



A new species of *Bryophryne* (Anura: Strabomantidae) from southern Peru

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Abstract

A new species of *Bryophryne* from southern Peru (Cusco Region) is described. Specimens were found in the leaf litter of cloud forest at elevations of 2350–3215 m. The new species has a maximum snout-vent length of 21.9 mm in adult females, 18.9 mm in adult males and is the smallest species of the genus. It lacks a tympanum and dentigerous processes of vomers, has dorsolateral folds, and males without vocal slits and without nuptial pads. The new species is most similar to *B. bustamantei* but differs in being smaller, having discontinuous dorsolateral folds, the males lacking vocal slits, and an overall darker ventral coloration. *Bryophryne* contains three species all of which lack a tympanum. The deep valley of the Río Apurímac as a distributional barrier separating *Phrynopus* from *Bryophryne* is discussed.

Key words: Andes, biogeography, *Bryophryne cophites*, *Bryophryne bustamantei*

Resumen

Se describe una nueva especie de *Bryophryne* del sur de Perú (Región Cusco). Los especímenes fueron encontrados en la hojarasca del bosque nublado a elevaciones entre 2350–3215 m. La longitud hocico-cloaca alcanza los 21.9 mm en hembras adultas y 18.9 mm en machos adultos, haciendo de esta la especie más pequeña del género *Bryophryne*. Se caracteriza por la ausencia de tímpano y procesos dentígeros vomerianos, la presencia de pliegues dorso-laterales, machos sin aberturas vocales y sin almohadillas nupciales. La nueva especie es similar a *B. bustamantei*, pero difiere por su menor tamaño, forma irregular de los pliegues dorso-laterales, ausencia de aberturas vocales en los machos, y coloración ventral más oscura. Las tres especies del género *Bryophryne* carecen de tímpano. Discutimos la relevancia del valle encañonado del río Apurímac como barrera geográfica entre los géneros *Phrynopus* y *Bryophryne*.

Palabras claves: Andes, biogeografía, *Bryophryne cophites*, *Bryophryne bustamantei*

Introduction

Several new species of strabomantid frogs have been described from southern Peru including species in the genera *Pristimantis* and *Phrynopus* (Chaparro *et al.* 2007, Lehr 2007). Based on molecular genetic data Hedges, Duellman & Heinicke (2008) allocated species of *Phrynopus* to five genera: *Bryophryne* Hedges, Duellman & Heinicke, *Lynchius* Hedges, Duellman & Heinicke, *Niceforonia* Goin & Cochran, *Phrynopus* Peters, and *Psychrophynella* Hedges, Duellman & Heinicke. De la Riva *et al.* (2008) resurrected *Noblella* Barbour and recognized *Phyllonastes* Heyer as its junior synonym. All the above mentioned genera have limited distributions in the Andes often not exceeding the type locality and belong to the family Strabomantidae

which contains direct developing frogs. Recent fieldwork in southern Peru (Cusco Region) by the junior author revealed a new species morphologically most similar to *Bryophryne cophites* (Lynch) and *B. bustamantei* (Chaparro *et al.*). Currently, the genus *Bryophryne* is known only from southern Peru and contains two medium-sized species which lack a tympanum and lack dentigerous processes of vomers. Herein we describe the third species.

Material and methods

Taxonomy follows Hedges *et al.* (2008) and the format for the description follows that of Lynch & Duellman (1997), except that the term dentigerous processes of vomers is used instead of vomerine odontophores (Duellman *et al.* 2006). We follow the definition of conditions of the tympanum by Lynch & 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. Measurements were taken with digital calipers under a microscope and rounded to the nearest 0.1 mm, including 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; lengths of Fingers I and II were determined by adpressing the fingers against each other. 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>). Locality names were spelled following standards of the US Board on Geographic Names (<http://gnswww.nga.mil>) and, for localities not listed in this database, according to Carta Nacional Calca, Hoja 27-s, Instituto Geográfico Nacional, Lima. Specimens collected were deposited in the herpetological collections of the Museo de Historia Natural, Universidad Nacional Mayor de San Marcos (MUSM, formerly MHNSM) in Lima, Peru, in the Natural History Museum in Geneva (MHNG), Switzerland, and in the Museum für Tierkunde Dresden (MTD), Germany. For specimens examined, see Appendix.

