

# B R E V I O R A

Museum of Comparative Zoology

US ISSN 0006-9698

CAMBRIDGE, MASS.

2 FEBRUARY 2009

NUMBER 515

**A NEW SQUEAKER FROG (ARTHROLEPTIDAE: *ARTHROLEPTIS*) FROM THE CAMEROON VOLCANIC LINE WITH REDESCRIPTIONS OF *ARTHROLEPTIS ADOLFRIEDERICI* NIEDEN, 1911 "1910" AND *A. VARIABILIS* MATSCHIE, 1893**

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**ABSTRACT.** We describe a new species of squeaker frog (*Arthroleptis*) from Mt. Manengouba in southwestern Cameroon. The new species is distinguished from other Cameroonian *Arthroleptis* by moderately larger body size; a darkened throat and posterior thigh, both with many white spots; and, in females, a fourth finger longer than the first and second fingers. This species corresponds to a Cameroonian taxon previously identified as *Arthroleptis adolfriederici* but which has been long recognized as distinct. Multivariate morphometric analysis demonstrates that the new taxon is distinct from *Arthroleptis variabilis*, which occurs in the surrounding lowlands. Because of the general similarity of the new species to *A. variabilis* and its previous confusion with *A. adolfriederici*, redescriptions of the latter two species are provided. This refinement of taxonomic knowledge will facilitate future study of cryptic or undescribed large *Arthroleptis* from western, central, and eastern Africa.

**KEY WORDS:** Amphibia; Anura; new species; biodiversity hotspot; Cameroon highlands; central Africa

**RÉSUMÉ.** Nous décrivons une nouvelle espèce de grenouille (*Arthroleptis*) du Mont Manengouba au sud du Cameroun. La nouvelle espèce se distingue des autres *Arthroleptis* Camerounaises par sa modérément plus grande taille corporelle, de nombreux points blancs trouvés à la fois sur le cou sombre et sur les cuisses postérieures, et, chez les femelles, un quatrième doigt plus long que les premier et deuxième doigts. Cette espèce correspond à un taxon Camerounais préalablement identifié en tant que *A. adolfriederici*, mais qui est depuis longtemps reconnu comme distinct de celui-ci. Des analyses morphométriques multivariées démontrent que ce nouveau taxon est différent de *A. variabilis*, qui est trouvé dans les basses plaines environnantes. Du fait de la confusion antérieure entre la nouvelle espèce et *A. adolfriederici*, et du fait de sa ressemblance à *A. variabilis*, nous décrivons à nouveau ces dernières deux

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espèces. Ce raffinement de notre connaissance taxonomique facilitera les études futures portant sur les *Arthroleptis* larges, cryptiques ou non décrits, et en provenance d'Afrique de l'Ouest, de l'Est et Centrale.

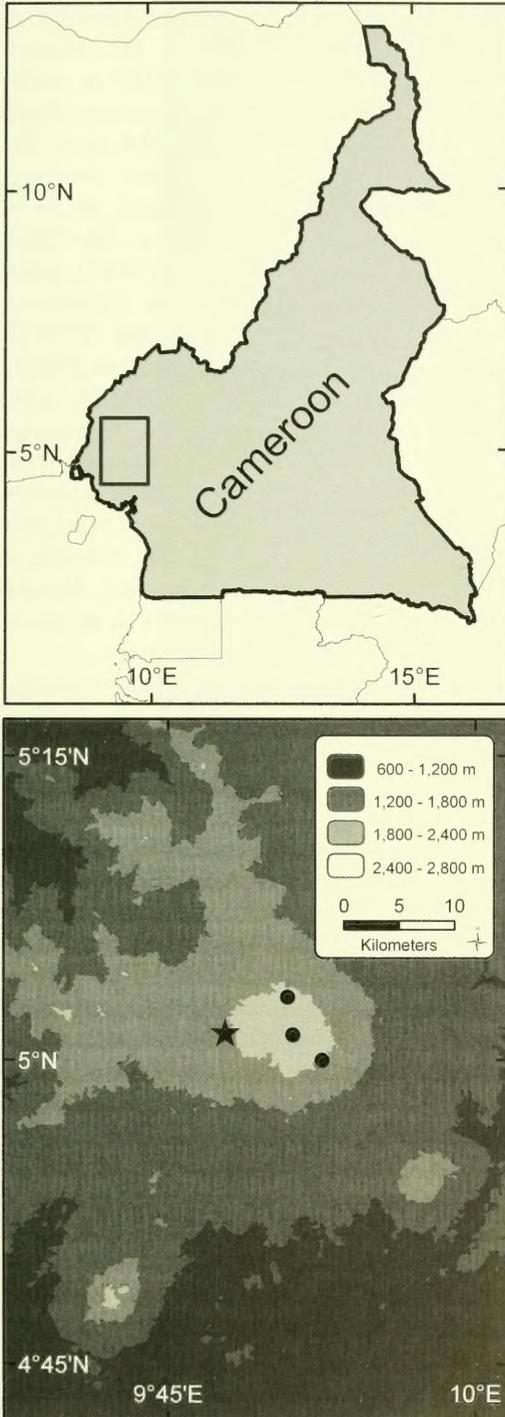
Squeaker frogs (*Arthroleptis sensu* Frost, 2007) are distributed throughout much of sub-Saharan Africa. This genus occurs in two biodiversity hotspots deemed conservation priorities (Myers et al., 2000) and likely contains high levels of cryptic species diversity (e.g., Poynton, 2003b; Rödel and Bangoura, 2004). The taxonomic history of *Arthroleptis* is characterized by long-standing disagreements between researchers about the status of both species and supraspecific taxa (e.g., Laurent, 1940, 1954, 1973; Perret, 1991; Poynton, 1976, 2003a; Poynton and Broadley, 1985; Schmidt and Inger, 1959). Typically, these disagreements focus on the smallest species, which previously were placed in *Schoutedenella* but now are included within *Arthroleptis* (Frost et al., 2006; see also Blackburn, 2008a). One large species that has caused significant taxonomic confusion is *Arthroleptis adolfifriederici* Nieden 1911 "1910," which was originally described on the basis of two specimens from the mountains of Rwanda. Shortly thereafter, Nieden (1913) assigned specimens from northeastern Tanzania to *A. adolfifriederici*, and Noble (1924) stated that this species occurs from "Cameroon eastward to the Lake Region." It is unclear, however, on what basis Noble's (1924) range was established. Over the past century, *A. adolfifriederici* has been claimed to occur in Cameroon at the western extent of its distribution (e.g., Noble, 1924; Perret, 1966) to the Eastern Arc Mountains of Tanzania and Kenya at its eastern extent (e.g., Barbour and Loveridge, 1928; Channing and Howell, 2006; Loveridge, 1942, 1957). Specimens from Cameroon have long been recognized as distinct from *A. adolfifriederici*; however, this taxon has remained undescribed (e.g., Amiet, 1987; Frost, 1985, 2007; Gartshore,

1986; Global Amphibian Assessment, 2006; Herrmann et al., 2005). Tanzanian populations previously assigned to *A. adolfifriederici* correspond to several currently recognized taxa, including *Arthroleptis affinis* Ahl, 1939 "1938," *Arthroleptis tanneri* Grandison, 1983, and possibly *Arthroleptis leleupi* Skelton-Bourgeois, 1961 (Grandison, 1983; Poynton, 2003b; Poynton and Loader, 2008), and it is unlikely that *A. adolfifriederici* occurs in eastern Tanzania (e.g., Poynton and Loader, 2008).

During recent fieldwork on Mt. Manengouba in southwestern Cameroon, specimens of an undescribed *Arthroleptis* species were found. These specimens are distinct from all other described Cameroonian species. The similarity between these specimens and Perret's (1966) description of *A. adolfifriederici* from near Nkongsamba, approximately 10 km southeast of Mt. Manengouba, initiated this study, which describes these specimens as a new species.

