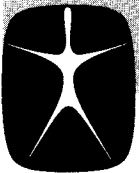


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A NEW SPECIES OF *ATELOPUS*  
(ANURA, BUFONIDAE) FROM  
NORTHEASTERN SOUTH AMERICA

*By* ROY W. MCDIARMID

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A NEW SPECIES OF *ATELOPUS* (ANURA, BUFONIDAE)  
FROM NORTHEASTERN SOUTH AMERICA<sup>1</sup>

By ROY W. McDIARMID<sup>2</sup>

**ABSTRACT:** A new species of bufonid frog, *Atelopus vermiculatus*, is described from a series of adults and juveniles from French Guiana. The new species has an internal tympanum and middle ear and in this respect differs from all species of *Atelopus* except *flavescens* and *spumarius*, from which it is easily distinguished by its small size and distinctive coloration.

The amphibian fauna of northern South America is poorly understood. New and little known species frequently are collected in biologically unworked areas of this vast tropical region. On three different occasions Dr. Philip A. Silverstone visited northern South America and made important collections of amphibians and reptiles incidental to his studies of dendrobatid frogs. Some of the new material has been described recently by Silverstone (1971), Trueb (1971), and Brame and Wake (1972). Among the specimens collected by Silverstone in a remote area of French Guiana was a series of an undescribed species of *Atelopus*. It is ironic that this new species of *Atelopus* should be found less than 100 km south of the type locality of *Atelopus flavescens* Duméril and Bibron 1841, the oldest taxon in the genus. With reference to the dorsal color pattern I propose that this frog be called

***Atelopus vermiculatus*, new species**  
Figures 1 and 2

*Holotype:* LACM 42060; an adult female (Figs. 1 and 2) collected by Philip A. Silverstone along a forest trail paralleling the lower Rivière Matarony, a tributary of the Fleuve Approuague, French Guiana during the day, 29 July 1968; 35 m elevation.

*Paratypes:* LACM 42049-59, 42061-63, 42070-79 are topoparatypes collected on 24-30 July and 17-18 August, 1968; LACM 42064-66 from forested hills near Crique Ipoucín on 5-6 August, 1968, between 8-180 m; LACM 42067, 42069 from forest near ORSTOM camp at Sant Tortue, on the Fleuve Approuague at its confluence with the Crique Tortue on 8 and 11 August, 1968, 75 m; LACM 42068 from along a trail between Fleuve Ap-

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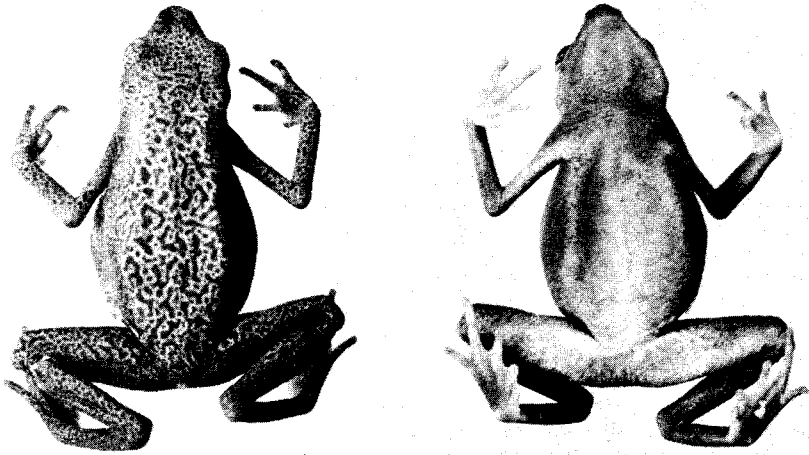


FIGURE 1. Holotype of *Atelopus vermiculatus*, new species (LACM 42060). Left, dorsal view; right, ventral view.

prouague and summit of Montagnes Tortue on 9 August, 1968, 100 m. All specimens were collected by Philip A. Silverstone.

