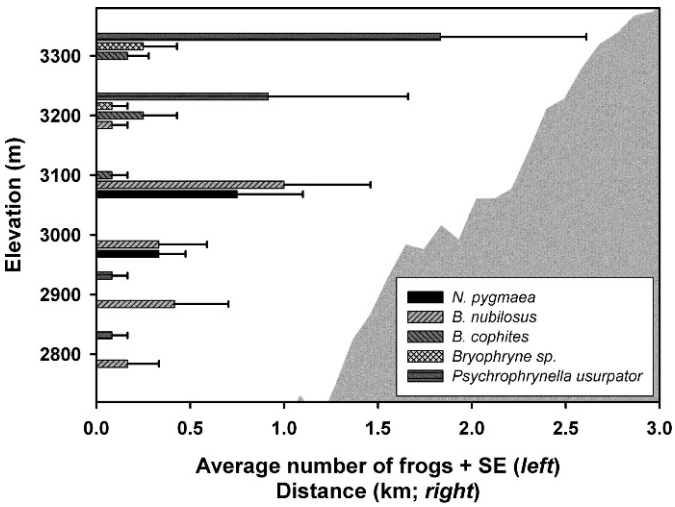

Fig. 4. Elevation profile (right) and estimated density (left; average number of frogs/100 m² + SE) of *Noblella pygmaea* and sympatric species of *Bryophryne* and *Psychrophrynella* between 2800 and 3400 m elevation in the upper Cosñipata Valley, based on 10 × 10 m² quadrat plots during the wet seasons of 1998, 1999, and 2008 and the dry season of 2007 (n = 72).

Fig. 5. Montane forest at the quadrat plot where one specimen of *Noblella pygmaea* (MUSM 26318) was collected, 250 m east of the type locality, on 1 August 2007. Photo by A. Catenazzi.

Wayqecha Research Center by a series of trails. The second locality is approximately 3 km northwest of the type locality, on the eastern ridge of Cerro Macho Cruz, along the Ericson trail connecting Acanaco to Pillahuata within the Manu National Park, at elevations of 3120–3190 m. This ridge separates the drainage basins of the Toqohuayqo and Pillahuata streams. We found five individuals of this species at Cerro Macho Cruz on 11 January 1998.

All type specimens were found in the cloud forest leaf litter (Fig. 5). Four of the six 10 × 10 m² quadrat plots where frogs were collected in 2007 and 2008 had large cover of *Chusquea* bamboos, accounting for the large arbustive cover (between 50 and 80%). Overstory density averaging 98.1 ± 0.3% and leaf-litter depth averaging 12.0 ± 0.4 cm in quadrat plots with *N. pygmaea* in 2007 and 2008 did not differ from overstory ($t = 1.15$, $df = 58$, $P = 0.25$) and leaf-litter depth ($t = 0.74$, $df = 58$, $P = 0.46$) values from all quadrat plots between 2800 and 3400 m.

The cloud forest grades into elfin forests and the high-Andean puna grasslands at elevations between 3200 and 3500 m, depending on slope aspect, steepness, and disturbance regimes. The ecotone between the montane forest and the puna grasslands at Toqoryuoc is located approximately 200 m NW of, and approximately 120 m (in elevation) above, the type locality. The ridge of Cerro Macho Cruz has more xeric vegetation, with reduced tree cover and a larger proportion of herbaceous plants. Two quadrat plots where *N. pygamaea* were found represented two habitat types found along this ridge: arbustive and herbaceous vegetation in montane scrub along the edge of the ridge, and elfin forest with abundant ground moss cover. Conspicuous plant genera in the upper Cosñipata valley include *Alnus*, *Begonia*, *Bomarea*, *Calceolaria*, *Clethra*, *Clusia*, several Ericaceae, *Juglans*, *Miconia*, *Oxalis*, *Peperomia*, *Weinmannia*, *Symplocos*, bamboos (*Chusquea*), terrestrial ferns (*Cyathea*), and epiphytic bromeliads (*Pitcairnea*, *Tillandsia*; Cano et al., 1995; Foster et al., 2007. Plantas llamativas de Pillahuata, Plantas llamativas de Acjanaco. http://fm2.fieldmuseum.org/plantguides/).

Skin swabs from all *Noblella pygmaea* captured in 2007 tested negative for *Batrachochytrium dendrobatidis*. Moreover, skin swabs from all sympatric frogs captured in quadrat plots between 2800 and 3400 m in 2007 tested negative for *B. dendrobatidis*.

