

# FIELDIANA • ZOOLOGY

Published by  
FIELD MUSEUM OF NATURAL HISTORY

Volume 51

JULY 25, 1966

No. 1

## A New Species of Lungless Salamander (Genus *Bolitoglossa*) from Panama

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Several years ago Edward H. Taylor directed our attention to several specimens of *Bolitoglossa* included in the Harold Trapido Panamanian collection at Field Museum of Natural History and suggested that they represented an undescribed form. Additional specimens of this strikingly distinct species have been collected on several occasions recently. All differ from other members of the genus in having bifurcated terminal phalanges. In reference to this unique structural feature the species may be known as

***Bolitoglossa schizodactyla***, new species. Figures 1 and 2.

*Holotype*.—FMNH 141241, an adult male from El Valle de Anton, 560 meters (1,837 feet), Provincia de Cocle, Panama, collected by Harold Trapido.

*Paratypes*.—PANAMA, Provincia de Cocle: El Valle de Anton, Finca Arce, collected by H. Trapido, G. Fairchild, and C. H. Michener (FMNH 142678, 152989-90); same locality, collected by P. Allen and H. Trapido (FMNH 152991); El Valle de Anton, 793 meters (2,600 feet) collected by G. Fairchild and H. Trapido (FMNH 152992-94). Provincia de Panama: Cerro la Campana, 850 meters (2,788 feet), collected by H. Trapido (FMNH 141240); 1 mile NW Posado San Antonio, collected by R. Dressler (UMMZ 124513); 3 miles NW Posado San Antonio, collected by O. J. Sexton (UMMZ 124514-15); vicinity of Altos de Pacora, E Cerro Jefe, 200-400

*Library of Congress Catalog Card Number: 66-25494*

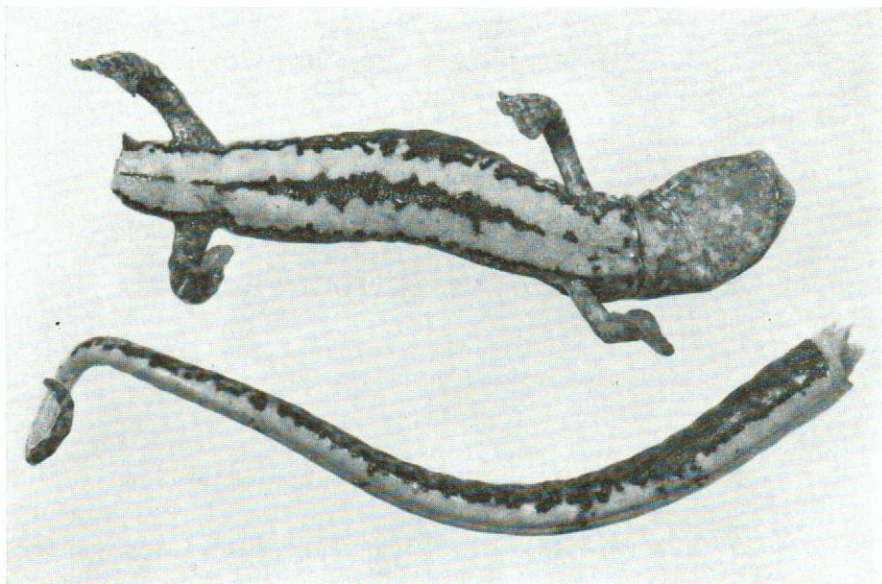


FIG. 1. *Bolitoglossa schizodactyla*. FMNH 152989, an adult male from El Valle de Anton, Provincia de Cocle, Panama.

meters (650–1300 feet), collected by J. Barrat, Jr. (KUMNH 93511). Provincia de Bocas del Toro: Isla de Colon near La Gruta, 20 meters (65 feet), collected by C. W. Myers (KUMNH-CWM 2892); Peninsula Valiente at Bluefields, near sea level, collected by C. W. Myers (KUMNH-CWM 4259, 4290–4291).

*Diagnosis.*—A medium-sized species of *Bolitoglossa* (8 adult males: 38.3–60.9, mean 48.3 mm standard length; 9 adult females: 45.8–62.0, mean 56.4 mm standard length) distinguished from all other members of the genus by having bifurcated terminal phalanges on some to most digits of the hands and feet (fig. 2); distinguished further from most species by having very high numbers of vomerine teeth (totals 27–61, mean 39.8) and from all species by its unique color pattern of a well defined ventral yellow band, unmarked on the tail but interrupted by a median irregular black stripe on the belly, or immaculate whitish venter.