Bryophryne nubilosus new species

Holotype: MUSM 26310 (Figs. 1A, B; 2), an adult male collected 500 m NE of Esperanza (coordinates 13°10'32.62"S, 71°36'1.07"W) at 2712 m elevation, Distrito de Cosñipata Provincia de Paucartambo, Región Cusco, Peru, on 5 August 2007 by A. Catenazzi, I. Chinipa, A. Machaca, W. Qertehuari and R. Santa Cruz.

Paratypes: Seven: four females (MUSM 20970, 26311–12, MTD 47294), and three males (MUSM 26316–17, MTD 47293). MUSM 20970 collected near Hito Pillahuata, 13°09'56.27"S, 71°35'54.55"W, at 2600 m elevation, on 30 August 1996. MUSM 26311 collected with the holotype on 5 August 2007; MUSM 26312 and MTD 47293 collected at Quebrada Toqoruyoc, 13°11'31.72"S, 71°35'28.87"W, at 3097 m elevation, on 3 August 2007; MHNSM 26316–17 collected at Esperanza 13°10'35.71"S, 71°36'7.93"W, at 2800 m elevation on 31 July 2007; MTD 47294 collected near the type locality, 13°11'33.21"S, 71°35'25.17"W, at 3065 m elevation on 3 August 2007; all specimens collected by A. Catenazzi, I. Chinipa, A. Machaca, W. Qertehuari and R. Santa Cruz, except for MUSM 20970 collected by A. Catenazzi.



FIGURE 1. Upper row: Male *Bryophryne nubilosus* (MUSM 26310, holotype, SVL 18.9 mm) in lateral (A), and (B) ventral views; middle row: female *Bryophryne nubilosus* (MUSM 26311, SVL 19.8 mm) in lateral (C), and ventral (D) views; lower row: female *Bryophryne cophites* (MTD 47288, SVL 20.6 mm) in lateral (E), and ventral (F) views. Photos by A. Catenazzi.

Diagnosis. A medium sized species of *Bryophryne* having the following combination of characters: (1) Skin on dorsum shagreen, skin on venter areolate; discoidal fold absent, thoracical fold present; prominent,

irregularly shaped, discontinuous dorsolateral fold; (2) tympanic membrane and tympanic annulus absent; (3) snout rounded in dorsal and lateral views; (4) upper eyelid with two enlarged tubercles; width of upper eyelid narrower than IOD; cranial crests absent; (5) dentigerous processes of vomers absent; (6) males without vocal sac, vocal slits, and nuptial pads; (7) Finger I shorter than Finger II; tips of digits rounded; (8) fingers without lateral fringes; (9) ulnar and tarsal tubercles present; (10) heel without tubercles; inner tarsal fold absent; (11) inner metatarsal tubercle ovoid, about as large as outer; outer metatarsal tubercle rounded; supernumerary plantar tubercles indistinct; (12) toes without lateral fringes; webbing absent; Toe V longer than Toe III; toe tips slightly pointed, about as large as those on fingers; (13) in ethanol, dorsum grayish brown with dark brown blotches, venter dark brown with pale gray spots and blotches; (14) SVL in adult females 19.8–21.9 mm ($n = 4$), in males 12.7–18.9 mm ($n = 4$).

