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## New Species of Marsupial Frog (Hemiphractidae: *Gastrotheca*) from an Isolated Montane Forest in Southern Peru

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**ABSTRACT.**—We describe a new species of marsupial frog (genus *Gastrotheca*) from an isolated patch of cloud forest in the upper reaches of the Pachachaca River, a tributary of the Apurímac River in southern Peru (Apurímac Region). The new species is small with males less than 30 mm and a single female 35.3 mm in snout–vent length. A juvenile was collected from inside an epiphytic bromeliad at ~3 m, suggesting that this species is arboreal or uses bromeliad tanks as microhabitats. We describe the advertisement call, which has a dominant frequency above 2.2 kHz. Based on morphology and advertisement call, the new species is most similar to *Gastrotheca piperata* described from the Yungas of Bolivia. The new species differs from *G. piperata* by having smaller size, no dermal fold on the tarsus, a bluntly rounded to vertical snout in profile, gray coloration on dorsal surfaces of Fingers I and II and by producing advertisement calls that have a higher dominant frequency and a smaller number of pulses.

**RESUMEN.**—Describimos una nueva especie de rana marsupial (género *Gastrotheca*) de un parche aislado de bosque nublado en las nacientes del río Pachachaca, un afluente del río Apurímac en el sur de Perú (Región Apurímac). La nueva especie es pequeña, con machos que miden menos de 30 mm y una hembra 35.3 mm en longitud hocico–cloaca. Un juvenil fue capturado dentro de una bromelia epífita a una altura de ~3 m, lo cual sugiere que esta rana es arbórea o usa las bromelias como microhábitats. Describimos el canto nupcial, cuya frecuencia dominante es de más de 2.2 kHz. En base a morfología y canto nupcial, la nueva especie se asemeja más a *Gastrotheca piperata* descrita de las Yungas de Bolivia. La nueva especie se diferencia de *G. piperata* por su menor tamaño, ausencia de pliegue tarsal, hocico redondeado o vertical en vista lateral, coloración gris en la superficie dorsal de los dedos I y II y por producir un canto nupcial con frecuencia dominante más alta y menor número de pulsos.

Biological inventories and phylogenetic and taxonomic research in the cloud forests of southeastern Peru over the past decade have led to the description of many new species of amphibians (Lehr and Catenazzi, 2008, 2009a,b). These recent discoveries point to the exceptional diversity of montane and high-elevation taxa in the eastern slopes of the Andes. Beta diversity of montane taxa is likely to be much higher than currently known, and as new inventories are conducted, we predict that many additional species will be discovered. These discoveries will help us better understand patterns of species abundance and distribution in relation to the heterogeneous environment of the eastern cordilleras and inter-Andean valleys of southern Peru.

The herpetofauna of the Apurímac region is poorly known. The west and central portions of this region are dominated by species that have a wide geographic distribution in the puna and other high-elevation habitats of the Peruvian Altiplano, such as *Gastrotheca marsupiata*, *Pleurodema marmoratum*, and *Tachymenis peruviana*. However, the eastern portion of the Apurímac Region has more species, several of which are endemic. The inter-Andean dry valleys of the Apurímac canyon and of its tributaries, for example, are inhabited by two endemic squamates, the lizard *Stenocercus apurimacus* and the snake *Drymoluber apurimancesis* (Lehr et al., 2004). These valleys often present heterogeneous environments, from dry, scrublike vegetation in places where the cordilleras function as rain shadows, to cloud forests where local topography intercepts moisture and favors the formation of fog. Many of these habitats are difficult to access and are poorly known biologically.

Based on museum collections, *G. marsupiata* is the only marsupial frog that has been reported previously from Apurímac. William E. Duellman collected a series of this species in four locations between Abancay and Huancavelica (voucher specimens at the Museum of Natural History,

University of Kansas; Appendix 1). After examining these specimens, and after comparisons with other similar species known to occur between central Peru and Bolivia, we conclude that specimens of a *Gastrotheca* we collected in an isolated montane forest in northern Apurímac belong to an unnamed species. Here we describe this new frog.

### MATERIALS AND METHODS

We follow Wiens et al. (2005) for taxonomy and Duellman et al. (2001, 2004) for the format of the revised diagnosis. Specimens were preserved in 10% formalin and stored in 70% ethanol. Measurements were taken with calipers under a Leica GZ7 dissecting microscope and rounded to the nearest 0.1 mm. Drawings of hand and foot were made by using a camera lucida attached to a Wild Heerbrugg dissecting microscope. We took the following measurements: snout–vent length (SVL), tibia length, foot length (distance from proximal margin of inner metatarsal tubercle to tip of Toe IV), head length (from angle of jaw to tip of snout), head width (at level of angle of jaw), eye diameter, tympanum diameter, interorbital distance, upper eyelid width, internarial distance, eye–nostril distance (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. We determined webbing formula by following the method proposed by Savage and Heyer (1967) and modified by Myers and Duellman (1982).

