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AN AQUATIC PLETHODONTID SALAMANDER FROM OAXACA, MEXICO

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ABSTRACT: We describe a new species of *Pseudoeurycea* from the northern versant of the state of Oaxaca, Mexico. This is the only aquatic species of bolitoglossine salamander known. Besides its aquatic behavior, this species differs from congeners by having very long legs, a triangular shaped head with nostrils that can be completely closed, and relatively few maxillary teeth. This remarkable new species of salamander may have become extinct over two decades ago.

Key words: Amphibia; Caudata; Plethodontidae; *Pseudoeurycea aquatica*; New species; Sierra Mixes; Oaxaca; Mexico

THE lungless salamanders (family Plethodontidae) have achieved high species diversity in Middle America, where more than 150 species occur. All of these species are fully terrestrial and as far as is known all of them lay eggs in terrestrial or arboreal habitats. These eggs develop directly, without a larval stage, and following a long embryonic period, hatchlings emerge that are miniatures of the adults. There are many aquatic and semiaquatic plethodontids, but all of them have larvae and all belong either to the subfamily Desmognathinae or the tribe Hemidactyliini of the subfamily Plethodontinae, neither of which occur south of the United States (Wake, 1966). The tropical plethodontids all are members of the tribe Bolitoglossini of the subfamily Plethodontinae. Here we report the discovery of a remarkable new aquatic species from the mountains of northern Oaxaca, Mexico, that appears to be morphologically specialized for aquatic life, although it lacks any obvious features such as gills or folds of loose skin that are found in other aquatic salamanders.

MATERIALS AND METHODS

We have employed the terminology and measurements described by Wake (1966) and Lynch et al. (1983). Measurements were made using digital calipers held under a dissecting microscope and rounded to 0.1 mm. All measurements of specimens are given in millimeters; standard

length is abbreviated to SL. Sex of specimens was determined by presence of secondary sexual characteristics (development of nasal cirri, mental gland, and cloacal lips). The color of living individuals is described from field notes and color transparencies on file at The University of Texas at Arlington. For purposes of habitat description, we recognize the vegetation associations described by Leopold (1950). Specimens were fixed in buffered formalin (diluted to 10% of stock solution) and transferred to 70% ethanol for permanent storage.

This new species was discovered many years ago, and it has not been observed since the type-series was first collected in April 1978. We have delayed description in the hope of obtaining fresh material which could be studied genetically, but as our hope has faded we have decided to present the description at this time. The new species will be known as:

Pseudoeurycea aquatica sp. nov.

Holotype.—UTA A-5773 (Fig. 1) (original field no. JAC 3426), an adult male from 5.8 km (by road) W Totontepec, Oaxaca, Mexico, 2103 m (17° 14' 24" N, 96° 03' 36" W), collected by J. A. Campbell during the night of 4–5 April 1978.

Paratypes.—UTA A-5772, same data as holotype; MVZ 230728 (formerly UTA A-5834), same locality as holotype, collected during the night of 8–9 April 1978.



FIG. 1.—*Pseudoeurycea aquatica*, holotype, UTA A-5773, 70.5 mm SL. Reproduced from UTA slide no. 23413.

Diagnosis.—A moderately large (approximately 70 mm snout–posterior vent, SL) and robust species that is a member of the Bolitoglossini because it has a tongue that is supported on a central stalk but is free of other attachments, and it lacks an ossified urohyal. It differs from all species of tropical plethodontid salamanders in being aquatic as adults; differing further from other *Pseudoeurycea* in having very long legs, a triangular-shaped head with closed external nostrils, and relatively few maxillary teeth.

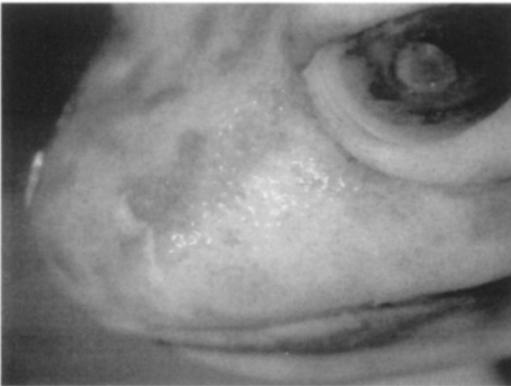


FIG. 2.—Lateral aspect of the head of the holotype of *Pseudoeurycea aquatica* (UTA A-5773), showing details of the flap-like structure that partially closes the nostril. The nasolabial groove is clearly visible as a light vertical line. Anterior rim of orbit to snout 4.3 mm.