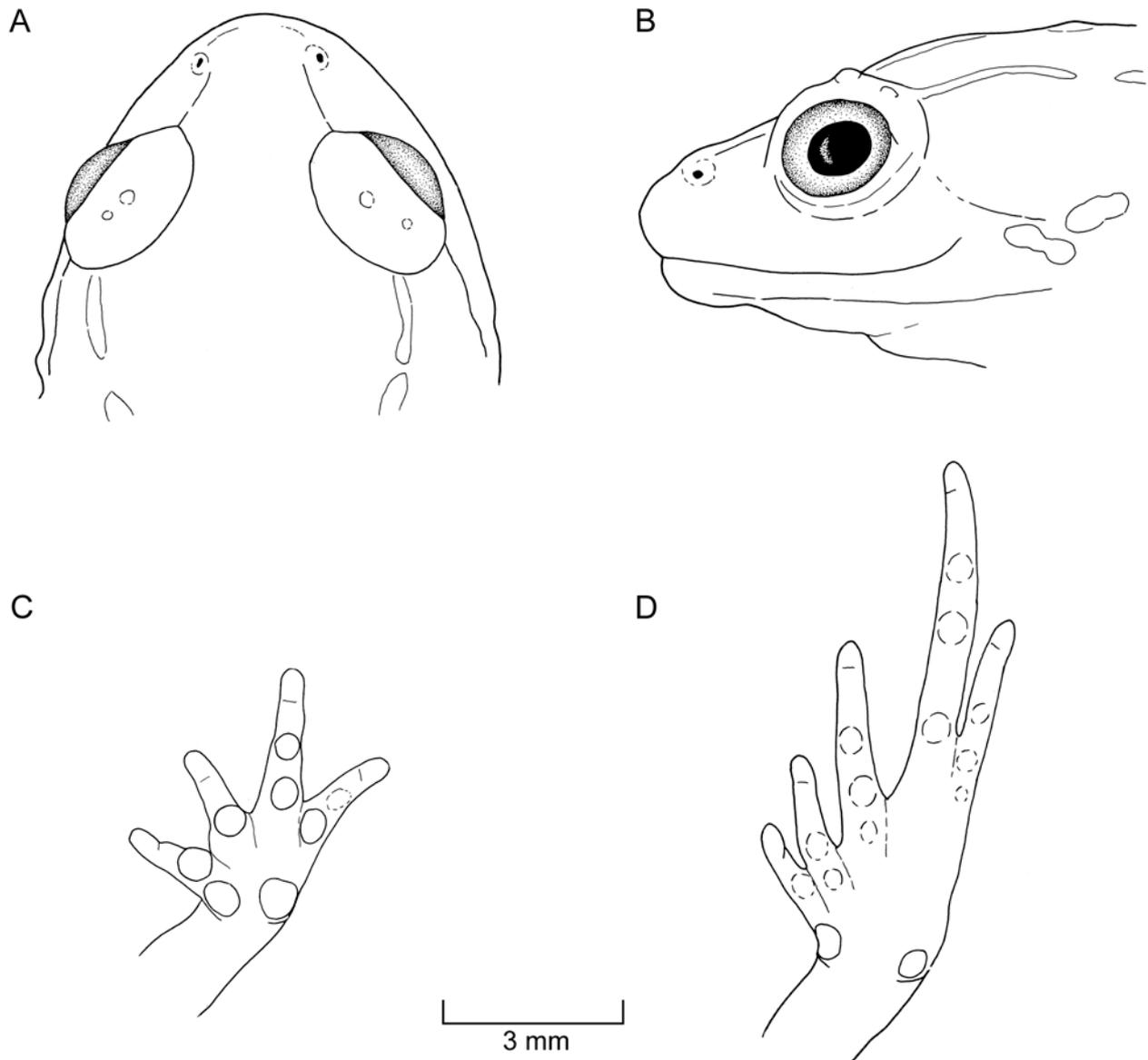


FIGURE 2. Lateral (A) and dorsal (B) views of head and ventral views of hand (C) and foot (D) of *Bryophryne nubilosus* (MUSM 26310).

Bryophryne nubilosus differs from *B. cophites* (Figs. 1E, F) in being smaller (maximum SVL 21.9 mm vs. 29.3 mm: Lynch, 1975), in having prominent dorsolateral folds (absent in *B. cophites*), in lacking nuptial pads (present), and in having the belly dark brown with white spots and blotches (belly dark brown with dark

brown mottling). *Bryophryne nubilosus* is most similar to *B. bustamantei* (see Table 1). Type localities of both species are separated from each other by about 80 km (airline, see Fig. 3) and *B. nubilosus* is known from elevations of 2350–3215 m, whereas *B. bustamantei* occurs at elevations of 3555–3950 m (Chaparro *et al.* 2007). *Bryophryne nubilosus* and *B. bustamantei* have males which lack nuptial pads, but males of *B. nubilosus* lack vocal slits which are present in *B. bustamantei*, and males of *B. nubilosus* are smaller than males of *B. bustamantei* (maximum SVL 18.9 vs. 22.9 mm: Chaparro *et al.* 2007). Furthermore both species have dorsolateral folds, but in *B. nubilosus* the dorsolateral folds are more prominent irregularly shaped and discontinuous (continuous from posterior margin of upper eyelid to sacral region in *B. bustamantei*). In *B. nubilosus* the flanks bear tubercles, whereas in *B. bustamantei* the flanks bear prominent warts. The upper eyelid bears two slightly enlarged tubercles in *B. nubilosus*, whereas upper eyelid tubercles are absent in *B. bustamantei*. Differences in coloration pattern in life are obvious: overall ventral coloration is darker in *B. nubilosus* than in *B. bustamantei*; the throat is dark brown and tan mottled in *B. nubilosus* (yellowish orange in *B. bustamantei*), and the iris is gold with black reticulations (metallic blueish-white with black reticulations in *B. bustamantei*). For comparisons among species of *Bryophryne* see Table 1.