We deposited specimens in the herpetological collection of the Museo de Historia Natural, Universidad Nacional Mayor de San Marcos (MUSM) in Lima, Peru and compared them with material deposited in the Natural History Museum at the University of Kansas (KU), the Museum of Vertebrate Zoology, University of California at Berkeley (MVZ), MUSM, and the Field Museum of Natural History (FMNH). Photographs taken by A. Catenazzi were used for descriptions of color in life and are available for all types at the Calphoto online database (<http://calphotos.berkeley.edu>). Locality names follow the

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spelling of the U.S. Board on Geographic Names (<http://gnswww.nga.mil>) and, for localities not listed in this database, according to the Carta Nacional, Instituto Geográfico Nacional, Lima. For specimens examined, see Appendix 1.

We recorded advertisement calls of male MUSM 28490 at the type locality on 17 January 2009. The air temperature during recording was 12.0°C. We used a directional microphone (Azden SMX-10) mounted on a digital recorder (Zoom H2, recording in uncompressed .wav format). We used Cool Edit recording 96 (Syntrillium Software Corporation) and Raven Lite, version 1.0 (Cornell Laboratory of Ornithology) to resample recordings and analyze call variables. We resampled and edited vocalizations at a sampling frequency of 44 kHz, FFT width 512 points, and 16-bit resolution. The Hamming window function for the spectrogram was set at 256 bands. Averages are reported  $\pm$  SD. We analyzed a total of 25 calls. We described the call by following the terminology proposed by Heyer et al. (1990).

*Gastrotheca pachachacae* sp. nov.  
Figures 1–3

*Holotype*.—MUSM 28489, adult female. Collected on 17 January 2009 at 2030 h in Chinchay, District of Pacobamba, Province Andahuaylas, *Región* Apurímac (formerly *Departamento*), coordinates 13°32'47"S, 73°6'11"W, elevation 3,050 m a.s.l., by A. Catenazzi, R. von May, J. C. Jahuanchi, and C. Quispe.

*Paratopotypes*.—Three; two males and one juvenile. MUSM 28490, adult male, collected on 17 January 2009. MUSM 28491, adult male collected on 20 January 2009 while calling from a tree. MUSM 28492, juvenile collected from inside a bromeliad at ~3 m height on 17 January 2009.

*Diagnosis*.—Adults of this small species of *Gastrotheca* are characterized by (1) snout–vent length of 28.7–29.2 mm in males ( $N = 2$ ) and 35.3 mm for a single female, tibia length 49.6–50.5% of the snout–vent length and 101.2–102.8% of the foot length; (2) interorbital distance about 1.18 times larger than width of upper eyelid; (3) skin on dorsum tuberculate, not coossified with skull, lacking transverse ridges; (4) supraciliary processes absent; (5) heel bearing small calcar and ulnar tubercles; (6) tympanic annulus distinct, smooth; (7) Finger I slightly shorter than Finger II, disc width on Finger III 137.5–155.6% of digit width and 61.1–70.0% of tympanum diameter; (8) fingers unwebbed; (9) webbing extending to maximally to point midway between preantepenultimate and antepenultimate subarticular tubercles on Toe IV, to point midway between antepenultimate and penultimate subarticular tubercles on Toe V; (10) dorsum pale brown to golden without dark markings, except for few small flecks; (11) head markings consisting of a short and pale labial stripe in the female and one male (absent in one male), interorbital bar absent; (12) pale dorsolateral stripe absent; (13) flanks as dorsum or pale with dark flecks, bluish with green tones in the axillary and inguinal regions; (14) venter cream without markings.

The recent generic allocation of *Hyla antoniiochoai* to *Gastrotheca* (Catenazzi and Lehr 2009) and this description bring the number of *Gastrotheca* species known from Peru (21 species) and Bolivia (6 species) to 26 (Köhler, 2000; Duellman and Köhler, 2005; Frost, 2010). Among these species, 17 occur in the Andes from central Peru to Bolivia and are considered for this diagnosis. *Gastrotheca testudinea* differs from all congeners by its large size, presence of tubercle on the heel, and by having finger I > II. *Gastrotheca antoniiochoai* and *Gastrotheca zeugocystis* differ from all others by having lateral brood pouches, whereas *Gastrotheca atympana* is unique in lacking a tympanic membrane, annulus, and stapes, *Gastrotheca splendens* in having the skin coossified with the head and webbing between the outer fingers, and *Gastrotheca cariniceps* in having prominent cranial crests. *Gastrotheca ochoai* has an acuminate snout in dorsal view (rounded in *G. pachachacae*)