## MATERIALS AND METHODS

Specimens were collected during visual encounter surveys on Mt. Manengouba in the Republic of Cameroon (Fig. 1). Surveys were conducted in and near the village of Nsong, as well as near Moabi and Ebomin and in forests near the summit. Animals were euthanatized in an aqueous solution of chlorotone following standard collections procedures (Simmons, 2002). Liver tissue samples were preserved in 95% ethanol; remaining voucher specimens were preserved overnight in 10% neutral buffered formalin before storage in 70% ethanol. Type material was examined of all species discussed, except those of *Arthroleptis stenodactylus* Pfeffer, 1893, which were destroyed during World



War II (Frost, 2007). All measurements ( $\pm 0.1$  mm) were taken with digital calipers and a dissecting microscope. Limb measurements were taken on the right side. Measurements follow Blackburn (2005), which is a modification of Matsui (1984). Images of preserved specimens were taken with a JVC 3-CCD digital camera mounted on a dissecting microscope with AutoMontage Pro 5.0 (Synoptics). Museum abbreviations follow Leviton et al. (1985), with the addition of Museums of Malawi, Blantyre (MMB).

To determine whether the new taxon differs morphologically from the superficially similar *Arthroleptis variabilis*, a multivariate analysis based on the type specimens was used for ordination. Twenty-seven adult specimens (including three syntypes) of *A. variabilis* were measured (Appendix 1). Because few male specimens have been collected of the new species, this analysis is restricted to female *A. variabilis*. Females were identified by large body size, the presence of ova (visible either in dissection or through the skin), the lack of male secondary sexual characters typical of the genus, or a combination of factors (Blackburn, in press). All data were natural log-transformed before analyses were conducted by R 2.7.1 for Mac OS X (The R Foundation for Statistical Computing, <http://www.R-project.org>). A multivariate ordination technique, principal component analysis (PCA), was used to analyze patterns of variation and covariation within the measurement data. The covariance matrix, rather than a correlation matrix, was used, and all component axes were scaled to be equal to their eigenvalues. Those components ac-

Figure 1. Distribution of *Arthroleptis perreti* on Mt. Manengouba in southwest Cameroon. Star designates type locality near village of Nsong; circles indicate paratype localities.

counting for 85% of the cumulative variance were retrieved from the analysis. The relationship between the two species in morphospace was evaluated by plotting principal component (PC) scores.

## DESCRIPTION OF NEW SPECIES

### *Arthroleptis perreti*, new species

Perret's Squeaker Frog

Figures 2, 3

*Arthroleptis adolfifriederici*: Perret (1966): 396.

*Arthroleptis* sp. 7: Gartshore (1986): 220. Following personal communication with J.-L. Amiet; Amiet (1987): 100.

*Holotype*. MCZ A-137978 (field number DCB 34368), adult female, Republic of Cameroon, Southwest Province, near village of Nsong, southwest slope of Mt. Manengouba, 04°59'05.5"N, 009°48'41.0"E, 1,400 m elevation, 13 July 2006, D. C. Blackburn, K. S. Blackburn, and M. T. Kouete.

*Paratypes*. MCZ A-136931 (DCB 34208), A-136932 (DCB 34209), subadult female and juvenile, respectively, Republic of Cameroon, Littoral Province, Mt. Manengouba, 05°00'38.9"N, 009°51'24.8"E, 2,160 m elevation, type locality of *Cardioglossa manengouba* (Blackburn, 2008b), 27 September 2004, D. C. Blackburn, J. L. Dikko, and L. N. Gonwouo; MCZ A-137980 (DCB 34432), adult female, Republic of Cameroon, Southwest Province, Mt. Manengouba, 05°01'48.9"N, 009°50'37.3"E, 2,110 m elevation, 21 July 2006, D. C. Blackburn, K. S. Blackburn, M. T. Kouete; MCZ A-137981 (DCB 34434), juvenile, Republic of Cameroon, Southwest Province, Mt. Manengouba, 05°01'09.1"N, 009°51'04.0"E, ~ 2,180 m elevation, same date and collectors as A-137980; ZMB 71471 (86G), Republic of Cameroon, Littoral Province, Mt. Manengouba, near summit, adult female (42.0 mm), 05°01'N, 009°52'E, 22 March 2006, L. N. Gonwouo; ZMB 71472

(705G), adult male (27.4 mm), Republic of Cameroon, Littoral Province, Mt. Manengouba, 05°00'N, 009°49'E, 2,045 m elevation, 6 August 2005, L. N. Gonwouo; ZMB 71473 (560G), adult female (39.6 mm), Republic of Cameroon, Southwest Province, Mt. Manengouba, near Nsong, 04°59'N, 009°48'E, 1,420 m elevation, 4 July 2004, L.N. Gonwouo; ZMB 71474 (103G), adult male (30.6 mm), Republic of Cameroon, Littoral Province, Mt. Manengouba, 05°00'N, 009°49'E, 2,045 m elevation, 6 August 2005, L. N. Gonwouo; ZMB 71475 (0883N), adult female (34.7 mm), Republic of Cameroon, Littoral Province, Mt. Manengouba, near summit, 05°00'N, 009°51'E, 2,200 m elevation, 17 March 2006, L. N. Gonwouo; ZMB 71476 (0023LG), adult female (39.3 mm), Republic of Cameroon, Littoral Province, Mt. Manengouba, 05°00'N, 009°51'E, 2,185 m elevation, 28 September 2006, L. N. Gonwouo.

*Additional Material*. Specimens collected by Legrand N. Gonwouo on Mt. Manengouba, Republic of Cameroon; sex and snout-vent length (SVL) are provided for each specimen.

ZMB 71484 (0263LG), juvenile (22.9 mm), western flank, no data available, ~ 1,500 m elevation, 20 December 2006; ZMB 71478 (0899N), adult female (41.5 mm), near Manengouba lakes, 05°01'49"N, 009°50'39"E, 2,155 m elevation, 20 March 2006; ZMB 71479 (282C), juvenile (22.6 mm), near Nsong, 04°59'N, 009°48'E, 1,420 m elevation, 4 July 2005; ZMB 71485 (0393N), adult female (37.9 mm), near Moabi, 05°10'N, 009°50'E, 1,980 m elevation, 12 August 2005; ZMB 71486 (0396N), juvenile (23.6 mm), near Moabi, 05°10'N, 009°50'E, 1,980 m elevation, 12 August 2005; ZMB 71487 (0804N), juvenile (23.1 mm), near Ebonemin, 05°00'N, 009°44'E, 1,650 m elevation, 18 November 2005; ZMB 71488 (0992N), juvenile (25.1 mm), near Ebonemin, 05°01'N, 009°46'E, 1,465 m elevation, 16 November