TABLE 1. Selected characters (+ = character present; — = character absent) and character conditions among *Bryophryne*.

Characters and source	<i>B. nubilosus</i> , this paper	<i>B. bustamantei</i> Chaparro <i>et al.</i> , 2007	<i>B. cophites</i> Lynch, 1975
Maximum SVL (mm)	21.9	23.4	29.3
Tympanum	—	Not apparent	—
Dentigerous processes of vomers	—	—	—
Dorsolateral folds	+, discontinuous	+, continuous	—
Vocal sac	—	+	—
Vocal slits	—	+	—
Nuptial pads	—	—	+
Finger I < II	+	+	+

Description of the holotype. Head narrower than body, about as long as wide; head width 38.1% of SVL; head length 38.1% of SVL; snout moderate, acutely rounded in dorsal and lateral views (Figs. 2A, B), eye diameter larger than eye–nostril distance; nostrils slightly protuberant, directed dorsolaterally; canthus rostralis straight in dorsal view, rounded in profile; loreal region slightly concave; lips rounded; upper eyelid with two enlarged, slightly elevated tubercles, one at its middle, the other near posterior margin of upper eyelid; width of upper eyelid narrower than IOD (upper eyelid width 56.0% of IOD); supratympanic fold short, narrow; tympanic membrane and tympanic annulus absent, postrictal tubercles coalescing in two short ridges on each side of head. Choanae small, ovoid, not concealed by palatal shelf of maxilla; dentigerous processes of vomers absent; tongue 2.5× as long as wide, not notched posteriorly, posterior one third free.

Skin on dorsum shagreen, discontinuous, irregularly shaped dorsolateral fold extending from posterior margin of upper eyelid to sacral region; skin on flanks coarsely tuberculate; skin on throat, chest, and belly areolate; discoidal fold absent, thoracal fold present; cloacal sheath short; large tubercles absent in cloacal region. Outer surface of forearm with minute tubercles; palmar tubercles low, outer palmar ovoid, approximately 2× the size of elongate, inner palmar tubercle; few supernumerary tubercles, weakly defined; subarticular tubercles prominent, ovoid in dorsal view, rounded in lateral view, most prominent on basis of fingers; fingers without lateral fringes; Finger I shorter than Finger II; tips of digits rounded (Fig. 2C).

Hind limbs slender, tibia length 41.3% of SVL; foot length 45.0% of SVL; upper surface of hind limbs smooth with small, scattered tubercles; posterior and ventral surfaces of thighs coarsely areolate; heel without

tubercles; outer surface of tarsus with minute tubercles; metatarsal tubercles low, inner metatarsal tubercle ovoid, about the same size as rounded outer metatarsal tubercle; few plantar supernumerary tubercles, weakly defined; subarticular tubercles weakly defined, low, ovoid in dorsal view; toes without lateral fringes, basal webbing absent; toe tips slightly pointed lacking marginal grooves, about as large as those on fingers; relative lengths of toes: $1 < 2 < 3 < 5 < 4$; Toe V longer than Toe III (Fig. 2D).

Measurements (in mm) of holotype: SVL 18.9; tibia length 7.8; foot length 8.5; head length 7.3; head width 7.2; eye diameter 1.8; interorbital distance 2.5; upper eyelid width 1.4; internarial distance 1.8; eye–nostril distance 1.4.

Coloration of holotype in preservative: Dorsum grayish brown with dark brown blotches, discontinuous dorsolateral folds pale grayish brown; each lower arm with one dark brown blotch; hind limbs with dark brown blotches; inner fingers and inner toes cream; dark brown canthal stripe and a dark brown blotch on upper lip below eye; flanks dark grayish brown with white flecks; groin dark brown with white blotches; throat dark brown, chest, belly, and thighs dark brown with white flecks and blotches; hand and fingers nearly entirely cream, feet grayish brown with toes partly cream; iris dark gray.