and a bifid palmar tubercle (indistinct); in addition, this species along with *Gastrotheca chrysostricta* and *Gastrotheca rebecca* have discs that are proportionally wider than in *G. pachachacae*, in which the disc of the third finger is only slightly wider than the distal end of the penultimate segment of the digit. The first finger is slightly shorter than the second in *G. pachachacae*, whereas these two fingers are equal in length in *Gastrotheca pacchamama*; moreover, the latter species has a snout strongly projecting beyond the margin of the lower jaw. In *G. chrysostricta*, *Gastrotheca excubitor*, *Gastrotheca ochoai*, *G. pacchamama*, and *G. rebecca*, the interorbital distance is >150% the width of the upper eyelid (114.3–122.2% in *G. pachachacae*). *Gastrotheca excubitor*, *Gastrotheca gracilis*, *Gastrotheca griswoldi*, *Gastrotheca lauzuricae*, and *Gastrotheca marsupiata* have interorbital or T-shaped marks, which are absent in *G. pachachacae*; furthermore, these species as well as *Gastrotheca peruana* have dorsal blotches or broad middorsal or parallel stripes (no dorsal marks or few and small flecks in *G. pachachacae*). *Gastrotheca gracilis* further differs in having a large trifold palmar tubercle, *G. griswoldi* in having feet longer than tibia, *G. peruana* in having pustular skin on dorsum and a protruding snout in profile. *Gastrotheca pachachacae* is similar to *G. piperata* in having similar interorbital distance to eyelid width ratio and in lacking a dark interorbital bar or T-shaped mark, but the latter is larger (up to 36.3 mm in males, 46.8 mm in females) and further differs (characters for *G. pachachacae*) in having a bluntly rounded snout in profile (bluntly rounded to vertical), yellow coloration on dorsal surfaces of Fingers I and II (gray), skin on dorsum smooth to finely tuberculate (tuberculate), fine black flecks on dorsum (dorsum without markings except for few small flecks), heel lacking calcar and ulnar tubercles (small tubercles present) and in having a dermal fold on the tarsus (absent). *Gastrotheca pachachacae* further differs from *G. griswoldi*, *G. marsupiata*, *G. peruana*, and *G. piperata* by producing advertisement calls that have a higher dominant frequency (above 2.2 kHz in *G. pachachacae* vs. frequencies below 2.1 kHz) and a number of pulses larger than in *G. marsupiata* but smaller than in *G. griswoldi*, *G. peruana*, and *G. piperata*.

*Description of the Holotype*.—An adult female; body moderately robust; head width 105% of head length; head length 34% of SVL; snout rounded in dorsal view and bluntly rounded to vertical in profile; canthus rostralis rounded in section; loreal region concave; lips slightly flared and rounded; top of head flat; interorbital distance 118% of width of upper eyelid; internarial area flat; nostrils slightly protuberant, directed anterolaterally at level of anterior terminus of canthus rostralis; diameter of eye 95% of the distance from eye to nostril; tympanum round, diameter 53% of eye diameter; tympanic annulus distinct, smooth; supratympanic fold distinct, tuberculate, extending from posterior corner of eye to point above insertion of arm, partially concealing the upper posterodorsal part of tympanum.

Arm moderately robust; ulnar tubercles absent; hand moderately large, about one-third of SVL; fingers unwebbed; discs relatively small, broadly rounded; width of Finger III about two-thirds of diameter of tympanum; relative lengths of fingers I < II < IV < III; subarticular tubercles large, subconical, none bifid; supernumerary tubercles smaller than subarticular tubercles, subconical, present only on proximal segments; palmar tubercle indistinct; prepollical tubercle elongate, elliptical. Hind limb moderately slender; tibia length 50% of SVL; foot length 49% of SVL; heel lacking calcar or tubercle; tarsus lacking dermal fold; outer metatarsal tubercle small and round; inner metatarsal tubercle elongated, elevated and visible from above; toes slender; relative length of toes I < II < III < V < IV; toes less than one-fourth webbed; webbing formula  $I2\frac{1}{2} - 2\frac{1}{2}II2 - 3^+III3^- - 3\frac{1}{2}IV3^+ - 2\frac{1}{2}V$ ; subarticular tubercles about the size or slightly smaller than those on