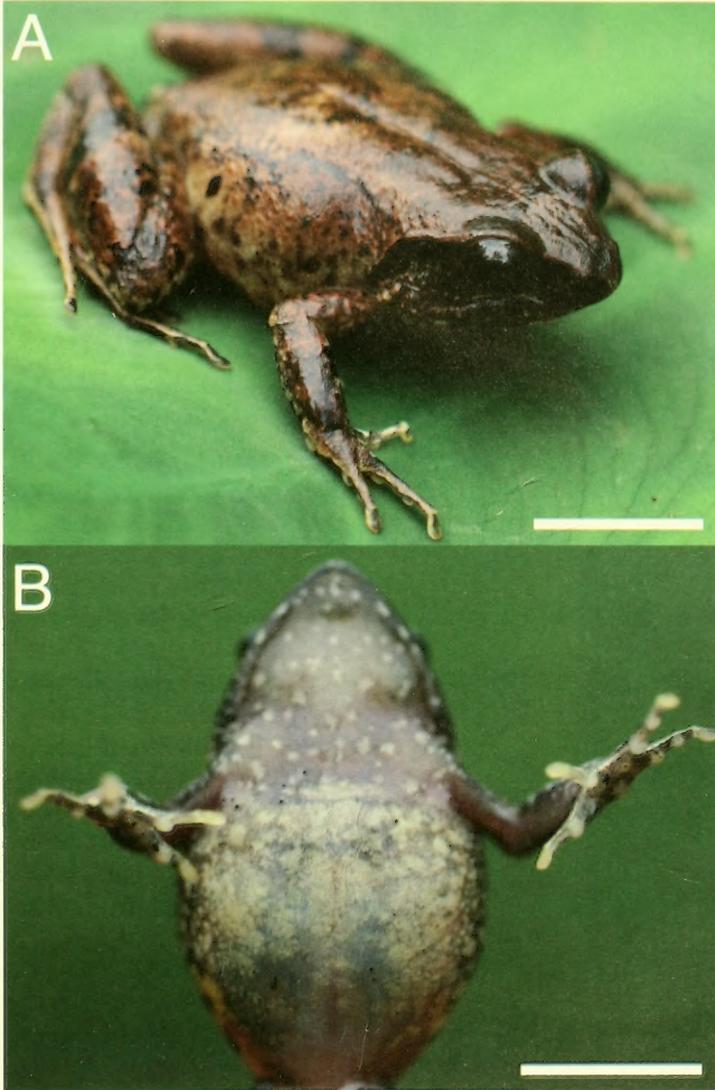


Figure 2. *Arthroleptis perreti* in life: holotype (MCZ A-137978) in rostrolateral view (A), and paratype (MCZ A-137980) in ventral view (B). Scale bar, 10 mm.

2005; ZMB 71489 (0945N), juvenile (25.1 mm), no data available, ~ 2,085 m elevation, 13 August 2005; ZMB 71490 (0963N), adult female (41.1 mm), no data available, ~ 2,085 m elevation, 5 September 2005; ZMB 71491 (88G), near summit, adult female (44.7 mm), 05°01'N, 009°52'E, 22 March 2006; ZMB

71492 (0865N), adult female (42.7 mm), near summit, 05°00'N, 009°51'E, 2,185 m elevation, 15 March 2006; ZMB 71494 (0884N), juvenile (21.7 mm), near summit, 05°00'N, 009°51'E, 2,200 m elevation, 17 March 2006; ZMB 71495 (0893N), adult female (33.0 mm), near summit, 05°00'N, 009°51'E, 2,200 m

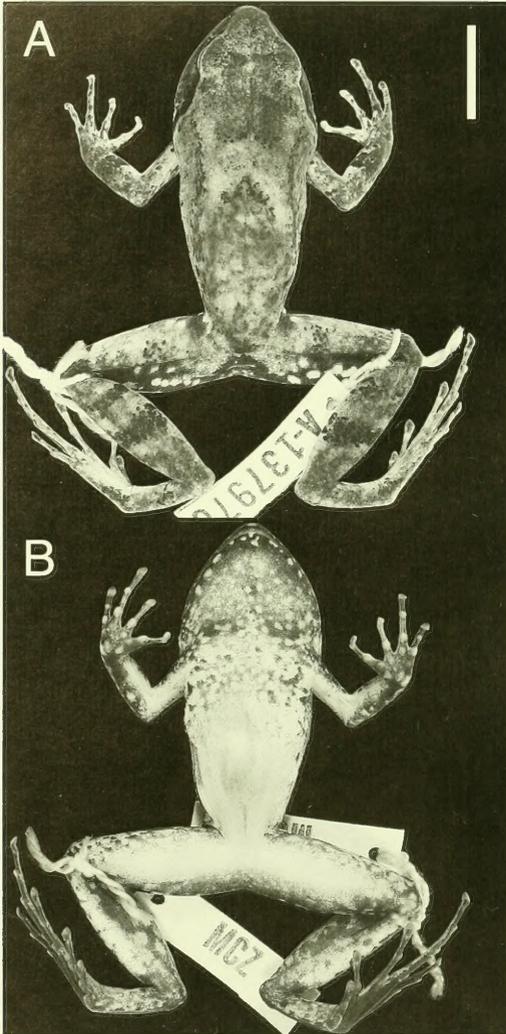


Figure 3. *Arthroleptis perreti* holotype (MCZ A-137978) in dorsal (A) and ventral (B) views. Scale bar, 10 mm.

elevation, 17 March 2006; ZMB 71496 (31G), adult female (35.5 mm), 4°59'N, 009°48'E, 2,045 m elevation, 6 August 2005; ZMB 71498 (553G), adult female (40.2 mm), 05°00'N, 009°49'E, 2,045 m elevation, 6 August 2005; ZMB 71499 (843C), adult female (34.2 mm), 05°00'N, 009°49'E, 2,045 m elevation, 6 August 2005; ZMB 71500

(0006LG), adult female (38.3 mm), 04°59'N, 009°50'E, 2,010 m elevation, 25 September 2006; ZMB 71501 (0007LG), adult male (30.4 mm), 04°59'N, 009°50'E, 2,010 m elevation, 25 September 2006; ZMB 71502 (0020LG), adult female (37.2 mm), 04°59'N, 009°50'E, 2,010 m elevation, 25 September 2006; ZMB 71503 (0022LG), adult female (37.6 mm), 05°00'N, 009°51'E, 2,185 m elevation, 28 September 2006; ZMB 71504 (0024LG), adult female (35.5 mm), 05°00'N, 009°51'E, 2,185 m elevation, 28 September 2006; ZMB 71505 (0027LG), juvenile (22.0 mm), 05°00'N, 009°51'E, 2,185 m elevation, 28 September 2006; ZMB 71506 (0044LG), juvenile (27.2 mm), 05°02'N, 009°86'E, 2,066 m elevation, 28 September 2006; ZMB 71507 (0045LG), adult female (36.8 mm), 05°02'N, 009°86'E, 2,066 m elevation, 28 September 2006; ZMB 71508 (0048LG), adult female (43.8 mm), 05°00'N, 009°49'E, 2,184 m elevation, 30 September 2006; ZMB 71509 (0053LG), adult female (27.4 mm), 05°00'N, 009°49'E, 2,184 m elevation, 30 September 2006; ZMB 71510 (0182LG), adult female (36.8 mm), 04°59'N, 009°47'E, 1,393 m elevation, 19 November 2006.

**Diagnosis.** A medium-sized *Arthroleptis* that is very similar to *A. variabilis* but readily distinguished from that species by lacking a midline gular stripe (Fig. 2) and by having a relatively longer snout and, in females, a fourth finger that is longer than the first and second fingers (see *Variation* section). In addition, the posterior surface of the thigh of *A. perreti* is dark gray with many small white spots (Fig. 3), whereas in *A. variabilis*, the posterior surface of the thigh exhibits poorly defined light mottling on a dark-brown or -gray background. Maximum body size in *A. perreti* (44.7 mm SVL, ZMB 71491) is larger than that of other described species of Cameroonian *Arthroleptis*, including *A. variabilis* (37.8 mm SVL; Blackburn, 2008a); mean male SVL of *A. perreti* is 29.5 mm ( $n =$

3;  $\pm 1.8$ ), whereas mean female SVL is 37.5 mm ( $n = 25$ ;  $\pm 4.3$ ). *Arthroleptis perreti* differs in the following ways from other medium to large *Arthroleptis* (maximum SVL  $> 35$  mm): from *A. adolfifriederici* by less granular skin, more extensive pigmentation on throat, and less globular inner metatarsal tubercle; from *A. affinis* by lacking supernumerary tubercles on the feet; from *Arthroleptis francei* and *A. stenodactylus* by tibiofibula length greater than 50% SVL; from *Arthroleptis krokosua* by lighter pigmentation on throat and vent, lacking large well-defined black spots on the lateral surface of the body, and by a fourth finger that is longer than the first and second fingers; from *A. stenodactylus* by an inner metatarsal tubercle length less than 80% of first toe length; from *Arthroleptis nikeae* by much smaller adult body size ( $> 50$  mm SVL in *A. nikeae*); from *A. tanneri* by a relatively narrower head; from *A. variabilis* by lacking a white stripe on the midline of throat; and from both *A. stenodactylus* and *A. variabilis* by having a relatively smaller and more globose inner metatarsal tubercle.