Coloration of holotype in life (Figs. 1A, B): Dorsum brown with dark brown blotches; dorsolateral folds brown; flanks grayish brown with pale gray flecks; inner fingers and inner toes pale brownish orange; throat mottled of pale and dark brown with pale gray flecks; chest, belly, and thighs dark brown with pale gray flecks; iris greenish gold with black reticulations.

Variation. Males are smaller (Figs. 1C, D) and have the dorsolateral folds more prominent than females. Male specimen MUSM 26317 has the most prominent dorsolateral folds. Males lack vocal slits, nuptial pads and a vocal sac. One female (MUSM 26311) is dorsally nearly entirely dark brown with dorsolateral folds slightly paler and canthal and labial bars are indistinct; the throat is dark brown and the chest, belly, and extremities (without hands and feet) black with pale gray flecks. One subadult male (MTD 47293) has the anterior half of ventral surfaces of thighs and concealed surfaces of shanks brownish orange. One female (MUSM 26312) has three fingers on the right hand, and Fingers I and II on left hand basally are fused. See Table 2 for measurements and Table 3 for ranges and proportions of the type series.

TABLE 2. Measurements (in mm) of *Bryophryne nubilosus*.

Character	MTD 47294	MUSM 26312	MUSM 20970	MUSM 26311	MUSM 26310	MUSM 26316	MTD 47293	MUSM 26317
sex	female	female	female	female	male	male	male	male
SVL	21.9	21.2	20.3	19.8	18.9	14.7	13.2	12.7
TL	8.0	7.7	7.9	7.6	7.8	6.0	6.1	5.5
FL	9.5	8.9	8.1	8.5	8.5	5.9	6.3	5.5
HL	7.2	8.2	7.5	7.9	7.3	5.8	5.5	5.1
HW	7.8	7.4	7.4	7.6	7.2	5.2	4.7	4.9
ED	2.2	2.0	2.1	1.9	1.8	1.8	1.5	1.4
IOD	2.5	2.7	2.4	2.6	2.5	1.8	1.8	1.8
EW	1.6	1.6	1.7	1.6	1.4	1.2	1.1	1.1
IND	2.0	1.8	1.8	2.0	1.8	1.4	1.3	1.5
E–N	1.7	1.7	1.8	1.5	1.4	1.3	1.2	1.1

Distribution and ecology. The new species was found in montane cloud forest and montane scrub at elevations of 2350–3215 m (Fig. 3). The type locality (Esperanza) is a cloud forest growing on the eastern slope of the valley drained by the stream Toqohuayqo, which along with the Pillahuata and Toqoruyoc streams form the Río Cosñipata. The Cosñipata valley is located on the eastern side of the Cordillera de Paucartambo, a

mountain range between the larger Cordillera de Urubamba (to the north) and Cordillera de Vilcanota (to the south). Esperanza is 3 km apart (by air) from the type locality of *B. cophites* (Abra Acanaco). The two congeneric species have not been observed syntopically, because *B. cophites* seems to be confined to grassland and elfin forest habitats above 3300 m. All specimens of *B. nubilosus* were collected in the leaf litter, except for MUSM 20970 that was collected under ground mosses. Based on number of captures in 10 x 10 m leaf litter quadrat plots between 2300 and 3300 m (*B. nubilosus* was absent from quadrat plots below 2300 and above 3300 m), *B. nubilosus* averaged 15.9 ± 7.3 frogs/ha during the 2007 dry season and 40.9 ± 14.3 frogs/ha during the 2008 wet season ($n = 44$ quadrat plots in both 2007 and 2008). Five individuals were found within one single quadrat plot (among 44 sampled plots between 2300 and 3300 m) at 3190 m elevation during the wet season in 1998 (Catenazzi, unpublished data). Quadrat plots where *B. nubilosus* was encountered were located in cloud forest growing on steep slopes (average $28.6 \pm 1.7^\circ$), with a closed canopy ($98.3 \pm 0.3\%$ canopy cover; 15.0 ± 0.6 m canopy height) ranging between 7 and 26 trees of diameter at breast larger than 10 cm (12.3 ± 1.5 trees/100 m²). Ground mosses and bamboos (*Chusquea* sp.) were frequent in these quadrat plots. None of the *B. nubilosus* individuals captured during the 2007 dry season tested positive for *Batrachochytrium dendrobatidis*. Syntopic strabomantid frogs include *Noblella* sp., *Psychrophrynella* sp., *Oreobates lehri* (Padial, Chaparro & De la Riva), and *Pristimantis pharangobates* (Duellman); other syntopic frogs include *Centrolene* sp., *Gastrotheca excubitor*, *Gastrotheca ochoai*, *Hyla antoniihoai* (De la Riva & Chaparro), *Hyloscirtus armatus* and *Telmatobius* sp. (Catenazzi, unpublished data; Catenazzi & Rodriguez 2001). Vegetation of the upper Cosñipata valley includes trees of the genera *Alnus*, *Clethra*, *Weinmannia*, *Clusia*, *Symplocos*, bamboos (*Chusquea*), arboreal ferns (*Cyathea*), terrestrial and epiphytic bromeliads (*Puya*, *Pitcairnia*, *Tillandsia*), ericaceous shrubs, and herbs, vines and epiphytes of the genera *Begonia*, *Bomarea*, *Calceolaria*, *Oxalis* and *Peperomia* (Cano *et al.* 1995).