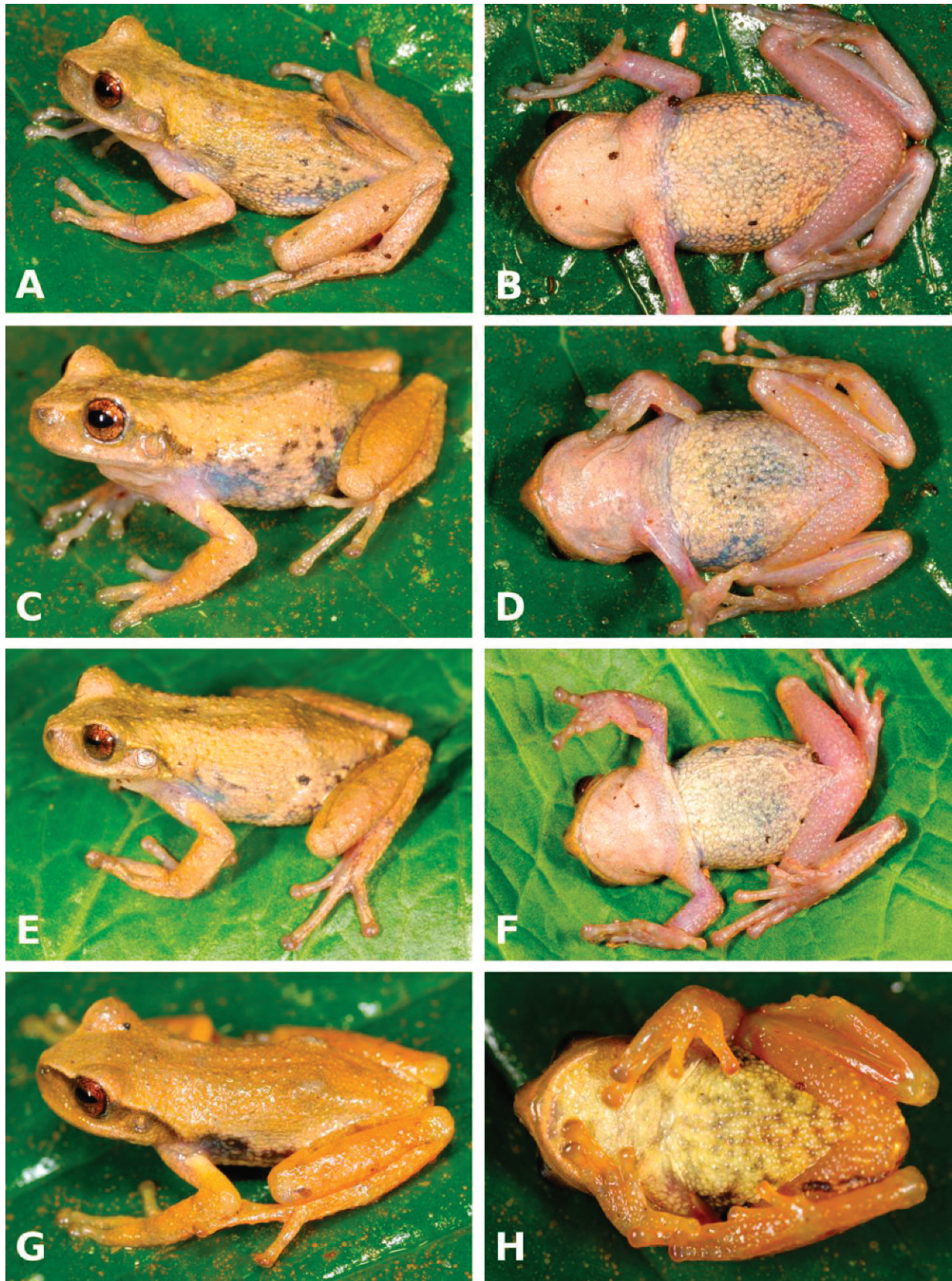


FIG. 1. Live types of *Gastrotheca pachachacae*: female MUSM 28489 (holotype, SVL 35.3 mm) in lateral (A) and ventral views (B); male MUSM 28490 (SVL 28.7 mm) in lateral (C) and ventral (D) views; male MUSM 28491 (SVL 29.2 mm) in lateral (E) and ventral (F) views; and juvenile MUSM 28492 (SVL 18.9 mm) in lateral (G) and ventral (H) views. Photos by A. Catenazzi. Color reproduction supported by the Thomas Beauvais Fund.