*Diagnosis:* *Atelopus vermiculatus* is a relatively small species (snout-vent lengths for adult males and females are 19.3-22.1 mm,  $\bar{x}$  = 21.27, N = 4 and 26.8-31.3 mm,  $\bar{x}$  = 28.96, N = 15, respectively) that is easily distinguished from all species of *Atelopus*, except *flavescens* and *spumarius*, by the presence of a well-developed internal tympanum, annulus tympanicus and middle ear. It differs from *A. flavescens* and *A. spumarius* in its smaller size and distinctive pattern and coloration. In addition, *Atelopus vermiculatus* can be defined on the basis of the following characters: presence of ostia pharyngea and vocal slits in males; the absence of dorsolateral rows of warts and obvious glandular areas on the sides of the head, over the eyes, in the paratoid region and dorsally and laterally on the back, sides and limbs; subacuminate and protruding snout; relatively smooth skin, lacking conical apicalia, moderately webbed foot, modal webbing formula (from Savage and Heyer, 1967) I 0 — 1 II  $\frac{1}{2}$  —  $2\frac{1}{2}$  III  $1\frac{3}{4}$  —  $3\frac{1}{2}$  IV  $3\frac{1}{2}$  —  $1\frac{3}{4}$  V; and dorsal color pattern of yellowish, greenish, or tan vermiculations on a dark brown background with a rose pink wash on the belly and thighs.

*Description of Holotype:* Adult female (Figs. 1 and 2); head narrower than body; head slightly longer than wide; snout subacuminate in dorsal view, tip slightly rounded; snout protruding over lower lip, acute in lateral profile; canthus rostralis rounded to slightly angular; loreal region flat; lips not flared; nostrils elliptical, directed laterally; nostrils closer to tip of snout than to eye; snout moderately long, distance from eye to nostril slightly greater than diameter of eye; interorbital width slightly greater than length of upper eyelid;

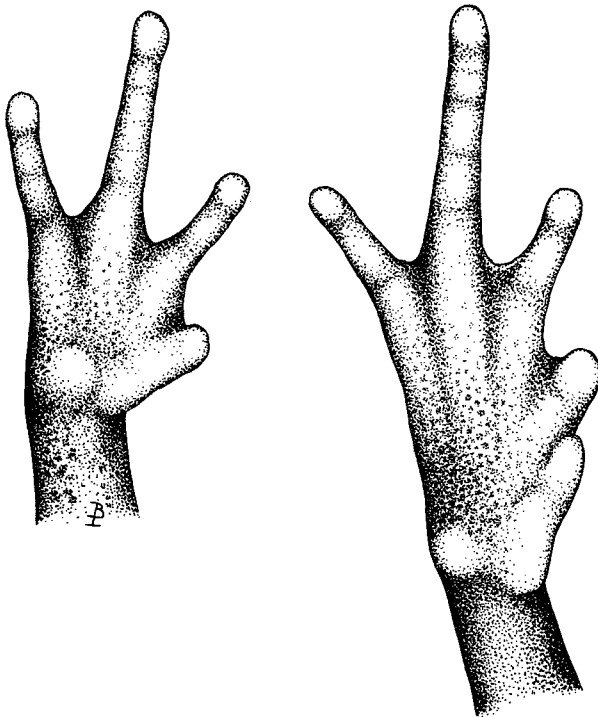


FIGURE 2. Holotype of *Atelopus vermiculatus*, new species. Ventral view of right hand and foot.

outer margin of upper eyelid not noticeably thickened; surface of head concave between nostril, flat to slightly rounded between eyes; external tympanum absent; supratympanic (paratoid) ridge well developed; pretympanic ridge moderately developed; tongue moderate in size, elliptical, posterior three-fourths free; two patches of pigment on anterior lateral third of tongue; choanae ovoid, not visible when roof of mouth viewed from directly below; ostia pharyngea large.