TABLE 3. Measurements (in mm) and proportions of *Bryophryne nubilosus*; ranges followed by means and one standard deviation in parentheses.

Characters	<i>B. nubilosus</i>	
	Females ($n = 4$)	Males ($n = 4$)
SVL	19.8–21.9 (20.8 \pm 0.8)	12.7–18.9 (14.9 \pm 2.4)
TL	7.6–8.0 (7.8 \pm 0.2)	5.5–7.8 (6.4 \pm 0.9)
FL	8.1–9.5 (8.8 \pm 0.5)	5.5–8.5 (6.6 \pm 1.2)
HL	7.2–8.2 (7.7 \pm 0.4)	5.1–7.3 (5.9 \pm 0.8)
HW	7.4–7.8 (7.6 \pm 0.2)	4.7–7.2 (5.5 \pm 1.0)
ED	1.9–2.2 (2.1 \pm 0.1)	1.4–1.8 (1.6 \pm 0.2)
IOD	2.4–2.7 (2.6 \pm 0.1)	1.8–2.5 (2.0 \pm 0.3)
EW	1.6–1.7 (1.6 \pm 0.0)	1.1–1.4 (1.2 \pm 0.1)
IND	1.8–2.0 (1.9 \pm 0.1)	1.3–1.8 (1.5 \pm 0.2)
E–N	1.5–1.8 (1.7 \pm 0.1)	1.1–1.4 (1.3 \pm 0.1)
TL/SVL	0.36–0.39	0.41–0.46
FL/SVL	0.40–0.43	0.40–0.48
HL/SVL	0.33–0.40	0.39–0.42
HW/SVL	0.35–0.38	0.35–0.39
HW/HL	0.90–1.08	0.85–0.99
E–N/ED	0.77–0.86	0.72–0.80
EW/IOD	0.59–0.71	0.56–0.67