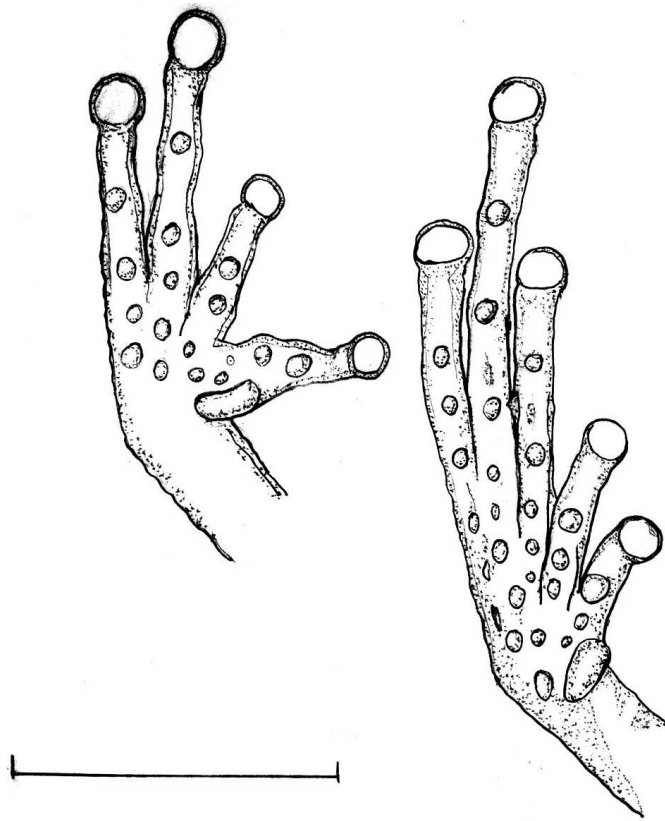


FIG. 2. Palmar surfaces of right hand and plantar surface of right foot of the holotype of *Gastrotheca pachachacae*, MUSM 24489. Scale bar = 10 mm. Drawing by R. von May.

fingers, subconical; supernumerary tubercles small, subconical, present only on proximal segments.

Skin on dorsal surfaces finely tuberculate, including dorsum, head, upper eyelids, and supratympanic folds; skin on flanks, belly and posteroventral surfaces of thighs granular; cloacal tubercles present. Pouch opening U-shaped with anterior border posterior to level of sacrum. Vomerine odontophores transverse and narrowly separated medially at level slightly behind the posterior margin of small and ovoid choanae; 3–4 odontophores visible on each side.

Dorsum gray with few small dark flecks, dorsal surfaces of limbs pale brown with transverse bars on thighs and shanks barely noticeable. Dorsal coloration extends onto the fourth finger and fifth toe only; dorsal coloration of other digits is cream. Flanks gray to pale brown with black flecks. Perianal

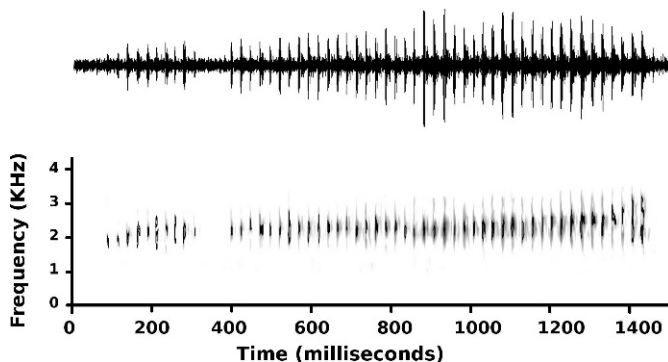


FIG. 3. Spectrogram and oscillogram of the advertisement call of *Gastrotheca pachachacae* (male MUSM 28490, SVL 28.7 mm) from Chinchay, Pacobamba, Apurímac. Recorded on 17 January 2009 at 2105 h, air temperature 12.0°C.

TABLE 1. Measurements of male and female *Gastrotheca pachachacae*. All measurements are in millimeters.

Character	MUSM 28489	MUSM 28490	MUSM 28491
	Female	Male	Male
Snout-vent length	35.3	28.7	29.2
Tibia length	17.5	14.5	14.5
Foot length	17.3	14.3	14.1
Head length	11.5	10.0	10.2
Head width	12.0	10.6	10.7
Eyelid width	3.5	2.7	2.9
Interorbital distance	4.0	3.3	3.4
Eye width	3.6	3.4	3.5
Internarial distance	1.9	1.7	1.8
Eye-nostril	4.2	3.4	3.5
Orbit-jaw	1.5	1.3	1.3
Nostril-jaw	2.6	2.0	2.2
Tympanum diameter	2.0	1.8	1.8
Thumb length	6.5	5.0	5.3
Third finger length	11.2	9.4	9.5
Third finger disc width	1.4	1.1	1.2
Third finger width	0.9	0.8	0.8

tubercles white. Venter surfaces cream. Canthal and supratympanic stripes diffuse dark brown, bordered with cream. Tympanum brown. Margin of upper lip like snout (brown to pale brown), except for a diffuse, cream stripe below the eye.

Dorsal surfaces of head and body pale brown to golden, with few small dark flecks and no interorbital bar (Fig. 1A). The middle part of the flanks is similar in coloration to the dorsum but have dark flecks, whereas the axillary and inguinal regions have diffuse bluish coloration with green tones. The venter is cream without marks; the ventral surfaces of limbs are pink (Fig. 1B). The canthal and supratympanic stripes are diffuse and dark brown, bordered with cream. The tympanum is brown. The margin of the upper eyelid is cream. The iris is bronze with black reticulations and the eye periphery is black. The bones are white. Color photographs of the living holotype are available online in the photographic database Calphotos (<http://calphotos.berkeley.edu>).

*Measurements of Holotype.*—All measurements are in millimeters: SVL 35.3, tibia length 17.5, foot length 17.3, head length 11.5, head width 12.0, interorbital distance 4.0, upper eyelid width 3.6, internarial distance 1.9, eye diameter 3.5, eye-nostril distance 4.2, tympanum diameter 2.0, orbit-jaw distance 1.5, nostril-jaw distance 2.6, thumb length 6.5, third finger length 11.2, diameter of disc on third finger 1.4 (Table 1).