*Description of the holotype.*—Adult male, snout moderately long, truncate at tip. Well-developed mental gland, ovoid in shape with concave posterior margin, 2.2 mm long and 3.8 mm broad. Nostril small; labial protuberances of nasolabial groove moderate. Canthus rostralis of moderate length, slightly rounded. Standard



length 6.2 times head width; standard length 4.2 times snout-gular fold length. Shallow groove below eye extends almost full length of opening following curvature of eye, does not communicate with lip. Eye of moderate size, only slightly protuberant. Well defined post-orbital groove extends posteriorly from eye as shallow depression for 2.5 mm, proceeds sharply ventrally at level of posterior end of mandible and extends across gular area as an indefinite depression parallel to and 3.7 mm anterior to gular fold. Vomerine teeth 47, in long double rows extending beyond the lateral borders of internal nares; rows only slightly curved posteriad medially. Maxillary teeth 61, extending posteriorly to a point about three-fourths through eye. Three premaxillary teeth, piercing lip. Tail long,  $1.37 \times$  standard length; slightly compressed; moderately constricted at base. No post-iliac gland. Limbs long, limb interval  $1\frac{1}{2}$ ; standard length  $4.1 \times$  right fore limb,  $3.8 \times$  right hind limb. Webbing of hands and feet almost complete with crescentic depressions between digital tips; tips of digits 2 through 4 plainly bifurcated although truncate in general outline. Parts of the terminal phalanges of fingers 2 and 3 and toes 2, 3, and 4 free from webbing. No obvious subterminal pads. Fingers in order of decreasing length: 3, 2, 4, 1; toes in order of decreasing length: 3, 2, 4, 5, 1.

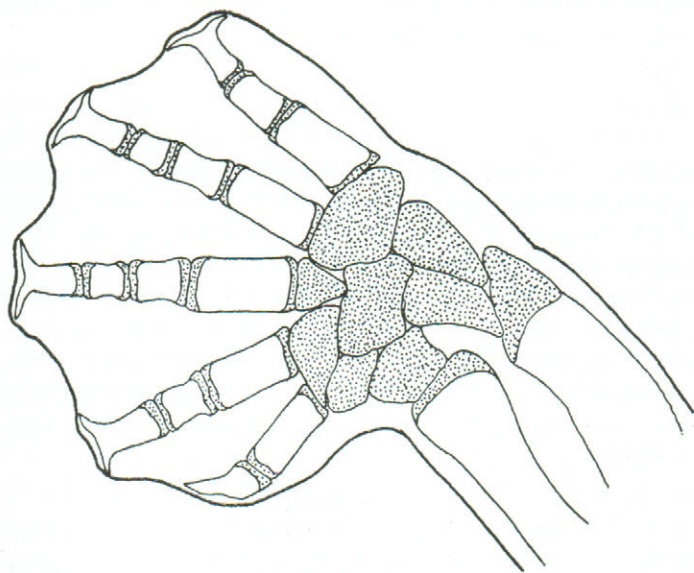


FIG. 2. Left hind foot of *Bolitoglossa schizodactyla*, FMNH 142678. Webbing outlined. Cartilage stippled.

*Measurements* (in mm).—Head width 8.1; snout to gular fold (head length) 12.0; head depth at posterior angle of jaw 4.3; eyelid length 3.7; eyelid width 1.8; anterior rim of orbit to snout 4.0; horizontal orbital diameter 2.7; interorbital distance 3.5; distance between vomerine teeth and parasphenoid tooth patch 0.6; snout to fore limb 15.2; distance separating internal nares 2.7; distance separating external nares 3.1; snout projection beyond mandible 1.4; snout to posterior angle of vent (standard length) 50.2; snout to anterior angle of vent 46.1; axilla to groin 26.0; tail length 69.0; tail width at base 4.1; tail depth at base 4.3; fore limb length 12.0; hind limb length 13.3; width of right hand 4.9; width of right foot 6.0.

*Coloration* (in alcohol).—Dorsal and lateral color of head, trunk, and tail black; dorsum of limbs medium brown with some pale mottling; feet light brown dorsally. Ventral color uniformly yellow-white from tip of tail to point just anterior to hind limb insertions where a median dark stripe appears in the center of the light band; stripe of irregular width, extends anteriorly to point just posterior to fore limb insertions. Yellow-white ventral band obscured by melanophores anterior to gular fold. Highly irregular line of intense black sharply sets off light ventral band from dorso-lateral dark coloration; demarcating line especially well developed on tail. Some brownish spots are scattered ventrally between the limb insertions and on the gular fold. Gular area grayish-brown.