Skin relatively smooth, lacking dorsolateral row of warts; skin covered with tiny scattered verrucae visible microscopically; outlines of suprascapulae, neural ridge of vertebrae, anterior and posterior portions of coccyx and dorsolateral expanses of sacral diapophyses visible through skin on dorsal surface; posteroventral quarter of belly and medioventral surface of thighs (rump patch) wrinkled; anal opening on low protuberance, directed posteriorly, opening slightly above midlevel of thighs; anal opening covered dorsally by anal flap consisting of one large and two smaller ventrally directed papillae; series of anal furrows radiating from opening, best developed ventral to opening; palmar tubercle single, smooth; thenar tubercle indistinct; subarticular



FIGURE 3. Variation in dorsal pattern of selected adult female paratypes of *Atelopus vermiculatus*, new species (from left to right, LACM 42076, SV-30.6 mm; 42065, 31.3 mm; 42068, 27.8 mm; 42064, 30.7 mm).

tubercles few, low and smooth; finger tips rounded, slightly swollen, slightly broader than penultimate joint; webbing between fingers fleshy, reduced; webbing formula for hand I  $1\frac{1}{2}$  —  $2\frac{1}{2}$  II 2 —  $3\frac{1}{2}$  III  $3\frac{1}{2}$  —  $2\frac{1}{2}$  IV; no tarsal fold; sole of foot smooth; inner metatarsal tubercle reduced, nearly continuous with subarticular tubercle of first toe; outer metatarsal tubercle small, oval; other metatarsal tubercles absent; subarticular tubercles low, oval, indistinct; supernumerary tubercles absent; toe tips rounded, not or very slightly expanded; webbing fleshy; webbing formula for foot I 0 — 1 II  $\frac{1}{2}$  —  $2\frac{1}{2}$  III  $1\frac{3}{4}$  —  $3\frac{1}{2}$  IV  $3\frac{1}{2}$  —  $1\frac{3}{4}$  V.

*Measurements and Proportions:* All measurements are in millimeters: snout-vent length (SV) 29.5; tibia length (TL) 13.2; foot length (FL) 9.9; head length (HL) 8.9; head width (HW) 8.6; snout length (SL) 4.4; eye diameter 2.5; interorbital width 3.7; distance from eye to nostril 3.0; sacral width 7.9; TL/SV 0.45; FL/SV 0.34; HL/SV 0.30; HW/SV 0.29; HW/HL 0.97; SL/HL 0.49.

*Coloration of Holotype* (in alcohol): Dorsal surface of body and limbs dark brown with extensive tan vermiculation. Vermiculate pattern most concentrated on head, least on sides of head and sides of body. Pale brown area between eye and upper lip. Poorly defined tan blotch over the suprascapulae. Posterior surface of thighs brown with scattered, irregular tan specks. Ventral surfaces dirty tan to light brown, darkest in pectoral-gular area. Posterior section of belly and medioventral surface of thighs creamy white. Ventral surface of hands tan; ventral surface of feet light brown; tubercles lighter tan to cream.

*Variation in Paratypes:* There are 14 adult female, 4 adult male and 12 immature (sex undetermined) paratypes. Except for details of coloration, the adult females are similar to the holotype. The males, however, are considerably smaller, have moderately developed brown dorsolateral nuptial pads on the thumbs and proportionately thicker upper forelimbs than the females. They have the same general variation in color and pattern found in the females. The immatures range from 14.6 to 25.9 SV and have the same basic pattern and color as the adults. There is no obvious indication in this series of ontogenetic change in color, pattern or proportions. The dorsal pattern of the females

varies from broadly vermiculate (LACM 42065) to nearly uniform light brownish tan (LACM 42064); most of the females have a fine vermiculate pattern similar to that of the holotype. This variation in dorsal pattern is illustrated by selected individuals (Fig. 3). There is considerable variation in ventral pigmentation in adult females. Generally the throat and anterior half of the body is washed, finely speckled, or vermiculated with various shades and intensities of brown over dirty white; all have a creamy white, grayish white or dirty white patch on the posterior part of the belly and ventral surfaces of the thighs. This light area may include most of the belly (extending to the pectoral area) and entire ventral surface of the limbs or may be restricted to a small area on the posterior eighth of the belly and central area of the thighs; most have some brown speckling on the lateral edges of the ventral surface of the thighs and on the ventral surface of the forelegs. The ventral surfaces of the manus are light; a few specimens have a brownish wash on the palms. All have a brown central solar patch; the toes are basically light; there is brown color between the subarticular tubercles in a few individuals.