Description and definition.—This is a robust species that reaches moderately large size (the male holotype is 70.5 mm SL; an adult female is 68.4 mm SL; a sub-adult male is 56.0 mm SL). The prominent head is generally triangular in dorsal view, with a narrow, bluntly pointed snout; it is strongly wedge-shaped in profile. The jaw adductor and depressor muscles are greatly enlarged and give the appearance of being swollen. In profile the jaw line is strongly sinuous, rising posteriorly, giving an impression of a smile. The eyes, while well developed, are relatively small and protrude only slightly from the outline of the head. The nostrils are remarkable in being closed by flap-like structures (Fig. 2) that may be capable of some movement in living animals. The nostrils are relatively high on the snout, and a nasolabial groove extends a long distance as a narrow, pale groove (Fig. 2). The head is broad (0.16–0.19 time SL in two males, 0.17 in the female) and moderately long (0.24–0.26 times SL in two males, 0.23 in the female). Maxillary teeth are relatively large and recurved, but few in number (19 total in the adult male and female, 16 in the smaller male). The jaw muscles are so strong that the mouths of the two adults cannot be opened sufficiently to observe vomerine teeth, but there are eight total in the smallest individual. The internal nares ap-



FIG. 3.—Left hind foot of the holotype of *Pseudoeurycea aquatica* (UTA A-5773), showing the long, unwebbed digits. Width of foot 8.3 mm.

pear to be normal for the clade, being rounded in shape and well separated from each other, and lying anterior to the middle of each curved row of vomerine teeth. Parotoid glands are not evident. The holotype has a prominent, oval mental gland located as far anteriorly as possible below the mandibular symphysis. The tail is stout basally, but tapers to a long slender tip. There is a well marked constriction at the base of the tail. Tails are longer than head plus body length (1.04–1.16 times SL in the males, 1.02 in the female). The limbs are long and robust (combined limb length 0.54–0.59 times SL in the two males, 0.53 in the female), and the limbs either meet (female) or overlap by from one and one-half (small male) to three and one-half costal folds when adpressed. The digits are long and slender (Fig. 3). The longest digit (third) is 0.07–0.08 times SL; the fifth toe is much shorter but still prominent. Subterminal pads are small but well developed. Webbing is slight to absent, and limited to the metatarsal region.

Measurements of holotype.—Head width 13.4; head depth 7.3; eyelid length 4.5; eyelid width 2.7; anterior rim of orbit to snout 4.3; interorbital distance 5.3; snout to forelimb 22.5; nostril diameter

0.0; distance between external nares 3.2; projection of snout beyond mandible 0.8; snout to gular fold 18.5; width across shoulders 9.7; snout to posterior angle of vent 70.5; snout to anterior angle of vent 64.1; axilla to groin 35.8; tail length 81.9; tail depth at base 7.3; tail width at base 6.5; forelimb length 17.4; width of hand 5.2; hind-limb length 20.9; width of foot 8.3; length of longest (third) toe 4.6; length of fifth toe 2.8. Numbers of teeth in holotype: premaxillary 3; maxillary 9–10.

Coloration of holotype.—In alcohol, this specimen is heavily mottled with dark brown alternating with pale brown to tan in a complicated but irregular pattern over the entire dorsal surface. Ventrally the coloration is much paler. The belly and the underside of the tail are pale gray with yellowish or cream-colored spots and blotches along the ventrolateral margins. The gular region is largely yellowish to cream-colored, with some obscure pale gray markings.

In life, the dorsal surfaces of the head, trunk, tail, and limbs are reddish brown with heavy dark brown mottling. The dorsum of the head has a slightly more reddish hue than the back and the upper eyelids are tan with only a few brown spots (Fig. 1).

Variation.—There are only three specimens, but they share all important features. The smallest specimen is a young male that is just developing a mental gland. This large size at maturity (56.0 SL) suggests that the species attains larger size than represented in our small sample. The female is much darker than the male but shares the mottled pattern, which however is much less pronounced. In life, the female and small male are more uniformly colored than the holotype, and are rich dark brown dorsally with discrete but small cream-colored spots, about 20 in total, which are scattered over the head and body in no discernable pattern. Several distinctive salmon-colored spots are present just anterior and posterior to the insertion of the forelimb of UTA A-5772. The iris is greenish with dark brown reticulations.