*Description of Holotype.* Medium-sized (37.4 mm SVL), moderately robust female with slender limbs (Figs. 2A, 3; Online Table 1); head somewhat broad, head length 79% head width; snout projecting approximately 1 mm beyond lower jaw; rostral tip rounded in dorsal view, blunt and only slightly curving posteroventrally in lateral view; eyes barely project beyond eyelids in dorsal view; eyes placed well medial of, and not projecting laterally beyond, margins of head; eyes flush with dorsal margin of head in lateral view; eye diameter approximately equal to interorbital distance; pupil round to slightly horizontally elliptical in preservative; loreal region weakly concave; naris small, rounded, facing laterally, and barely visible in dorsal view; canthus rostralis short, indistinct, rounded; eye diameter 1.5 times

eye-narial distance; eye diameter 2.1 times distance from naris to rostral tip; internarial region flat; internarial distance 90% interorbital distance; tympanum distinctly ovoid, height slightly less than half the diameter of eye; tympanic annulus poorly defined; supratympanic fold absent; tongue very broad, heart-shaped, covered with many small pustules; anterior attachment of tongue narrow; posterior notch of tongue approximately one fourth anteroposterior length of tongue; prominent, flat, flap-like median papilla on dorsal tongue surface near anterior attachment; choana hidden by maxillary shelf in ventral view; premaxillary and maxillary teeth present, but hidden by lips; vomerine teeth absent.

Skin of limbs, dorsal surface of head and body, and ventral head smooth (more tuberculate in life; Fig. 2); skin of lateral body glandular, becoming more indistinct on ventral surface; median skin raphe prominent in life (Fig. 2), but very indistinct in preservative; cloacal region weakly glandular.

Limbs and digits well developed but slender; digits of both manus and pes slender; relative length of fingers: III  $>$  IV  $>$  II  $\geq$  I; fingertips rounded, slightly swollen, approximately same width as rest of finger; finger with rounded, prominent, globular, single subarticular tubercles; palmar and metacarpal tubercles present but weakly developed and barely projecting from surface of hand; webbing between manual digits absent; thigh length 93% of crus length; relative length of toes: IV  $>$  III  $>$  V  $>$  II  $>$  I; toe tips pointed and slightly expanded to approximately same width as interphalangeal regions; toes with prominent, single, elongate, and slightly conical subarticular tubercles; webbing between pedal digits absent; prominent flange-like inner metatarsal tubercle, length 72% of first toe length.

*Measurements.* See Online Table 1.

*Coloration of Holotype (in Alcohol).* Dorsal ground color silvery brown with small, weakly defined gray and well-defined dark-brown spots (Fig. 3); iris dark brown with pale cream pupil; snout silvery gray to dark brown near rostral tip; loreal and suborbital regions nearly solid medium to dark brown becoming lighter and slightly broken posterior to eye; interorbital bar medium brown but broken and poorly delimited from other brown spots on posterodorsal surface of head; dark-brown supratympanic band extending from posterodorsal margin of orbit, slightly continuous with dark mask of suborbital region, extending posteroventrally and terminating anterior to and just dorsal of arm; tympanum translucent, with silver flecks, and darkened dorsally becoming confluent with supratympanic band; dorsal surface of arms silvery gray grading into dark brown on forearm and wrist; single, broken dark-brown band on forearm; dorsal surface of hands mottled gray and brown with large cream-colored spots on second and first fingers; ultimate interphalangeal joint of all fingers unpigmented and cream in color; posterior to skull, two dark-brown, highly broken chevrons with apices directed anteriorly, separated by light gray-brown region approximately 3.8 mm in anteroposterior length; highly broken, dark-brown band at lateral margin of dorsum extending from just above arm along lateral surface toward inguinal region before becoming indistinct; lateral surface of body with many small medium- and dark-brown spots and base color much lighter than dorsum grading into creamy white of ventral surface; dorsal surface of hind limbs grayish brown; very indistinct, broken, dark-brown band on dorsal surface of thigh; posterior surface of thigh dark brown with prominent large white spots (Fig. 3A); crus with two prominent transverse dark-brown stripes; feet mottled gray and brown with poorly defined medi-

um-brown spot on lateral margin of foot at base of metatarsal V; base color of dorsal foot silvery and creamy with many small brown well-defined melanocytes; general trend of lighter and less pigmentation from lateral to medial toes; dorsal surface of toe tips dark brown; ultimate phalangeal joints of toes I–III unpigmented and creamy; ultimate phalangeal joints of toes IV–V lighter in pigmentation than surrounding skin; dark-brown triangle with apex directed dorsally centered on cloaca.

Lateral margin of lower jaw dark brown with small white spots at regular intervals; throat brown with distinct white spots (Fig. 3B); posterior throat, just anterior to clavicles and laterally bordering omosternum, darker than rest of throat; medial surfaces of arm and forearm unpigmented and creamy; ventral surface of forearm very dark brown with several prominent white spots; ventral surface of hand and fingers brown; palmar, metacarpal, and subarticular tubercles unpigmented; ventral fingertips lighter in color than rest of finger; brown pigmentation of throat broken into mottling over pectoral girdle extending ventrally as diffuse brown pigmentation with large, poorly defined white spots; venter and ventral thigh both cream colored with few scattered brown melanocytes; ventral surface of crus mottled brown and cream; plantar surface homogeneous dark brown; subarticular tubercles on toes and inner metatarsal tubercle lighter brown, tending to gray, than surrounding skin but not unpigmented.

*Coloration in Life.* Based on D. C. Blackburn's field notes and photographs (Fig. 2). Dorsal coloration ranging from dark gray with brown markings (MCZ A-137980) to brown with red tones (MCZ A-137978; Fig. 2A); darker markings on dorsal and lateral surfaces ranging from light to dark brown and even black; lighter markings on lateral surface ranging from white to gray;

ventral surface of throat generally gray with faint creamy yellow tones; venter with more pronounced creamy yellow tones; bright yellow splotches in inguinal region (Fig. 2B).

*Variation.* Meristic variation is documented in Online Table 1. The median papilla of the tongue is more conical in MCZ A-137980. Sexual dimorphism in *A. perreti* is similar to that of other species of *Arthroleptis* (Blackburn, in press) and includes larger body size in females and the presence of an elongate third finger and both digital and inguinal spines in males. In male *A. perreti* (e.g., ZMB 71472 and 71474), small spines line the medial surface of both the second (MDII) and third (MDIII) fingers. The number of digital spines is comparable between the male paratypes (ZMB 71472, MDII right–6, left–8, MDIII right–17, left–18; ZMB 71474, MDII right–13, left–12, MDIII right–18, left–20). In the one larger male paratype (ZMB 71474), pronounced white spines are found in the inguinal region and extend both forward along the lateral surface of the body and dorsally onto the posterior dorsal surface of the body and the proximal dorsal surface of the hind limbs. Unlike females, the fourth finger of males of *A. perreti* is similar in length to that of the first and second fingers.