Three of the four males have a typical vermiculate dorsal pattern. The fourth (LACM 42066) is irregularly marked with tan and brown; traces of the vermiculate pattern are evident on the head, sides and limbs. Ventrally the males are lighter than the females; as compared to the females, the brown pigmentation is reduced on the chin and anterior belly and consists of only a few small light brown irregular lines or faint scattered speckling.

All immatures are marked with the typical vermiculate pattern. The ground color in one specimen (LACM 42067) is faint and the vermiculation, while still present, is gray both on the limbs and dorsal surface. Ventrally the immatures have the same range in pattern and coloration as described for the adults.

In life the dorsal coloration for all specimens is about the same as described above except that the vermiculate pattern is brighter, sometimes greenish golden (comparison of coloration of preserved animals and Kodachrome slides). The females and largest immatures have a striking rose pink ventral wash, brightest on the belly and thighs; obscured to various degrees on the ventral surfaces of chin, chest, and limbs by brown coloration and pattern. The rump patches are much lighter and only have a faint rose pink coloration.

Dr. Silverstone provided the following color notes made in the field from living specimens LACM 42049 (PAS 4187) immature, 20.1 mm snout-vent length and LACM 42050 (PAS 4188) adult female, 27.9 mm SV: "Iris black with gold ring around pupil; dorsum dull dark brown with very faint light yellowish reticulum on back and limbs; extreme posterior belly orange pink; ventral surface of thighs, anterior part of posterior belly and axillae rose pink; rest of venter dull medium brown with slight rose pink tinge." Color notes from LACM 42064 (PAS 4404) adult female, 30.7 mm SV and LACM 42065 (PAS 4405) adult female, 31.3 mm SV are: "Back and head in one specimen (LACM 42064) dull greenish with purplish areas dorsolaterally; limbs above mixed purple and green; the other specimen (LACM 42065) is dark purple-

brown above, with dull green reticulum on entire dorsal surface; venter on both specimens dull purple, brighter than back, lightest and brightest on limbs; posterior belly and part of right side of belly bright rose pink; on one specimen (LACM 42065) tiny black spotting on throat, breast, edges of limbs, and edges of belly."

Measurements and proportions for the paratypes are contained in Table I. Specimens were categorized as adult female (eggs present), adult male (enlarged testes and nuptial pads present), immature (no eggs, gonads not enlarged, no nuptial pads). No attempt was made to sex the immatures. There is well-defined size dimorphism between males and females; the adult females are much larger than adult males. The data also suggest that proportionately males have a slightly larger head than females.

TABLE I  
Range and Mean of Measurements and Proportions  
of Paratypes of *Atelopus vermiculatus*

	Male (N = 4)	Female (N = 14)	Immature (N = 12)
SV*	19.3 -22.1 (21.27)	26.8 -31.3 (28.92)	14.6 -25.9 (18.68)
TL*	9.2 -10.4 (9.82)	12.2 -13.9 (13.03)	6.5 -11.5 (8.45)
FL*	6.2 - 8.7 (7.37)	9.1 -11.1 (9.99)	4.9 - 8.8 (6.27)
HL*	6.4 - 7.2 (6.90)	8.0 - 9.5 (8.67)	5.1 - 7.6 (6.01)
HW*	6.1 - 6.9 (6.60)	7.7 - 9.0 (8.31)	4.9 - 7.4 (5.77)
SL*	3.2 - 3.5 (3.37)	3.9 - 4.6 (4.29)	2.5 - 3.8 (3.04)
TL/SV	0.45- 0.48 (0.461)	0.44- 0.48 (0.450)	0.43- 0.49 (0.452)
FL/SV	0.32- 0.39 (0.345)	0.32- 0.38 (0.344)	0.30- 0.38 (0.336)
HL/SV	0.32- 0.33 (0.324)	0.29- 0.31 (0.298)	0.29- 0.36 (0.323)
HW/SV	0.30- 0.32 (0.310)	0.27- 0.30 (0.286)	0.28- 0.34 (0.310)
HW/HL	0.94- 0.97 (0.956)	0.91- 0.99 (0.957)	0.89- 1.05 (0.962)
SL/HL	0.48- 0.50 (0.489)	0.44- 0.54 (0.495)	0.43- 0.57 (0.505)