Noblella pygmaea is a rare species with a known elevational distribution between 3000 and 3200 m (Fig. 4). Based on our quadrat plots from 1998, 2007, and 2008, *N. pygmaea* is the second most common leaf-litter frog between 3000 and 3200 m, where it was found syntopically with *Bryophryne nubilosus*. The number of *N. pygmaea* in quadrat plots averaged 0 (1998/99), 0.50 ± 0.29 (2007) and 0.50 ± 0.29 (2008) between 3000 and 3099 m (n = 4 plots/season) and 1.50 ± 0.86 (1998/99), 0.75 ± 0.48 (2007), and 0 (2008) between 3100 and 3199 m (n = 4 plots/season). Anurans found in other quadrat plots between 2800 and 3400 m include *Bryophryne cophites*, *B. nubilosus*, *B.* sp., *Gastrotheca excubitor*, *Oreobates lehri*, *Pristimantis pharangobates*, and *Psychrophrynella usurpator*. Additional species are known to occur between 2800 and 3400 m: *Centrolene* sp., *Gastrotheca ochoai*, *Telmatobius* sp., *''Hyla'' antoniiochoai*, and *Hyloscirtus armatus* (De la Riva and Chaparro, 2005; Catenazzi, pers. obs.).

Frog calls were heard (not recorded) in 1998, 2007, and 2008 in quadrat plots that contained *Noblella pygmaea* and *Bryophryne nubilosus*. The holotype contains four unpigmented ovarian eggs (two in each ovary) that are indicative of terrestrial deposition.

Etymology.—The specific name *pygmaea* is the feminized form of the Latin noun *pygmaeus* meaning ''dwarf'' and refers to the small size of this species.

DISCUSSION

The herpetofauna of the upper Cosñipata Valley (Cusco Region) was largely unknown before the construction of the Paucartambo–Pilcopata road connecting Andean locations to the Amazon lowlands. Duellman's fieldwork in 1971 and 1975 resulted in the description of five new species of *Pristimantis* (Duellman, 1978). Lynch (1975) described *Bryophryne cophites* and placed *Noblella peruviana* under the new combination *Phrynopus peruvianus* based on specimens collected near Abra Acanaco (=Acjanaco, Acanacu), close to the type locality of *N. pygmaea*. De la Riva et al. (2008a) stated that this population actually represents an undescribed species of *Psychrophrynella*, recently named as *P. usurpator* (De la Riva et al., 2008b). Lehr and Catenazzi (2008) described *B. nubilosus*, which occurs syntopically with *N. pygmaea*. Therefore, with this description and a forthcoming description of a new *Bryophryne* species, five species of strabomantid frogs are known to occur in the leaf litter of the elfin and cloud forests of the upper Cosñipata Valley above 2800 m.

Miniaturization in anurans has evolved independently in diverse lineages (Wells, 2007; Table 3). The smallest frog is *Brachycephalus didactyla* from Brazil: females reach a maximum snout–vent length of 10.2 mm (Izecksohn, 1971). The term ''smallest frog'' is problematic (Estrada and Hedges, 1996). Accurate estimation of body sizes requires a large series of specimens to cover variation in body size within a population. Records of body sizes often rely on a low number of individuals (*Eleutherodactylus iberia:* Estrada and Hedges, 1996: four specimens, this paper: seven specimens) despite the availability of large series in some cases (Izecksohn, 1971). Some reports may reflect sex-based sampling bias (Biju et al., 2007).

Studies focussing on ecophysiological adaptations among high-elevation anurans are scarce (Navas, 1996), and we are not aware of any study trying to explain ecophysiological aspects of miniaturization in anurans. There seems to be no

Table 3. Selected Anurans with Maximum Male Snout–Vent Lengths below 17 mm, Arranged by Increasing Maximum SVL. Range is followed by mean, SD, and sample size, if data are available.