*Habitat and Range.* All specimens were collected in montane forest during the day (1000–1400 h) when they were active in moist leaf litter. The type series comes from high elevations (1,400–2,200 m elevation) on Mt. Manengouba (Fig. 1). Populations of *A. perreti* might also occur on several other nearby mountains, including Mt. Nlonako, Mt. Kupe, and in the Rumpfi Hills (Gartshore, 1986; Herrmann et al., 2005; Lawson, 1993; Perret, 1966). However, specimens studied by Lawson (1993) and Herrmann et al. (2005) do not correspond to *A. perreti* and represent *A. variabilis* (i.e., Lawson, 1993) or possibly another undescribed species (i.e.,

Herrmann et al., 2005). Even if present at these other localities, *A. perreti* would still have an extent of occurrence less than 20,000 km<sup>2</sup>.

*Conservation.* Given the small number of possible localities, extent of occurrence (presumably < 20,000 km<sup>2</sup>), and that both the extent and quality of forest habitats on Mt. Manengouba, and probably other nearby mountains, are declining (Gartshore, 1986; Global Amphibian Assessment, 2006; Gonwouo et al., 2006; Stuart, 1984), *A. perreti* should be considered Vulnerable according to IUCN (2001) criteria.

*Etymology.* This species is named in honor of Dr. Jean-Luc Perret who provided preliminary, but accurate, comments on this new species more than 40 years ago (Perret, 1966).

*Morphological Comparison with Arthroleptis variabilis.* As indicated in previous literature (Perret, 1966), this species is extremely similar to *A. variabilis* yet lacks the prominent white gular stripe. These species appear to be osteologically indistinguishable on the basis of radiographic analysis (Blackburn, unpublished data). PCA indicates that several morphological characters differentiate *A. perreti* from *A. variabilis* (Fig. 4). The first principal component axis (PC1) accounts for the majority (52.7%) of the variance in the data and is taken as a general measurement of body size (Table 1); *A. perreti* and *A. variabilis* are not differentiated along PC1. The second principal components axis (PC2) accounts for 19.4% of the variance and plots of PC2 scores reveal that *A. perreti* and *A. variabilis* are differentiable along this axis (Fig. 4). Plots of PC3 scores do not reveal differences between these two species. PC2 loads most strongly, and positively, on inner metatarsal tubercle length, eye diameter, and tympanum height (Table 1). The strongest negative loadings for PC2 are on snout length, fourth finger length, and fifth toe length. Because

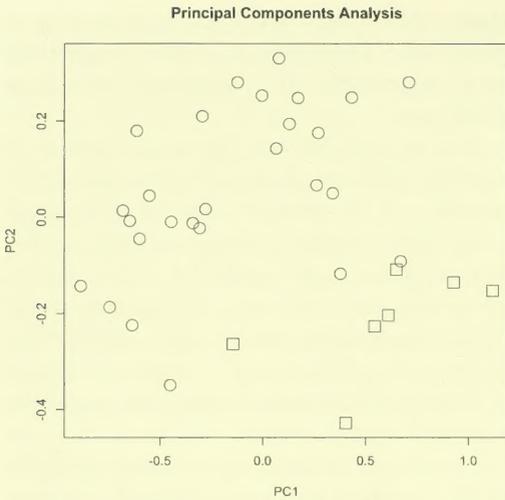


Figure 4. Scatterplot of the first and second principal component scores. The second principal component (PC2) is plotted against the first principal component (PC1), an indicator of body size. Circles represent *Arthroleptis variabilis*, squares represent *Arthroleptis perreti*.

PC2 scores for *A. perreti* are lower than all but one specimen of *A. variabilis*, these results together indicate that the length of the inner metatarsal tubercle, eye diameter, and tympanum height are relatively greater in *A. variabilis* and that the snout, fourth finger, and fifth toe are relatively longer in *A. perreti*. Following this PCA, visual inspection of the specimens indicated that only relative fourth finger length is a reliable diagnostic without actually taking measurements.

### REDESCRIPTIONS

*Arthroleptis perreti* has been previously confused with *A. adolfifriederici* (e.g., Amiet, 1975; Gartshore, 1986; Herrmann et al., 2005; Lawson, 1993; Perret, 1966; Plath et al., 2004). Although the features given by Perret (1966) are sufficient to distinguish *A. perreti* from both *A. adolfifriederici* and *A. variabilis*, this species remained undescribed for more than 40 years. This is likely due, at least in part, to the general inadequacy of the original

TABLE 1. PRINCIPAL COMPONENTS ANALYSIS COMPARING *ARTHROLEPTIS PERRETI* AND *ARTHROLEPTIS VARIABILIS*. EIGENVALUES, PERCENT VARIANCE, CUMULATIVE VARIANCE, AND LOADINGS FOR THE FIRST THREE PRINCIPAL COMPONENT (PC) AXES.

	PC1	PC2	PC3
Eigenvalue	0.278	0.038	0.023
Percent variance	52.68	19.44	15.13
Cumulative variance	52.68	72.12	87.25
Loadings			
Snout-vent length	0.171	0.117	-0.219
Head width	0.150	0.121	-0.171
Tympanum height	0.220	0.224	-0.446
Eye diameter	0.119	0.166	-0.552
Snout length	0.266	-0.245	-0.107
Forearm length	0.163	0.174	-0.153
Manual digit I	0.205	0.327	0.293
Manual digit II	0.252	0.166	0.135
Manual digit III	0.246	0.072	0.107
Manual digit IV	0.335	-0.231	0.053
Thigh length	0.210	-0.061	-0.235
Crus length	0.195	-0.086	-0.125
Pedal digit I	0.275	-0.099	0.315
Pedal digit II	0.256	-0.124	0.117
Pedal digit III	0.270	-0.151	0.069
Pedal digit IV	0.256	-0.177	-0.007
Pedal digit V	0.314	-0.293	0.073
Inner metatarsal length	0.224	0.659	0.267

descriptions of *A. adolfifriederici* and *A. variabilis*. Furthermore, recent studies describing new species of large *Arthroleptis* from the Eastern Arc Mountains have had to rely on only a single specimen of *A. adolfifriederici* from near the type locality for this species (Poynton, 2003b; Poynton and Loader, 2008). Redescriptions of *A. adolfifriederici* and *A. variabilis* are thus provided here.

#### *Arthroleptis adolfifriederici* Nieden, 1911 "1910"

Rugege Forest Squeaker Frog  
Adolf Friedrich's Squeaker Frog  
Figure 5

*Arthroleptis adolfi-friederici*: Nieden (1911): 440. Syntypes: ZMB 21787, FMNH 73836 (formerly ZMB 21789): Rwanda, Rugege

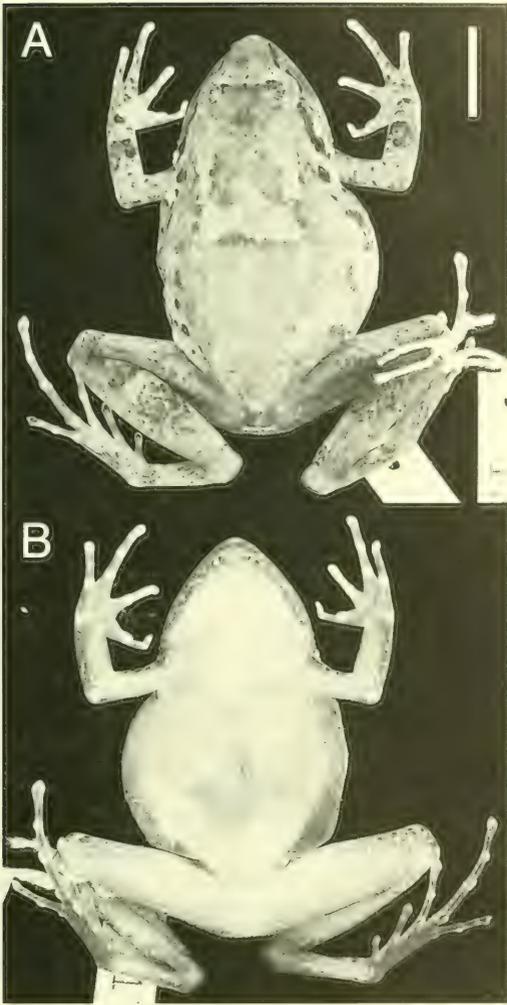


Figure 5. *Arthroleptis adolfifriederici* (CAS 177031) in dorsal (A) and ventral (B) views. Scale bar, 10 mm.