*Variation.*—The only female is larger than the two males. This female has some immature ovarian eggs. The edges of the brood pouch opening are distinct, but the pouch is closed, indicating that this female has not reproduced before. The two males have distinct nuptial pads on the prepollical tubercle; the pads are brown in MUSM 28490 and pale brown in MUSM 28491. The juvenile specimen has a darker iris and the coloration has yellowish tones on the posterior half of the dorsum and on the dorsal and ventral surfaces of hind limbs; the venter is cream with diffuse dark spots. Proportions for the three adult types are tibia length/SVL 48.3–50.5%, foot length/SVL 48.3–49.8%, head length/SVL 32.6–34.9%, head width/SVL 34.0–36.6%, interorbital distance/eyelid width 114.3–122.2%, diameter of tympanum/diameter of eye 51.4–55.6%, diameter of eye/eye-nostril distance 85.7–100.0%, width of disc on Finger III/diameter of tympanum 61.1–70.0% (Table 1).

*Advertisement Call.*—The advertisement call consisted of a long note  $1,294.4 \pm 132.3$  ms (range 956–1,476 ms) in duration with  $48.9 \pm 5.2$  pulses (range 39–58 pulses). Pulse rate average  $37.9 \pm 2.8$  Hz (range 27.6–40.9 Hz). We did not record any secondary notes (in many *Gastrotheca*, one or more single-pulsed short notes follow the long note), but this might be attributable to the short time we spent in the field and the low

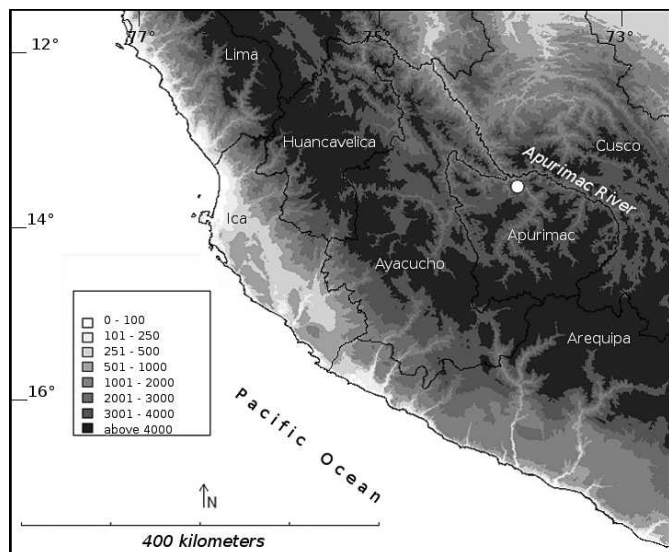


FIG. 4. Map showing the type locality of *Gastrotheca pachachacae* in southern Peru. Lines indicate boundaries of *Regiones* (formerly *Departamentos*).

number of calls we recorded (Fig. 2,  $N = 25$  calls of male MUSM 28490, recorded around 1900 with  $T_{\text{air}} = 12.0^{\circ}\text{C}$ ). Intervals between calls averaged  $3,740.4 \pm 1,147.6$  ms (range 2,370–7,201 ms), and call frequency averaged  $11.2 \pm 2.3$  calls/min (range 8.9–13.4 calls/min). Fundamental frequency ranged between 2,173 and 2,438 Hz (median 2,279 Hz). The call had consistent amplitude and frequency modulation: the first 7–10 pulses were lower in amplitude and the fundamental frequency gradually rose from 1,696–1,908 Hz (first pulse, median 1,855 Hz) to 2,120–2,279 Hz (pulses 7–10, median 2,200 Hz).

**Distribution and Ecology.**—*Gastrotheca pachachacae* is known only from the type locality in the Chinchay cloud forest of Pacobamba district, Apurímac region at approximately 3,000 m a.s.l. (Fig. 4). The area can be accessed by trail crossing the pass of Rumi Cruz (3,800 m a.s.l.) from the nearby town of Ccerabamba-Andina. The cloud forest covers approximately 2,000 ha of steep slopes in the upper watershed of a tributary of the Pachachaca River, north of the Apurímac River (J. Baiker, pers. comm.). This forest is bound at 2,200 m a.s.l. by the transition to the dry forest of the Pachachaca Canyon and at 3,800 m a.s.l. by ridges separating the moist and forested watershed from the drier surrounding puna. The cloud forest is a naturally isolated patch whose extension is restricted to the upper slopes of the Pachachaca watershed. This upper watershed is shaped like a gigantic amphitheater exposed to the east, which presumably promotes local rainfall by rapid cooling of warm air masses ascending from the Apurímac valley and by trapping moisture.