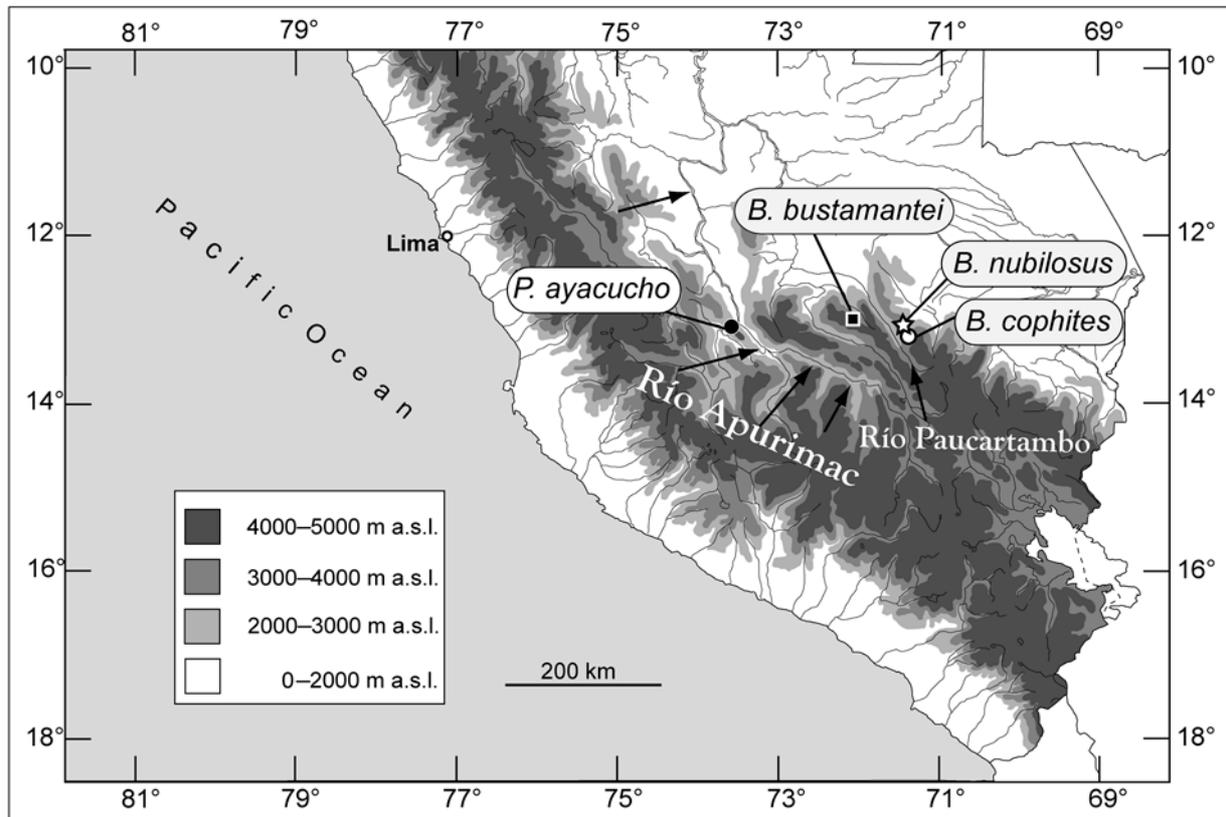


FIGURE 3. Map illustrating the type localities of *Bryophryne cophites*, *B. bustamantei*, and *B. nubilosus* in southern Peru. The Río Paucartambo separates *Bryophryne bustamantei* from *B. cophites* and *B. nubilosus*. Another biogeographic barrier separating *Phrynopus* (*P. ayacucho* is the southernmost known species) from *Bryophryne* is the Río Apurímac as indicated by arrows.

Etymology. The specific name *nubilosus* is the Latin adjective meaning "cloudy", "dull". The name refers to the weather conditions in cloud forests in the eastern Andes.

Discussion. *Bryophryne* contains three species all of which lack a tympanum and dentigerous processes of vomers. These characters are currently synapomorphic, but we think that it is just a matter of time until species with a tympanum and with dentigerous processes of vomers will be discovered. Sixteen species of *Phrynopus* for example lack a tympanum whereas only three have one; and only four species of *Phrynopus* have dentigerous processes of vomers. In a phylogeny based on genetic data species of *Phrynopus* lacking a tympanum formed a clade (Lehr *et al.* 2005, Hedges *et al.* 2008).

Towards southern Peru, the *Phrynopus* species geographically closest to *Bryophryne* is *Phrynopus ayacucho* Lehr 2007. *Phrynopus* and *Bryophryne* as well as *Phrynopus* and *Psychrophrynella* are separated from each other by the deep valley of the Río Apurímac (Fig. 3), which seems to present a significant north-south distributional barrier for Andean herp taxa. This border also separates the two Andean colubrids *Drymoluber apurimacensis* Lehr, Carrillo & Hocking 2004 and *D. dichrous* Amaral, 1930 (Lehr *et al.* 2004). Yet the effect of this barrier on the distribution of amphibians and reptiles has been less documented than what has been done for example for the Huancabamba Depression in northern Peru (e.g., Cadle 1991, Duellman & Wild 1993, Lehr *et al.* 2007). *Psychrophrynella* currently contains 20 species which are distributed in the Cordillera Occidental in southern Peru and Bolivia (Hedges *et al.*, 2008). *Bryophryne* and *Psychrophrynella* differ as follow: tympanic annulus and tympanic membrane absent (present or absent in *Psychrophrynella*), dentigerous processes of vomers absent (present or absent in *Psychrophrynella*), Finger I < II (Finger I shorter, equal or

longer than Finger II in *Psychrophrynella*), nuptial pads present or absent (absent in *Psychrophrynella*), dorsolateral folds present or absent (absent). Continuing fieldwork in southern Peru, especially in the less surveyed of Ayacucho and Apurímac, will likely increase anuran diversity and help to better understand its biogeography.