Habitat.—*Pseudoeurycea aquatica* is

known only from the type locality which was in cloud forest at 2103 m. The western and southern slopes of this ridge system were covered by a dry pine-oak forest. To the south of the type locality, the road steadily ascended the mountainside and at the crest, about 15 km distant, lush cloud forest gave way to pine-oak forest. The stream from which these specimens were taken is a small tributary of the Río La

Lana (Fig. 4). Several other streams are present in the general area, above and below the type locality. Despite repeated collecting efforts, *P. aquatica* was not observed in these streams. On the map issued by the Instituto Nacional de Estadística, Geografía, e Información of Mexico (1:250,000, Oaxaca E14-9), the type locality is on the eastern slope of a mountain indicated as Cerro Montaña Mixe, but lo-

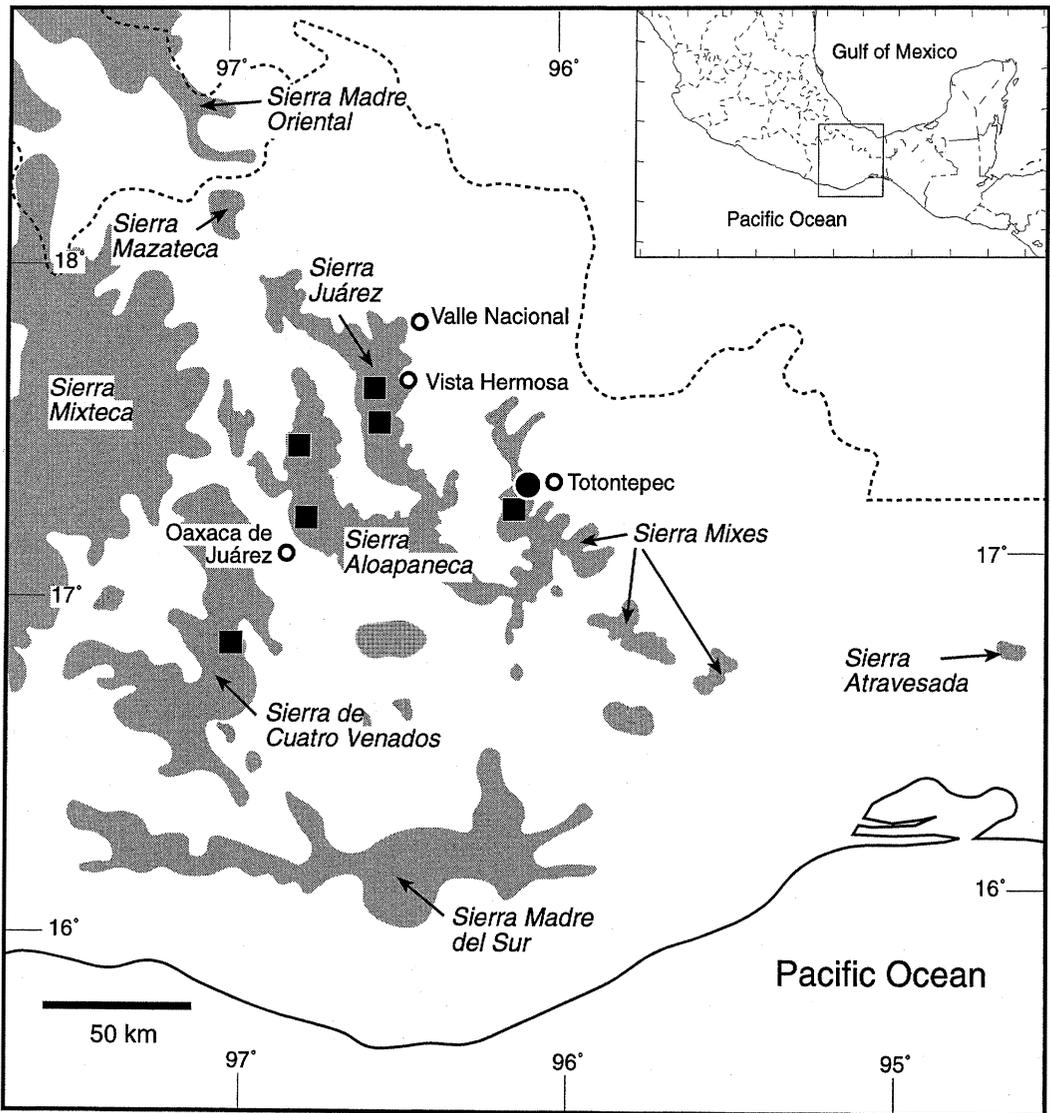


FIG. 4.—Map of highlands of Oaxaca showing major mountain ranges (areas above 2000 m are shaded), certain towns and villages (circles), the type locality for *Pseudoeurycea aquatica* (dot), and localities where populations of *Pseudoeurycea smithi* and populations thought to be relatives of both *P. aquatica* and *P. smithi* are known to exist (squares).

cal inhabitants seem to be unaware of this name. All specimens of *P. aquatica* were collected in early April 1978, at the end of the dry season, before the onset of the rains. This stream was <1.5 m wide in most places, but some of the plunge pools at the base of waterfalls were up to about 5 m across and 1 m deep. The only other salamander found at this site, *P. bellii*, was found on the slopes considerably above the stream. Several other species of *Pseudoeurycea* and *Thorius* were collected at a somewhat higher elevation (about 2536 m) on the same ridge as the type locality. Several species of hyliids were sympatric with *P. aquatica*.