All individuals of *G. pachachacae* were found at night on vegetation 1.5–3 m above the ground, suggesting that it is a nocturnal and arboreal species. Male MUSM 28490 was calling perched on *Chusquea* sp. bamboo, the female was on the branch of a nearby tree, and the juvenile was found on a bromeliad leaf axil at approximately 3 m above the ground. Many arboreal bromeliads were found in the area, but it is unknown whether adults use them as retreat sites. Melastomataceae is the most abundant of at least 61 plant families recorded in the forest (J. Baiker and C. Reynel, pers. comm.). Although in many respects the forest looks relatively undisturbed and the vegetation structure is similar to that encountered in other cloud forests, we found a paucity of leaf litter invertebrates and herpetofauna when sampling leaf litter quadrant plots. Invertebrates were dominated numerically by millipedes, and we found no frogs in eight  $10 \times 10$  m leaf litter plots. Strabomantid frogs are common in the leaf litter around 3,000 m a.s.l. in other cloud forests of

southern Peru (Catenazzi and Rodriguez, 2001; Lehr and Catenazzi, 2009a; Catenazzi et al., 2011); its absence at Chinchay suggests that the surrounding drier habitats could be an effective barrier to the colonization of the cloud forest by these frogs. No other anurans were observed during our expedition to the type locality, but a small strabomantid, most likely a *Pristimantis* sp., has been photographed by J. Baiker in May 2008 at 1,450 m a.s.l., in the dry valley of the Pachachaca River.

**Etymology.**—The specific name alludes to the type locality of this frog, an isolated patch of cloud forest drained by an affluent of the Pachachaca River.

## DISCUSSION

Only one species of marsupial frog had previously been reported from the Apurímac region of southern Peru, based on a series of *G. marsupiata* from four high-elevation sites between Abancay and Huancavelica. These specimens were slightly larger (average SVL  $31.3 \pm 3.6$  mm in 16 males) and had proportionally shorter shanks (tibia length/SVL 40.7–47.8%, mean  $\pm$  SD =  $44.3 \pm 2.0\%$ ) than *G. pachachacae* and feet longer than shanks (foot length/tibia length 101.6–108.3%, mean  $\pm$  SD =  $104.0 \pm 2.1\%$ ; foot length less than tibia length in *G. pachachacae*). Moreover, these *G. marsupiata* specimens had the characteristic T-shaped interorbital bars and dorsal markings, which are absent in *G. pachachacae*. Finally, all the *G. marsupiata* specimens were collected in puna and other high-Andean grassland habitats, whereas specimens of *G. pachachacae* were collected in a cloud forest with continuous canopy cover.

The advertisement call of *G. pachachacae* is similar to that known for species in the *G. marsupiata* group (Sinsch and Juraske, 2006), after comparing call variables that do not vary with temperature (Sinsch and Joermann, 1989). Of these variables, fundamental frequency of *G. pachachacae* is higher than what has been recorded in species evaluated by Sinsch and Juraske (2006), possibly because of the smaller size of the new species. The number of pulses was intermediate between that of *G. marsupiata* and *G. piperata* (and most similar to *Gastrotheca pseustes*, a form that is not morphologically similar to *G. pachachacae*). Other call variables are difficult to compare because our recordings are restricted to air temperatures of  $12^{\circ}\text{C}$ . Of these, call duration seemed to be most similar to *Gastrotheca griswoldi* and *G. piperata*. Additionally, intervals between calls in *G. pachachacae* were much longer than what measured for the species exhibiting the longest intervals (*G. piperata*; Sinsch and Juraske, 2006). Overall, the call structure appears to be most similar to that of *G. piperata*, a species with which *G. pachachacae* also shares morphological similarities.

The relationship of the new species to congeners is presently unknown, but morphological and bioacoustic similarities between *G. pachachacae* and members of the *G. marsupiata* group suggest inclusion of *G. pachachacae* in this group. Morphologically, the new species seems to be most similar to the larger *G. piperata* from Bolivia, which lives in montane forests on the eastern slopes of the Andes. Most species of *Gastrotheca* inhabiting montane forests have embryos that undergo direct development (Duellman and Maness, 1980; Duellman et al., 2001). A species recently discovered from southern Peru, *G. antoniiochoai*, inhabits the cloud forest between 2,800 and 3,300 m a.s.l. and is thought to undergo direct development based on the small number and large size of eggs females carry in their lateral pouches (Catenazzi and Lehr, 2009). In the closely related *G. piperata*, eggs hatch as tadpoles and are released from the female's pouch at Gosner stages 35 and 37 (Duellman and Köhler, 2005). Our finding of only one female of *G. pachachacae* with a dorsal pouch lacking eggs or embryos did not enable us to determine whether this species also exhibits direct development.