\*SV=snout-vent length; TL=tibia length; FL=foot length; HL=head length; HW=head width; SL=snout length; all measurements are in mm.

*Osteology:* All information was obtained from a cleared and stained adult female (LACM 42075), 28 mm SV. Only those osteological traits that have been demonstrated to have interspecific variation are discussed (see McDiarmid, 1971). This specimen was included in the analysis and definition of the genus *Atelopus* presented elsewhere (McDiarmid, 1971).

The following osteological points are of interest: nasals separated medially, fused to underlying chondrocranium; occipital grooves in frontoparietal covered; wings of vomer well developed; anterior end of the parasphenoid pointed, slightly overlapping sphenethmoid; no anterior projection on squamosal; quadratojugal well developed, overlapping maxillary; lateral head of posterior end of prootic reduced; atlas completely fused with first trunk vertebra; neural arches ornately adorned, without connection between dorsal ornamentation on consecutive vertebrae; transverse processes of trunk vertebrae about equal in length with irregular, scalloped edges; anterior edges



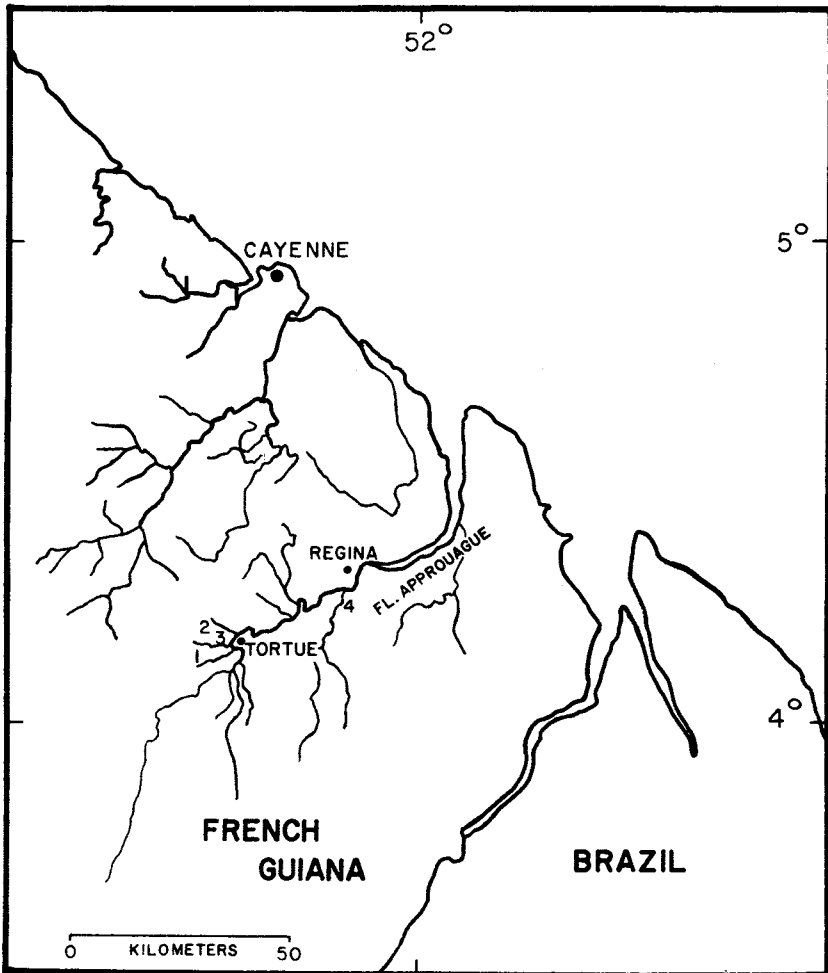


FIGURE 4. Map of the Fleuve Approuague Drainage System in French Guiana showing the locality records of *Atelopus vermiculatus*: 1-near Crique Ipoucin; 2-trail from Fleuve Approuague to Montagnes Tortue; 3-near confluence of Crique Tortue and Fleuve Approuague; 4-lower Rivière Matarony.