(presently called Nyungwe; Gartshore, 1986) and Bugoie (= Bugoya?) Forests; Nyungwe Forest, ca. 02°20'S to 02°45'S, 029°05'E to 029°25'E, ca. 1,800–2,400 m elevation (lat., long., elev., estimated).

*Arthroleptis adolfi-friederici*: Nieden (1913): 165. Incorrect subsequent spelling.

*Arthroleptis* (*Abroscaphus*) *adolphi-friederici*: Laurent (1940): 82.

*Arthroleptis adolfifriederici*: Loveridge (1942): 429 (part). Hyphen removed from name.

*Arthrolepis adolfifriederici adolfifriederici*: Loveridge (1953): 387; Skelton-Bourgeois (1961): 323.

*Abroscaphus adolfi-friederici*: Laurent (1957): 275.

*Arthroleptis adolfifriederici*: Loveridge (1957): 352 (part). Incorrect subsequent spelling.

*Reference Sample*. Type material, sex, and SVL (mm) indicated in parentheses. Democratic Republic of Congo: MCZ A-14696 (female). Rwanda: FMNH 73836 (syntype [formerly ZMB 21789]; female, 40.1); ZMB 21787 (syntype; female, 42.0); KU 154322 (male), 154323–325 (females, 30.1, 38.0, 39.1). Uganda: CAS 177029 (female, 35.8), 177030 (cleared and stained; female, SVL undocumented), 177031 (female, 43.4), 177032 (juvenile, 22.2), 177033 (male, 27.6).

*Diagnosis*. A medium-large *Arthroleptis* characterized by long, slender hind limbs, a fourth finger as long as or much longer than the first and second fingers, and generally glandular skin. *Arthroleptis adolfifriederici* differs in the following ways from other medium to large *Arthroleptis* (maximum SVL > 35 mm): from *A. affinis* by a less prominent and less round tympanum and by lacking supernumerary tubercles on the feet; from *A. francei* and *A. stenodactylus* by crus length much greater than 50% SVL; from *A. krokosua* by lighter pigmentation on throat and vent and lacking large well-defined black spots on the lateral surface of the body; from *A. perreti* by a more globose inner metatarsal tubercle, more glandular skin, and less pigmentation on throat; from *A. nikeae* by smaller adult body size (> 50 mm in *A. nikeae*); from *A. stenodactylus* by an inner metatarsal tubercle length less than 80% first toe length; from *A. tanneri* by a relatively narrower head; from *A. variabilis* by lacking a white stripe on the midline of throat; from both *A. stenodactylus* and *A. variabilis* by having a globose inner metatarsal tubercle.

TABLE 2. MEASUREMENTS (MM) OF FEMALE SYNTYPES OF  
*ARTHROLEPTIS ADOLFRIEDERICI*.

	ZMB 21787	FMNH 73836
Snout-vent length	42.0	40.1
Head width	14.7	14.0
Tympanum height	2.4	2.1
Eye diameter	4.9	4.6
Snout length	3.8	4.0
Forearm length	10.5	9.8
Manual digit I	3.6	3.9
Manual digit II	4.3	4.1
Manual digit III	6.7	6.1
Manual digit IV	4.5	4.1
Thigh length	24.2	22.3
Crus length	26.6	23.5
Pedal digit I	3.1	2.8
Pedal digit II	5.3	4.6
Pedal digit III	9.6	7.8
Pedal digit IV	14.7	12.8
Pedal digit V	8.1	7.1
Inner metatarsal length	1.9	1.8

*Description.* Based on syntype ZMB 21787: large (42.0 mm SVL), moderately robust female with long, slender limbs (Table 2); dissected and missing left forelimb beyond distal two thirds of humerus; head somewhat broad; head length 79% head width; head width 35% SVL; snout projecting approximately 1 mm beyond lower jaw; rostral tip rounded in dorsal view, blunt and essentially straight in lateral view; eyes projecting beyond eyelids in dorsal view, such that pupil just visible; eyes close to but not projecting beyond lateral margins of head; eyes projecting well above dorsal surface of head in lateral view; eye diameter approximately equal to interorbital distance; pupil horizontally elliptical in preservative; loreal region essentially flat; naris large, rounded, facing laterally, and obvious from above; distinct triangular papilla at ventral narial rim; canthus rostralis very indistinct and rounded; eye diameter 1.5 times eye-narial distance; eye diameter 2.9 times distance from naris to rostral tip; internarial region flat; internarial distance 91% interorbital distance; tympanum distinct,

round, and tending toward ovoid, height just less than half diameter of eye; tympanic annulus poorly defined; supratympanic fold absent; tongue lozenge-shaped, width approximately half of head width; tongue covered with many small pustules, posterior notch approximately one eighth anteroposterior length of tongue; anterior attachment of tongue narrow; prominent, flat, flap-like median papilla on dorsal anterior tongue surface; choana visible behind maxillary shelf in ventral view; premaxillary and maxillary teeth present, but hidden by lips; vomerine teeth absent.

Skin of dorsal surface of head and body very weakly tuberculate; skin of fore and hind limbs smooth; skin of lateral body glandular, becoming more distinct extending onto ventrolateral surface; ventral surface weakly glandular and somewhat wrinkled; median skin raphe indistinct in preservative; cloacal region very glandular.

Limbs and digits well developed; digits of manus slightly robust and of pes more slender; relative length of fingers: III > IV > II > I; fingertips rounded, slightly swollen, approximately same width as rest of finger; finger with rounded, prominent, globular, single subarticular tubercles; palmar and metacarpal tubercles present but very weakly developed and barely projecting from surface of hand; webbing on manual digits absent; hind limbs long and slender; thigh length 91% of crus length; relative length of toes: IV > III > V > II > I; toe tips swollen but damaged from past dehydration; toes with prominent, single, rounded, and globular subarticular tubercles; webbing between pedal digits absent; prominent rounded and ovoid inner metatarsal tubercle, length 61% of first toe length.

*Measurements.* Table 2.

*Coloration in Alcohol.* Little of the original pigmentation is preserved on ZMB 217897, the skin of which is mostly transparent, and

FMNH 73836. This description of coloration is a summary based on all of the reference specimens.

Dorsal base color light to medium brown with small dark-brown spots (Fig. 5A); iris dark gray with white pupil; snout lighter brown than interorbital bar but grading to dark brown near rostral tip; loreal and suborbital regions light brown; dark-brown supratympanic band extending from postero-dorsal margin of orbit, extending posteroventrally and terminating just posterior to the ventral tympanum margin; tympanum translucent and light brown; dorsal surface of arms light brown to tan; single, somewhat broken brown band on forearm; dorsal surface of hands mottled light and dark brown; interorbital bar medium to dark brown; posterior to skull, two dark-brown, highly fragmented chevrons (e.g., MCZ A-14696) with apices directed anteriorly, separated by light-brown region; scattered medium- to dark-brown small spots on dorsal and lateral surfaces of body; lateral surface of body with many small medium- and dark-brown spots and base color much lighter than dorsum; dorsal surface of hind limbs light brown with medium- to dark-brown mottling; crus with two variably developed transverse brown stripes.