Species	Max male SVL	Range	Females	Males	Country	References
Brachycephalus didactylus	8.6	8.6–10.2 (n = 80)	10.2	8.6	Brazil	Izecksohn, 1971
Eleutherodactylus iberia	10.0	9.6–10.5 (n = 4)	10.5 (n = 1)	9.6–10.0 (9.80 ± 0.12, n = 3)	Cuba	Estrada and Hedges, 1996
Stumpffia tridactyla	11	10–11	?	10–11	Madagascar	Glaw and Vences, 2007
Noblella pygmaea	11.1	10.3–12.4 (n = 7)	11.3–12.4 (12.9 ± 0.5, n = 4)	10.3–11.1 (10.7 ± 0.3, n = 3)	Peru	This paper
Eleutherodactylus limbatus	11.7	9.8–11.8 (n = 9)	11.1–11.8 (11.6 ± 0.17, n = 4)	9.8–11.7 (10.5 ± 0.36, n = 5)	Cuba	Estrada and Hedges, 1996
Stumpffia pygmaea	12	10–12	11 (n =1)	10–12	Madagascar	Glaw and Vences, 2007
Noblella myrmecoides	?	12.0–13.6 (n = 3)	12.0–13.6 (n = 3)	unknown		Lynch, 1976
Brachycephalus ferruginus	12.5	11.6–14.5 (n = 13)	13.0–14.5 (13.8 ± 0.6, n = 4)	11.6–12.5 (12.2 ± 0.3, n = 9)	Brazil	Alves et al., 2006
Brachycephalus pombali	13.9	12.6–15.3 (n = 8)	14.6–15.3 (15.0 ± 0.3, n = 4)	12.6–13.9 (13.3 ± 0.5, n = 4)	Brazil	Alves et al., 2006
Nyctibatrachus minimus	14.0	10.0–14.9 (n = 16)	14.9 (n = 1)	10.0–14.0 (12.3 ± 1.4, n = 15)	India	Biju et al., 2007
Noblella heyeri	14.1	12.9–15.9	13.1–15.9	12.9–14.1	Peru	Lynch, 1986
Pristimantis trachyblepharis	15.8	12.1–19.2 (n = 39)	15.8–19.2, (17.2, n = 19)	12.1–15.8, (13.8, n = 20)	Ecuador	Lynch and Duellman, 1980
Phrynopus bracki	16.2	13.2–19.8	17.5–19.8	13.2–16.2	Peru	Hedges, 1990; this paper
Psychrophrynella bagrecito	16.3	13.8–18.6	14.4–18.6	13.8–16.3	Peru	Lynch, 1986
Psychrophrynella iatamasi	16.48	15.74–16.48	15.74 (n = 1)	16.48 (n = 1)	Bolivia	Aguayo-Vedia and Harvey, 2001
Psychrophrynella boettgeri	16.8	11.3–18.4 (n = 23)	14.0–18.4 (16.2 ± 1.4, n = 14)	11.3–16.8 (14.1 ± 1.6, n = 9)	Peru	Lehr, 2006

relationship between body size and temperature (i.e., Bergmann's rule) in amphibians (Feder et al., 1982; Adams and Church, 2007, but see Ashton, 2002). Moreover, Navas (2006) suggests that amphibians are able to shift their physiology to adjust for activity at lower temperatures, which implies that temperature is less likely to drive patterns of distribution and evolution of body sizes in amphibians at high elevations. The advantage of small body size may be that it results in a better use of small patches of suitable habitat and food resources (the 'mosaic elements model' of Hutchinson and MacArthur, 1959). Cloud forest leaf-litter provides a unique habitat for anurans, yet it is often distributed in patches which alternate with other types of habitats (elfin forests, montane scrub, grassland). Strabomantid frogs do not need to migrate for reproduction (they lay eggs in the leaf litter) and probably have very small home ranges. Under these circumstances, the evolution of a small body size could be beneficial to frogs that can exploit a specific niche not occupied by larger species. Given the extent of Andean cloud forests, we are certain that many other new species of frogs will be discovered if habitats are thoroughly sampled. Unfortunately, cloud forests are threatened by habitat destruction, fragmentation, and climate change. In addition to these threats, the amphibian fungal infection *Batrachochytrium dendrobatides* has been recorded in high elevation anurans in Cusco (Seimon et al., 2007), is known from elevations above 3400 m in the Cosñipata Valley (A. Catenazzi, pers. obs.), and is likely to affect *N. pygmaea* in the future.

MATERIAL EXAMINED

Bryophryne cophites. Peru: Cusco, Paucartambo, Cosñipata, S slope Abra Acanaco, 14 km NNE Paucartambo, 3400 m, KU 138884 (holotype); N slope Abra Acanaco, 3450 m, KU 138885–908, 138911–5 (all paratypes); Tres Cruces, MUSM 26313, 26315, 26266–67, 26283–84.

Bryophryne nubilosus. Peru: Cusco, Paucartambo, Cosñipata, 500 m NE Esperanza, 2712 m, MUSM 26310–11; Quebrada Toqoruyoc, 3097 m, MUSM 26312, MTD 47293; 3065 m, MTD 47294; Esperanza, 2800 m, MUSM 26316–17.

Psychrophrynella bagrecito. Peru: Cusco, Quispicanchis, Marcapata: Río Marcapata, below Marcapata, ca. 2740 m, KU 196512 (holotype), KU 196513–18, 196520–21, 196523–25 (all paratypes); La Convención: Hacienda Huyro between Huayopata and Quillabamba, 1830 m, KU 196527–28.

Psychrophrynella usurpator. Peru: Cusco, Paucartambo, Cosñipata: N slope Abra Acanaco, 3450 m, KU 138917; N slope Abra Acanaco, 3450 m, KU 138919–24, KU 138929–35; Tres Cruces, KU 17325, KU 173327–29; Esperanza, 3090 m, MTD 46371–72; N slope Abra Acanaco, Paucartambo, 3400 m, MTD 45021–22.

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