The isolated cloud forest where we found *G. pachachacae*, along with the surrounding dry forest and puna, represents an



important habitat for the threatened Andean bear (*Tremarctos ornatus*) and other native animal and plant species (Baiker, 2008). Land and forest conservation efforts are currently being promoted by local authorities and other community members and by the Programa Regional ECOBONA-INTERCOOPERATION. However, the area still requires formal protection under Peruvian law.

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#### APPENDIX 1

##### Additional Specimens Examined

*Gastrotheca antoniiochoai*.—PERU: Cusco: Paucartambo: near Quebrada Toqoryuoc, Wayqecha Research Center, Cosñipata Valley, Provincia de Paucartambo, Región de Cusco, Peru, 13°11'21.0"S, 71°35'05.5"W, 2,845 m, MHNC 0068 (photo of live holotype); Paucartambo–Shintuya road, Wayqecha Research Center, 13°11'07.8"S, 71°35'18.5"W, 2,950 m, MUSM 27944–49.

*Gastrotheca excubitor*.—PERU: Cusco: Paucartambo: north slope of Abra Acanacu, 31 km north-northeast of Paucartambo, 3,370 m, KU 139194 (holotype) and KU 139195–139196 (paratypes); 33 km north-northeast of Paucartambo, KU 139193 (paratype); 29 km north-northeast of Paucartambo, KU 139198 (paratype); Abra Acjanaco, MUSM 27934–27935, 27872–27874, KU 139199–139201 (paratypes).

*Gastrotheca griswoldi*.—PERU: Junín: Maraynioc, 72 km northeast of Tarma, KU 137583–137587 (paratypes); 6 km east-northeast of Paccha, 3,840 m, KU 181701–181720; 3 km west-southwest of Huaricolca, 3,890 m, KU 181721–181723; Huaropampa, Río Mantaro, 3,540 m, KU 181724; 32 km southeast of La Oroya, 3,600 m, KU 181725–181726; 14 km southwest of La Oroya, 4,020 m, KU 181727–181728.

*Gastrotheca marsupiata*.—PERU: Cusco: Paucartambo: Tres Cruces, 18 km north of Paucartambo, 3,670 m, MVZ 57804; 14.5 km south of Paucartambo, 3,450 m, KU 139187–139188. Cusco: San Jerónimo, 3,150 m, KU 204007–20411. Apurímac, 39 km northeast of Abancay, 3,900 m, KU 163219–163228; 70 km west of Abancay, 3,760 m, KU 163229–163231; 35 km west of Andahuaylas, 3,720 m, KU 163232–163245; Abra Soracococha, 4,080 m, KU 163246–163248. Ayacucho: 38 km south of Ayacucho, 3,710 m, KU 163249–163250; 7 km north of Mahuayura, 3,710 m, KU 163251–163252; 31 km southwest of Ayacucho, 3,720 m, KU 163253; 18 km east of Niñobamba, 3,570 m, KU 163254–163269.

*Gastrotheca ochoai*.—PERU: Cusco: La Convención: Chilca, 10 km north of Ollantaytambo, 2,760 m, KU 139202 (holotype), KU 138631–138635, 138645–138658, 139203–139209 (paratypes); along Río Marcapata below Marcapata, approximately 2,745 m, KU 196951–196952.

*Gastrotheca pacchamama*.—PERU: Ayacucho: north slope Abra Tapuna, 7 km north of Mahuayura, 3,710 m, KU 163288 (holotype), KU 163279–163287, KU 163289–163301 (paratypes).

*Gastrotheca peruana*.—PERU: Junín: Ondores, 4,115 m, KU 207815; between Casa Pato and Anascancha, approximately 10 km south of Carhuamayo, KU 139189–139190. Huánuco: 5 km northeast of La Union, KU 138411–138452.

*Gastrotheca piperata*.—BOLIVIA: Santa Cruz: Empalme, KU 291622–291624 (paratypes).

*Gastrotheca rebecca*.—PERU: Ayacucho: 7.5 km southwest of Cano, 2,970 m, KU 163302–163303, 196800; Yuraccyacu, on Tambo-Valle del Apurímac path, approximately 2,620 m, KU 196801–196805; Ccarapa, below Tambo on Valle del Apurímac road, approximately 2,440 m, KU 196806–196811; Ayacucho: La Mar, FMNH 39877 (Field No. 450, 451, 453) and FMNH 39878 (Field No. 456, 459, 463).

*Gastrotheca testudinea*.—PERU: Cusco: Paucartambo: Paucartambo–Shintuya road, MUSM 27942–27943; 4 km southwest of Santa Isabel, Río Cosñipata, 1,700 m, KU 163270. Ayacucho: Río Piene, Tutumbaro, 1,840 m, KU 163271–163274, 163276–163278.

*Gastrotheca zeugocystis*.—PERU: Huánuco: Cordillera de Carpish, 2,920 m, MUSM 18675 (holotype), MTD 45984 (C&S).