The stream from which the type series of *P. aquatica* was collected ran through apparently pristine cloud forest in 1978. When we returned a year later (8–10 April 1979), the forest had been cleared to the edge of the stream on one side and the water was full of burned logs and ashes. No salamanders were seen during three nights of careful searches. We returned again in 1983 and 1984 and found the entire area has been cleared and the stream badly silted. The habitat was so badly degraded that we find it highly improbable that this aquatic salamander has been able to persist in the area—a notion supported by our lack of success in finding additional specimens in spite of searches involving many nights.

Behavior.—Two individuals of *P. aquatica* were taken during the night of 4–5 April 1978, and a single specimen was collected several days later on 8–9 April. This species appears to be strongly nocturnal; individuals were seen between about 2200 h and 0300 h; two of the three specimens captured were found well past midnight. One salamander (UTA A-5834), collected at 0030 h, was in water that was 10 C. Specimens were seen only in plunge pools, never in riffles. When first seen, individuals were resting on sand or gravel at the bottom of pools, but reacted to the beam of a flashlight within several seconds and tried to flee beneath huge boulders, most frequently near the bases of waterfalls. In the water, this species was quick and agile, and about half a dozen individuals were

seen that managed to escape; several of these appeared to be considerably larger than any in the type series. Salamanders were photographed the morning following their capture. When out of water, *P. aquatica* seemed lethargic and moved very slowly in comparison to terrestrial *Pseudoeurycea* collected in the area. When even slightly threatened, *P. aquatica* angled the head downwards (Fig. 1), making their large jaw musculature even more conspicuous.

Etymology.—The specific epithet is derived from the Latin *aquaticus*, meaning living in water, in reference to the habits of this species, unique among the bolitoglossine salamanders.

Comparisons and relationships.—When this species was discovered, its morphological similarity to *Pseudoeurycea smithi* (Taylor, 1938) was evident. Both are robust, with prominent heads and strong jaws, and *P. smithi* is subject to considerable geographic variation so we were unsure of the systematic status of the new species. What we now recognize as an undescribed species belonging to this complex occurs in terrestrial situations at slightly higher elevations near the type locality, and we thought it possible that *P. smithi* displayed substantial phenotypic plasticity and was responsible for what might have been ecophenotypes. Recent studies of mitochondrial genes (Parra-Olea, 1999) have clarified the picture with respect to *P. smithi*, and we are confident that populations that we once assigned to that taxon from the Totontepec and Cerro Pelon regions now constitute different species, both undescribed. This understanding has enabled us to sort the species appropriately and to discern that stable morphotypes are associated with genetic species, even though morphotypes show considerable variation. Accordingly, although we do not have tissue samples for *P. aquatica*, we are confident in describing it as a distinct new species.

Based on morphological similarities, *P. aquatica* appears to be a member of the *P. gadovii* species group, as redefined by Parra-Olea (1999). This group contains a large number of species, including several po-

tential relatives of *P. aquatica*. Best known of these is *P. smithi*, from the vicinity of the type locality on Cerro San Felipe in the Sierra de Aloápáneca and Llano de las Flores in the southern Sierra de Juárez. Morphologically similar, but apparently undescribed, species occur in the vicinity of Cerro Pelon and Cerro Humo Chico in the northern Sierra de Juárez, and in mountains to the southwest of the city of Oaxaca de Juárez. At present, these species are under study, and recently obtained DNA sequence data suggest that levels of divergence are great (Parra-Olea, 1999). All of these related species are terrestrial, as typical for the genus, and one of them (noted above) occurs at slightly higher elevations very near the type locality of *P. aquatica*. It is unlikely that the phylogenetic relationships of the new taxon will be determined with any more accuracy until tissue for molecular systematic studies become available. However, on the basis of numerous morphological features (based on external features and studies of x-ray radiographs), the species are securely placed in *Pseudoeurycea* and they are strongly differentiated from other nearby species of that genus, including the short-legged *P. mystax*, the heavy-bodied *P. belii*, and the gracile *P. saltator* and *P. juarezi*. Northern Oaxaca has been a region of local diversification of members of the genus, and additional descriptions are forthcoming.

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RESUMEN

Se describe una nueva especie de *Pseudoeurycea* de la vertiente norte del estado de Oaxaca, México. Esta es la única especie acuática conocida de salamandras bolitoglosinas. Además de su comportamiento acuático, la especie difiere de sus congéneres por tener patas muy largas, una cabeza de forma triangular con nostriles completamente cerrados y por poseer relativamente pocos dientes maxilares. Es muy posible que esta extraordinaria nueva especie de salamandra se extinguiera dos décadas atrás.

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