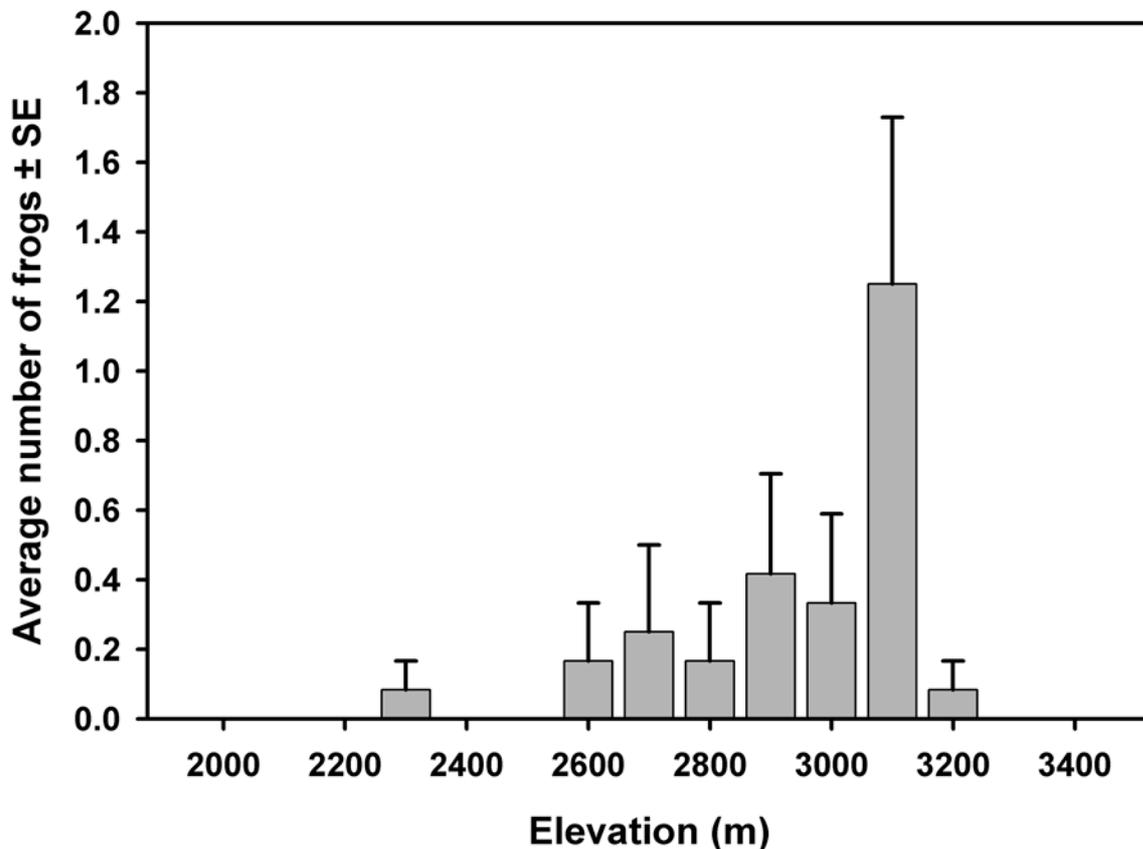


FIGURE 4. Altitudinal distribution of *Bryophryne nubilosus* based on number of individuals captured in 10x10 quadrat plots in the dry season of 2007 and the wet seasons of 1998 and 2008 ($n = 180$ plots between 2000 and 3400 m).

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Appendix: Specimens examined

Bryophryne cophites: PERU: CUSCO: Provincia Paucartambo: Distrito Cosñipata: S slope Abra Acanaco, 14 km NNE Paucartambo, 3400 m: KU 138884 (holotype); N slope Abra Acanaco, 27 km NNE Paucartambo, 3450 m: KU 138885–908, 138911–5 (all paratypes); 2 km NE of Abra Acanaco, 13 11.367' S, 71 36.223' W, 3280 m: MHNG 2698.24.