*Variation*.—Although our sample is relatively small (17), the sexual dimorphism characteristic of the genus is apparent. Males average 48.3 mm standard length and females average 56.4 mm. These sizes are moderate within the genus. Sexual dimorphism is also apparent in limb length; males have hind limbs that range from 24.0 to 27.5 (mean 25.9) per cent of standard length, while those of females range from 20.4 to 25.9 (mean 23.5) per cent. Legs are long with limb intervals of from 1 to 2 (mean  $1\frac{1}{2}$ ) in males and from  $1\frac{1}{2}$  to  $3\frac{1}{2}$  (mean  $2\frac{1}{2}$ ) in females. Females have more maxillary and vomerine teeth than males, both absolutely and relative to size. Standard length is 5.7 to 6.2 (mean 6.0)  $\times$  head width in males, 5.6 to 6.6 (mean 6.2) in females. Sexual dimorphism is not apparent in other dimensions.

There is some variation in foot shape, possibly an artifact of preservation. The feet are highly distinctive in shape with extensive webbing that is very obviously demarcated from the stout digits. The digital tips are broad, truncate, and usually somewhat concave, following the outline of the bifurcated terminal phalanges.

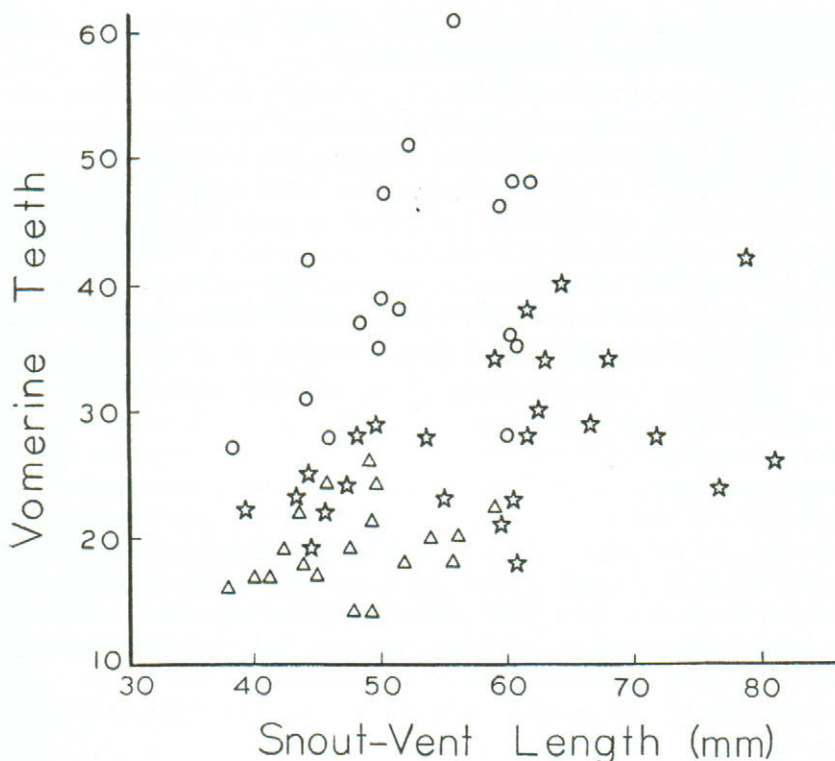


FIG. 3. Variation in vomerine dentition. Circle, *B. schizodactyla*; triangle, *B. vallicula*; star, *B. lignicolor*.

Some geographic variation in color pattern is apparent in the sample. Specimens from the southern and eastern parts of the range have a bright yellow ventral band which extends from the gular fold to the tip of the tail. The band is almost immaculate and has a shiny or enameled appearance. Trunk and tail melanophores partially obscure the band in some individuals. An irregular black stripe of variable width typically interrupts the yellow band midventrally; the stripe is broadest midway between the limb insertions and tapers to a point anteriorly and posteriorly (fig. 1). The brownish black coloration of the lateral surfaces is usually separated from the yellowish ventral coloration by a narrow, dark black border.

Specimens from the northern and western parts of the range usually lack well demarcated ventral bands. The venters are immaculate whitish with a slight reddish tinge. Numerous small pig-



mented dermal gland openings are evident. No midventral dark stripes or bordering dark lines are present.