Throat very light brown with scattered medium-brown spots especially concentrated at margins of lower jaw (Fig. 5B); venter mostly very light brown with few to no dark spots; medial surfaces of arm and forearm unpigmented and creamy; ventral surface of fore limbs very light brown; palmar, metacarpal, and subarticular tubercles generally less pigmented than surrounding skin; ventral surface of thigh very light brown, with essentially no markings; ventral surface of crus very light brown to weakly mottled with light to medium brown; plantar surface light to medium brown.

*Variation.* Measurement variation is documented in Table 2.

*Habitat and Range.* Specimens similar to the type specimens have been collected in mountainous areas to the north and east of Lake Kivu in the Democratic Republic of Congo, Rwanda, and southwestern Uganda (Drewes and Vindum, 1994; Nieden, 1911, 1913). We have not examined, nor found explicit reference to, specimens from Burundi, although it has been reported as occurring there (Channing and Howell, 2006; Global Amphibian Assessment, 2006). Specimens examined from Tanzania, Malawi, and Kenya previously referred to as *A. adolfifriederici* invariably represent different species (see *Remarks* section).

*Remarks.* Nieden (1913) referred Tanzanian specimens from Tanga and Amani to *A. adolfifriederici*. Given that the material later used by Ahl (1939) to describe *A. affinis* is a single large specimen collected by S. G. Awerinzew in Amani, it seems likely that Nieden (1913) had examined the same specimen but referred it to *A. adolfifriederici*. Following Nieden's (1913) precedent, Barbour and Loveridge (1928) assigned many specimens from eastern Tanzania to *A. adolfifriederici* and Loveridge (1942, 1957) later recognized *A. affinis* as a junior synonym of *A. adolfifriederici*. These records extend the range of *A. adolfifriederici* throughout much of the Eastern Arc Mountains. Later authors recognized *A. adolfifriederici* and *A. affinis* as two distinct species (e.g., Channing and Howell, 2006; Grandison, 1983; Poynton, 2003b; Skelton-Bourgeois, 1961), but records of *A. adolfifriederici* from throughout the Eastern Arc Mountains continue to be reported (e.g., Channing and Howell, 2006). Examination of MCZ specimens from Tanzania and Kenya that were assigned to *A. adolfifriederici* (Barbour and Loveridge, 1928; Loveridge, 1942) indicates that these should be referred to *A. affinis*, *A. stenodactylus*, *A. tanneri*, and possibly a large undescribed species from southwestern Tan-

zania (Blackburn, unpublished data; see *Material Examined* section). One of these specimens (MCZ A-13166) was designated a paratype of *A. tameri* by Grandison (1983). In their recent study of morphological variation in populations of *A. affinis* from throughout much of the Eastern Arc Mountains, Poynton and Loader (2008) were unable to identify any large *Arthroleptis* from eastern Tanzania as morphologically similar to the type specimen of *A. adolfifriederici* that they examined (ZMB 21787).

*Etymology.* Based on the “stately form” of this species (Nieden, 1913), it was named in honor of German explorer Adolf Friedrich, Duke of Mecklenburg, who led an expedition in the mountains of Central Africa from 1907 to 1908.

***Arthroleptis variabilis* Matschie, 1893**

Variable Squeaker Frog

Figure 6

*Arthroleptis dispar*: Peters (1875): 210, plate 3.

*Arthroleptis variabilis*: Matschie (1893): 173.

Syntypes: ZMB (85 specimens): Cameroon, Southwest Province, Buea, ca. 04°09'N, 009°14'E, ~ 950 m elevation.

*Arthroleptis Seimundi*: Boulenger (1905): 180.

*Arthroleptis variabilis*: Boulenger (1906): 320.

*Arthroleptis Seimundi* recognized as a junior synonym of *Arthroleptis variabilis*.

*Arthroleptis (Arthroleptis) variabilis*: Laurent (1940): 85.

*Abroscaaphus variabilis*: Laurent (1957): 275. By implication.

*Reference Sample.* Type material, sex, and SVL (in mm) indicated in parentheses. Cameroon: MCZ A-2654 (female, 34.6), A-3428–29 (females, 30.5, 29.4), A-46985 (male?, 35.0) A-136744 (female, 35.8), A-136775 (female, 28.7), A-136777–79 (females, 29.0, 29.0, 29.4), A-136820 (female, 34.6), A-136823–25 (females, 31.8, 29.6, 29.4), A-136827 (female, 33.5), A-136830 (female,

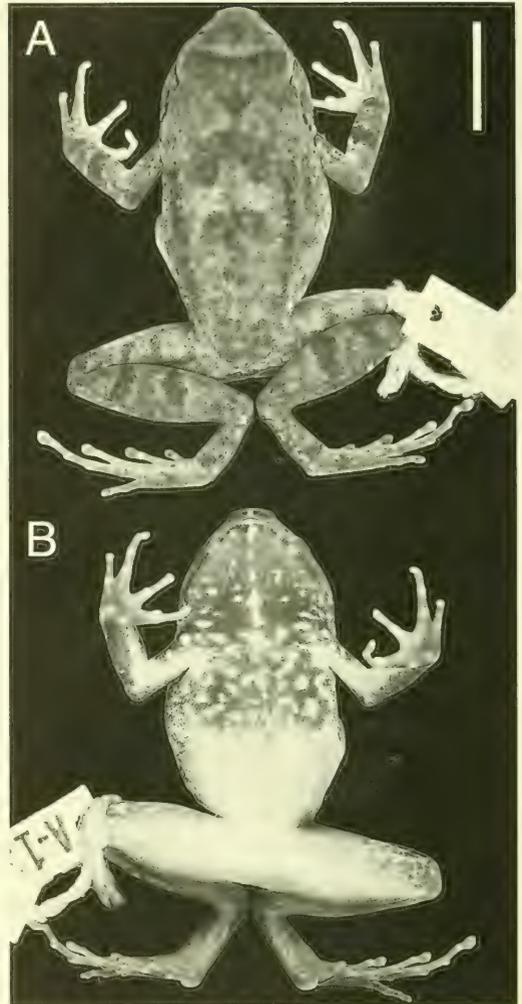


Figure 6. *Arthroleptis variabilis* (MCZ A-136830) in dorsal (A) and ventral (B) views. Scale bar, 10 mm.

35.0), A-137297 (female, 35.6); USNM 563684 (female, 37.8), 563685 (male?, 26.3), 563686 (juvenile, 20.8), 563688 (male, 31.0) 563689 (female, 37.8); UTA A-35924 (female, 32.3), A-35933 (male, 32.1), A-35940 (female, 36.0), A-35949–50 (females, 34.7, 37.4), A-44447 (female, 35.4), A-44451 (female, 37.7); ZMB 15206 (syntype; female, 36.7), 70085–86 (syntypes; females, 30.8, 32.1).

**Diagnosis.** A medium-sized *Arthroleptis* characterized by a dark-gray throat that is bisected by a prominent, white gular stripe (Fig. 6B) and a fourth finger that is approximately the same length as or shorter than the first and second fingers. This species differs from nearly all other similarly sized or larger *Arthroleptis* by the presence of the white gular stripe (incipient in *A. nikeae*); this stripe can be obscured in *A. variabilis* males with darkened throats. *Arthroleptis variabilis* differs in the following ways from other medium to large *Arthroleptis* (maximum SVL > 35 mm): from *A. affinis* by lacking supernumerary tubercles on the feet; from *A. francei* and *A. stenodactylus* by crus length much greater than 50% SVL; from *A. nikeae* by smaller adult body size (> 50 mm SVL in *A. nikeae*); from *A. krokosua* by smaller body size and generally lacking large well-defined black spots on the lateral surface of the body; from *A. perreti* by relatively shorter snout and fourth finger and by lacking the distinctive pattern of many white spots on the darkened posterior thigh; from *A. stenodactylus* by an inner metatarsal tubercle length usually less than 80% first toe length; from *A. tameri* by a relatively narrower head.