of sacral diapophyses irregular; coccyx with bicondylar articulation and lateral flange extending about half its length; sternum of pectoral girdle well developed and ossified; prepollex a single distinct element about the same length as metacarpal 1; prepollex and metacarpal 1 fused at proximal end; phalangeal formula 1-2-3-3 for manus and 2-2-3-4-3 for foot.

*Habitat and Distribution:* All specimens of *Atelopus vermiculatus* were collected during the day between 0800 and 1800 from 24 July to 18 August,



FIGURE 5. Map of northeastern South America showing locality records of *Atelopus vermiculatus* (triangles) and *Atelopus flavescens* (solid circles).

1968. When collected the frogs were moving slowly (making short jumps or walking) on the forest floor.

The area around the Bruynzeel lumber camp on the lower Rivière Matarony (Fig. 4) consists of low forested hills; the hills are well drained but there are swampy creeks at their bases. The forest is relatively undisturbed. Some large, buttressed trees, greater than 25 m high, are present but the forest consists primarily of palms and some smaller trees. The undergrowth is not very dense and walking is easy. The undergrowth shrubs are head high or less; a species of *Dracontium* (Araceae) is common. There is a heavy cover of dead leaves on the forest floor. Some of the common trees are the spiny palm *Astrocaryum*, *Lecythis davisii* (Lecythidaceae), *Clusia* sp. (Guttiferae), *Sterculia* sp. (Sterculiaceae), *Apeiba* sp. (Tiliaceae), and *Parkia* sp. (Leguminosae).

The other three localities are farther up stream along tributaries of the Fleuve Approuague (Fig. 4). Apparently there is no tidal influence in the creek at these localities. The forest in this area is undisturbed and similar in stature to

that near the Bruynzeel camp. The spiny palm *Astrocaryum* is common here also, together with *Attalea spectabilis* (Palmae), species of *Sterculia* and *Caryocar* (Caryocaraceae).

At present, *A. vermiculatus* is known only from the drainage system of the Fleuve Approuague. Additional collecting in the basins of the Rivière Compté to the northwest and the Rio Oiapoque to the south may reveal its presence in those river systems. The closely related species *A. flavescens* has been collected east of the Fleuve Approuague at several localities in the region drained by the Crique Grand Inini, a tributary of the Maroni Rivière (MCZ 43502-08). *Atelopus flavescens* also is known from Cayenne (type locality) and several localities in Surinam and Guyana to the east (Boulenger 1882; Van Lidth de Jeude 1904) as well as from the Brazilian territory of Amapá (LACM 42045-48), and the state of Pará (KU 129954-60) to the south (Fig. 5).

*Ecology:* It is interesting that mature females outnumbered males nearly 4 to 1. The larger size of the females might lead one to conclude that a collecting bias for larger frogs influenced the sample. While this might in part account for the difference, the relatively large sample of immature specimens suggests no such bias. A more reasonable explanation may lie in the habitats sampled. McDiarmid (1971) suggested that male *Atelopus* spend much of the breeding season along streams while the females often are found on hillsides and in the forest some distance from the streams. Silverstone collected most of the specimens along trails leading through the forest and away from the rivers and streams. Thus, it appears that most of the collecting was done in areas where females might be more common than males. In this sense *A. vermiculatus* apparently partitions the habitat according to sex. This same situation has been recorded for *A. varius* in Costa Rica (McDiarmid, 1971) and *A. cruciger* in Venezuela (Sexton, 1958).