Most of our sample resembles the holotype in dorsal coloration, but the specimens from Peninsula Valiente differ markedly from the others. In these atypical individuals an irregular mid-dorsal stripe of purplish black is bordered by irregular dorsolateral bands of light reddish yellow. Irregular lateral bands of purplish black to dark brown gradually blend into the light ventral color. Dorsal portions of the head and tail are mottled with reddish yellow and purplish black. The dorsal surfaces of the limbs are very dark purplish black.

Generally the dorsal and lateral ground color of melanic to purplish black in *B. schizodactyla* is covered and often largely concealed by varying amounts of metallic bronze and silver to grayish coloration (iridiophores and guanophores). This superficial coloration may be arranged in spots and blotches, or more or less evenly distributed over the lateral surfaces. The individuals available may be grouped as follows (based on dorsal and dorsolateral coloration): solid black (2), irregular purplish black mid-dorsal with reddish brown dorsolateral bands (3), large whitish to brownish blotches on a black background (4), whitish spots on a dark brown background (4), even gray suffusion (2), even brown suffusion (1).

*Osteology.*—Osteological information has been obtained from a single cleared and stained example (FMNH 142678). Frontal processes of the single premaxilla are relatively long with slight distal dilation. The processes remain separated for their entire lengths. Nasals are relatively large for the genus. Septomaxillae and prefrontals are absent. A large internasal space separates the vomers for their entire lengths, and the bones approach each other only posteriorly where the tooth bearing portions extend as processes toward the midline. Vomerine preorbital processes are large and long, extending beyond the lateral margins of the vomers proper. Very low otic crests are present. The opercular plates are oval and lack columellae. Vertebrae are amphicoelous with no sign of calcification of the intervertebral cartilages. No obvious boss is present on the atlas vertebra. There are 14 trunk, 1 sacral, 2 caudosacral, and 42 caudal vertebrae. Hypapophyses and basapophyses are absent. No tibial spurs are evident. Distal tarsals 4 and 5 are fused; eight cartilaginous elements occur in both carpus and tarsus. Terminal phalanges are bifurcated distally except on the first digit (see fig. 2).

*Habitat.*—The bifurcated terminal phalanges and the shape and webbing of the hands and feet suggest that *B. schizodactyla* is a

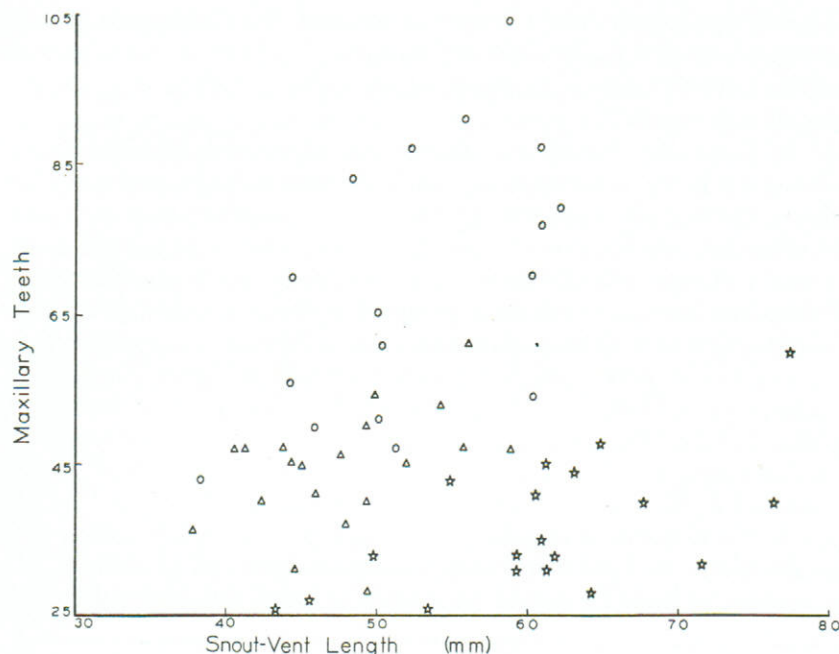


FIG. 4. Variation in maxillary dentition. Circle, *B. schizodactyla*; triangle, *B. valleculla*; star, *B. lignicolor*.

climbing or arboreal species. The La Gruta salamander was collected in vegetation, four feet above the ground. At least several of the specimens from El Valle de Anton (FMNH 142678, 152989-91) were collected in banana plants. The Bluefields specimens were found at night walking on palm and *Helaconia* leaves along a stream.

*Relationships.*—*B. schizodactyla* is apparently sympatric with *B. biseriata*, at least in central Panama. Several specimens of *B. biseriata*, collected from bananas at El Valle de Anton, are included in the Trapido collection. The two species occupy similar microhabitats, but are quite distinct structurally. *B. biseriata* is smaller, has fewer teeth, is lighter colored, and has flattened, more fully webbed hands and feet than *B. schizodactyla*.

*B. schizodactyla* is a remarkably distinct species and it is difficult to suggest its closest relatives. The shape of the terminal phalanges of the hands and feet and the highly distinctive color pattern are unique. Individuals of only five (*B. dofleini*, *B. lincolni*, *B. macrinii*, *B. morio*, *B. yucatana*) Guatemalan and Mexican species have as many as the mean number of vomerine teeth in *B. schizodactyla*.

The maximum number of vomerine teeth of *B. schizodactyla* (61) is exceeded only by *B. dofleini* (76 maximum). All of the above species differ markedly from *B. schizodactyla* in many characters and are not closely related to it.

*B. lignicolor* of Panama and Costa Rica, and *B. valleculea* of Colombia share characteristics with *B. schizodactyla* and may be close relatives. *B. lignicolor* resembles *B. schizodactyla* in size and habitus, and both species have extensively webbed hands and feet. Vomers of both species are well separated by large intervomerine fontanelles and have medially directed, spinous, toothed processes. Many differences distinguish the species. *B. lignicolor* has rather high numbers of vomerine teeth, but fewer than *B. schizodactyla* (fig. 3). *B. schizodactyla* has many more maxillary teeth (fig. 4). *B. schizodactyla* lacks vertebral basapophyses and prefrontal bones, both present in *B. lignicolor*, and has a somewhat broader head and longer limbs than has *B. lignicolor* (mean ratio of standard length to head width is 6.3 in males, 6.6 in females; mean limb interval is 3 in males, 3½ in females). *B. lignicolor* lacks bifurcated terminal phalanges. *B. schizodactyla* lacks the light dorsal wash or band, the dark trunk and

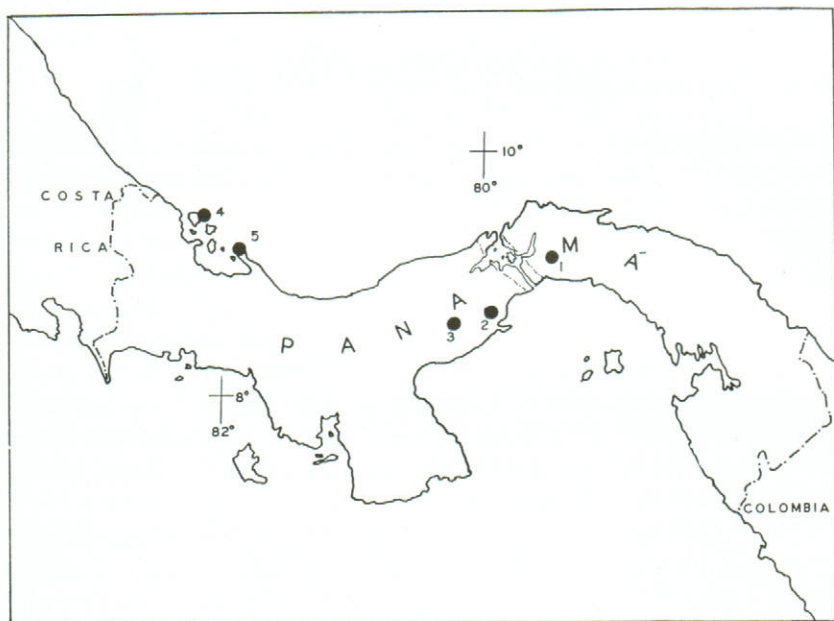


FIG. 5. Distribution of *B. schizodactyla* in Panama. 1. Cerro Jefe; 2. Cerro la Campana and Posada San Antonio; 3. El Valle de Anton; 4. La Gruta; 5. Peninsula Valiente.



tail venters, and the small ventral and limb gnanophores of *B. lignicolor*.