All large females collected contain ovarian eggs. No recently spent females were found. The largest males were reproductively active and have moderately developed nuptial pads and enlarged testes. It appears that these frogs were about to begin breeding. All other species of *Atelopus* for which data are available breed in streams (McDiarmid, 1971). Streams in seasonal tropical forests are subject to tremendous fluctuations in water level during the rainy season. Amphibians that breed in streams during the rainy season experience high mortality to eggs and early larval stages as a result of high water and movement of rocks and debris on the stream bottom during torrential storms. As a result, there has been strong selection to concentrate breeding activity in the dry season in some stream breeding frogs (i.e., *Smilisca sordida*, James, 1944; Duellman and Trueb, 1966). The breeding sites and larvae of *A. vermiculatus* are unknown. However, it is assumed that this species is also a stream breeder. The timing of breeding activity in *A. vermiculatus* apparently corresponds to the seasonal distribution of rain in the area. April and May are the wettest months (>450 mm/month) with a gradual drying through June, July, and August; the main dry season (< 40 mm/month) occurs in September and October. The fact that all large females and males collected in July and

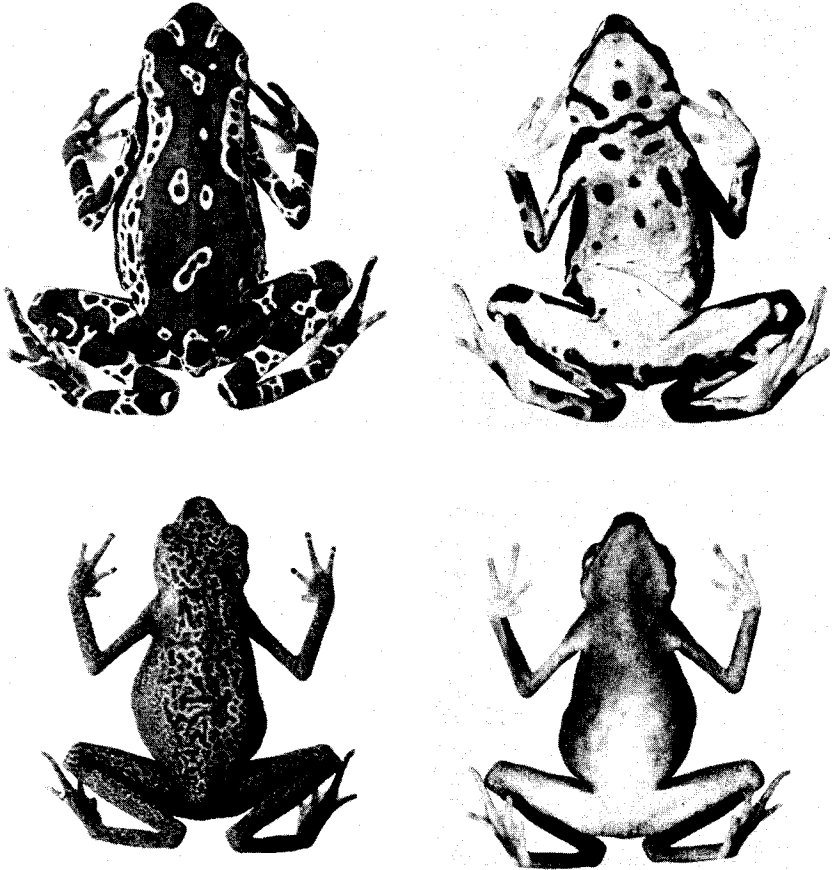


FIGURE 6. Dorsal and ventral views of an adult female *Atelopus flavescens* (LACM 42046, SV-35.9) and an adult female *Atelopus vermiculatus*, new species (LACM 42056, SV-28.2).

August are reproductively active and that September and October are the driest months supports my contention that *Atelopus vermiculatus* carries on breeding activity during the dry season. The streams are slower and quieter during this period, and there is less chance of periodic flooding that could result in high mortality to the eggs and larvae.