*B. schizodactyla* resembles the somewhat smaller *B. valleculea* in having light colored trunk and tail venters and in general habitus. Ventral surfaces tend to be pinkish in *B. valleculea*, but bright yellow in *B. schizodactyla*. *B. valleculea* has incompletely webbed hands and feet and its truncated digits apparently lack bifurcated terminal phalanges. It also has fewer maxillary and many fewer vomerine teeth than *B. schizodactyla* (figs. 3 and 4). The head of *B. valleculea* is narrower (mean ratio of standard length to head width is 6.4 in males, 6.9 in females) and its limbs are slightly shorter (mean limb interval 2 in males, 3 in females) than those of *B. schizodactyla*. No skeletons of *B. valleculea* are available.

Other species which resemble *B. schizodactyla* include the poorly known Costa Rican forms *B. alvaradoi* and *B. arborescendens*.

TABLE I.—Data on *Bolitoglossa schizodactyla*.

Museum number		Snout-vent length	Axilla-groin	Head width	Hind limb length	Snout-gular fold	Limb interval	Tail length	Maxillary teeth	Vomerine teeth
KUMNH 93511	♂	60.9	34.0	10.4	16.0	16.0	2	66.8	77	35
FMNH 141241 <sup>1</sup>	♂	50.2	26.0	8.1	13.3	12.0	1½	69.0	61	47
FMNH 142678	♂	50.1	27.3	8.2	12.9	12.1	1½	68.6	51	39
FMNH 152990	♂	50.0	27.1	8.1		11.7		67.0	65	35
FMNH 152989	♂	48.3	25.8	8.4	13.3	11.8	1	76.4	82	37
FMNH 152994	♂	44.4	24.0	7.8	11.2	11.1	2	60.0	70	42
UMNZ 124513	♂	44.1	23.8	7.2	11.4	10.0	1	51.8	56	31
UMMZ 124514	♂	38.3	17.7	6.5	9.2	10.5	1½		43	27
FMNH 152992	♀	62.0	33.2	9.5	13.3	13.9	2½	85.0	79	48
UMMZ 124515	♀	60.7	33.2	9.5	14.3	13.8	2½	60.2	87	48
KUMNH-CWM 4259	♀	60.3	33.9	9.1	12.3	13.0	3½	65.7	54	36
KUMNH-CWM 2892	♀	60.1	33.4	9.5	15.1	14.8	2	63.0	70	28
FMNH 152991	♀	59.2	32.5	10.0	14.8	14.8	2	70.8	104	46
KUMNH-CWM 4291	♀	55.9	31.4	9.3	12.6	13.8	3		91	61
FMNH 152993	♀	52.2	25.5	9.3	13.5	13.8	1½	68.0	87	51
FMNH 141240	♀	51.2	28.5	8.2	12.2	12.8	3		47	38
KUMNH-CWM 4290	♀	45.8	27.8	7.6	11.0	11.0	2½	49.2	50	28

<sup>1</sup> Holotype

Neither resembles *B. schizodactyla* in coloration, but they have extensively webbed hands and feet and are as large or larger than *B. schizodactyla*. These species lack truncated digital tips and have no indication of bifurcated terminal phalanges. *B. alvaradoi* resembles *B. schizodactyla* in head width but has fewer teeth. *B. arborescens* has rather large numbers of teeth but has a narrower head than *B. schizodactyla*.

Several other species of *Bolitoglossa* (*biseriata*, *flaviventris*, *striatula*) have fully webbed hands and feet and light ventral coloration, but they differ so strikingly from *B. schizodactyla* in most other characters that close relationship is unlikely.

*Distribution*.—The species is known from western and central Panama (fig. 5). Dr. A. S. Rand (*in litt.*) has recently found the species on Barro Colorado Island.

*Acknowledgements and abbreviations*.—Material for the present study was made available through the courtesy of Robert F. Inger and Hymen Marx of Field Museum of Natural History (FMNH), Harold Trapido of the Rockefeller Foundation, Charles F. Walker of the University of Michigan Museum of Zoology (UMMZ), Curt R. Schneider and Eustorgio Mendez of the Gorgas Memorial Laboratory, and Charles W. Myers and William E. Duellman of the University of Kansas (KUMNH). We especially thank Edward H. Taylor for drawing our attention to the material and suggesting that it be described. We are grateful to Jay M. Savage and Robert F. Inger for their review of the manuscript and to William A. Bussing for photographic assistance. This investigation was aided by a grant from the Dr. Wallace C. and Clara A. Abbott Memorial Fund of the University of Chicago to the senior author, and from the National Institutes of Health (GM 12020) to William E. Duellman.