*Remarks:* One of the major problems encountered in understanding relationships among species of *Atelopus* is the lack of well-defined species groups. McDiarmid (1971) referred to long-legged and short-legged species of *Atelopus* and mentioned some morphological traits associated with some of the species in each group. In some respects (i.e. habitus) *A. vermiculatus* would be associated with the long-legged species, as represented by *A. spurrelli* and

*A. varius*. However, *A. vermiculatus* has an internal tympanum and middle ear and in this respect is most closely related to *A. flavescens* and *A. spumarius* (including *A. pulcher*, Rivero, 1968). These three species form a natural group and are distinct from all other species of *Atelopus* that have been studied.

Rivero (1968) included *Atelopus flavescens* and *A. spumarius* in the same group and suggested the two species probably were remnants of a once-continuous population. At that time *A. flavescens* was known only from French Guiana (Duméril and Bibron, 1841), British Guiana and "Interior of Brazil" (Boulenger, 1882), and Surinam (Van Lidth de Jeude, 1904). Literature reports of *A. flavescens* from near Quito, Ecuador (Cornalia, 1849) and from Central Brazil (Miranda-Ribeiro, 1926) are in error. *Atelopus spumarius* is known from eastern Peru and Ecuador. Collection of specimens from the Amazon Basin (Fig. 5) indicates a much wider range for *A. flavescens* and lends support to Rivero's suggestion of a once-continuous population. Additional material from the western parts of the Amazon Basin and subsequent detailed analysis of the species might indicate that *A. flavescens* and *A. spumarius* are conspecific.

*Atelopus vermiculatus* apparently was derived from *A. flavescens* and subsequently isolated in the drainage system of the Fleuve Approuague in French Guiana. A morphometric comparison of *A. vermiculatus* and four samples of *A. flavescens*, using the proportions listed in Table I, was of little use in distinguishing the two species, primarily because of the interpopulational variation in *A. flavescens*. Thus, the two species are most easily distinguished on the basis of the striking differences in size and coloration. Adult *A. flavescens* are considerably larger (mature male SV 24.2-32.2,  $\bar{x}$  = 28.9, N = 15; mature female SV 29.5-40.3,  $\bar{x}$  = 34.3, N = 10) than adult *A. vermiculatus* (mature male SV 19.3-22.1,  $\bar{x}$  = 21.3, N = 4; mature female SV 26.8-31.3,  $\bar{x}$  = 28.9, N = 14). The marked differences in coloration between the two species are illustrated in Figure 6.

#### SPECIMENS EXAMINED

##### *Atelopus flavescens*:

Guyana (British Guiana): Kartabo (AMNH 21332-34, 53304-05, 13528-29); Kalacoon (AMNH 70997-71001 + 6); Kangaruma (AMNH 39725).

Surinam: Brownsberg (AMNH 77449).

French Guiana: Degrade Leonce, Petite Inini Rivière (MCZ 43502); on trail between Sophie and La Greve (MCZ 43503-07); on trail between Dorlin and Sophie (MCZ 43508).

Brazil: Território de Amapá, Serado Navio, Serra de Veado, hills east of mine (LACM 42045-48); Pará, Sudam Floral Reserve, 74 km SE Santarem (KU 129954-60).

#### ACKNOWLEDGMENTS

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Zoology, Harvard University (MCZ); John W. Wright, Natural History Museum of Los Angeles County, Los Angeles (LACM); and Richard G. Zweifel and Charles W. Myers, American Museum of Natural History, New York (AMNH). Mercedes McDiarmid and John Wright read an earlier draft of this paper and made several helpful suggestions. Jim Feigl photographed the specimens of *Atelopus* and Betty Ingalls illustrated Figure 2. I would like to thank all of these people for their help.

#### RESUMEN

Una nueva especie de rana, *Atelopus vermiculatus*, se describe basada en una serie de adultos y juveniles colectados en Guiana Francés. La nueva especie tiene un tímpano interno y oído medio y, en este respecto, se distingue de todas otras especies de *Atelopus* con excepción de *A. flavescens* y *spumarius*, de cuales puede ser distinguida fácilmente por el tamaño pequeño y la coloración distintiva.

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