**Description.** Medium-sized, robust species with moderately robust limbs (Fig. 6; Table 3); mean male SVL 31.1 mm ( $n = 4$ ;  $\pm 3.1$ ), mean female SVL 33.1 mm ( $n = 27$ ;  $\pm 3.0$ ); head somewhat broad; head length 80–85% head width; head width 38–45% SVL; posterior margin of head not always distinct from body; snout projecting less than 1 mm beyond lower jaw; rostral tip rounded in dorsal and lateral views; in dorsal view, eyes projecting beyond eyelids such that pupil just visible; eyes close to or just projecting beyond lateral margins of head; eyes projecting slightly or well above dorsal surface of head in lateral view; eye diameter just larger than interorbital distance; pupil rounded to horizontally elliptical in preser-

TABLE 3. MEASUREMENTS (MM) OF FEMALE SYNTYPES OF *ARTHROLEPTIS VARIABILIS*.

	ZMB 15206	ZMB 70085	ZMB 70086
Snout-vent length	36.7	30.8	32.1
Head width	14.1	12.8	12.7
Tympanum height	2.6	2.1	2.1
Eye diameter	5.1	5.0	4.9
Snout length	2.7	2.4	2.8
Forearm length	9.5	7.5	7.9
Manual digit I	3.8	3.1	3.3
Manual digit II	3.9	3.0	3.4
Manual digit III	5.5	4.6	4.7
Manual digit IV	3.1	2.9	2.8
Thigh length	18.9	15.9	15.8
Crus length	19.5	16.3	17.0
Pedal digit I	2.6	2.3	2.2
Pedal digit II	3.8	3.2	3.3
Pedal digit III	6.7	5.5	6.0
Pedal digit IV	10.4	8.7	8.7
Pedal digit V	5.4	4.3	4.6
Inner metatarsal length	2.2	1.7	1.7

vative; loreal region ranging from flat to slightly concave; naris small and rounded, directed laterally, but visible from above; distinct small, triangular papilla at ventral narial rim; canthus rostralis indistinct, rounded; eye diameter 1.8–2.3 times eye-narial distance; eye diameter 1.2–1.5 times distance from naris to rostral tip; internarial region slightly convex; internarial distance 85–92% interorbital distance; tympanum distinct, ovoid, height ranging from 40–50% diameter of eye; tympanic annulus usually poorly defined; supratympanic fold absent; tongue broad and heart shaped, width approximately half of head width; tongue covered with many small pustules, posterior notch ranging from very shallow to less than one fifth of anteroposterior length of tongue; anterior attachment of tongue narrow; prominent, conical, median papilla on dorsal anterior tongue surface; choana hidden by maxillary shelf in ventral view; premaxillary and maxillary teeth present, but hidden by lips; vomerine teeth absent.

Skin of dorsal surface of head and body smooth, sometimes weakly granular posteriorly; skin of fore and hind limbs smooth; skin of lateral body glandular; most of ventral surface very smooth, but tending toward glandular posteriorly; median skin raphe ranging from indistinct to indiscernible in preservation; smooth skin surrounding cloacal region.

Limbs and digits well developed; relative length of fingers: III > I  $\approx$  II > IV; fingertips rounded and often very swollen but not expanded; finger with rounded, prominent, globular, single subarticular tubercles; palmar and metacarpal tubercles ranging from weakly developed (mostly in old preserved material) to very prominent and projecting from surface of hand; webbing on manual digits absent; thigh length ranges from 78 to 102% of crus length (90–98% thigh length in majority of specimens); relative length of toes: IV > III > V > II > I; toe tips slightly expanded to just greater than width of toe at interphalangeal joints; toes with prominent, single, rounded, and globular subarticular tubercles; webbing between pedal digits absent; very prominent, flange-like inner metatarsal tubercle, length ranging from 55 to 120% of first toe length.

*Measurements.* Table 3.

*Coloration in Alcohol.* This species exhibits a remarkable diversity of coloration and patterns that was first noted long ago (e.g., Andersson, 1905; Matschie, 1893; Noble, 1924). The following description of coloration is a summary based on the reference specimens, but it is premature to consider it exhaustive.

Base color of dorsal and lateral body, and limbs, grayish brown to brownish gray (Fig. 6A); iris dark gray or black with white or creamy pupil; usually solid interorbital bar medium to dark brown; snout usually uniformly lighter than interorbital bar and typically similar to remaining dorsum; loreal

and suborbital regions uniformly darker than dorsal surfaces; variably present dark band extending from ventral eye to lip of upper jaw, with loreal region much lighter; prominent dark-brown or black supratympanic band extending from posterodorsal margin of orbit, extending posteroventrally and terminating posterior to tympanum or even extending posterior to arm; tympanum translucent and typically lighter than supratympanic band; dorsal markings similar coloration as dorsal base coloration but shades darker; some specimens with scattered small light spots; usually two fairly complete dark-brown bands on forearm; dorsal surface of hands mottled light and dark brown or gray; variably present color morph in which all lateral surfaces distinctly darker and different color than dorsal surfaces, with sharp boundary between regions; variably present, usually continuous, white vertebral line extending from snout tip to vent; other dorsal markings, if present, usually comprising dark triangle between eyes (apex directed posteriorly) often, but not necessarily, confluent with broad circular, elliptical, or diamond-shaped dark mid-dorsal marking located over suprascapulars; mid-dorsal marking often, but not necessarily, confluent with circular or elliptical dark posterior dorsal marking, located over sacrum, poorly defined along most posterior margins; dorsal markings sometimes discontinuous or reduced to poorly defined or even paired blotches symmetrical across midline; lateral body with scattered well-defined dark-brown spots and, in some cases, small, less defined light spots; hind limbs fairly uniform in coloration and pattern; thigh usually with two dark transverse stripes; dorsal and posterior thigh fairly uniform in coloration and pattern; crus with two, sometimes three, pronounced transverse brown stripes; dark spot on lateral margin of foot at base of metatarsal V; dark region

covering cloaca, well defined dorsally and extending onto and becoming less distinct on posterior thigh.

Throat light to dark gray with very small, irregularly placed light spots (Fig. 6B); light spots at jaw margin very irregularly placed; well-defined, usually continuous, white stripe extending from rostral tip along throat midline to level of pectoral girdle; posterior to pectoral girdle pattern becomes dominated by large light spots with dark pigmentation becoming lighter and more diffuse posteriorly; posterior venter mostly white or very light gray with no markings; medial surfaces of arm and forearm white, creamy, or light gray; dark ventral surface of forearm; palmar surface and fingers light to dark gray; palmar, metacarpal, and subarticular tubercles unpigmented; ventral fingertips lighter in color than rest of finger; venter and ventral thigh both cream colored with few scattered brown melanocytes; light-creamy or light-gray ventral surface of thigh with few markings; ventral surface of crus mottled dark gray and cream; plantar surface homogeneous dark gray or black; subarticular tubercles on toes and inner metatarsal tubercle lighter shades than surrounding skin.

*Coloration in Life.* Based on D. C. Blackburn's field notes and photographs. Dorsal base coloration black, dark gray, dark, light, and ruddy brown, red, or olive green; markings on dorsal and lateral surfaces ranging from tan, orange, light or dark brown, and even black; mid-vertebral stripe, when present, ranging from gray to orange; lighter markings on lateral surface ranging from white to gray; ventral surface of throat generally dark gray to black with white or creamy stripe along midline; venter white or gray with light- to dark-gray spots; inguinal region ranging from pale yellow to orangey red.

*Variation.* Measurement variation is documented in Table 3. No relationship is obvious between the great diversity of dorsal

patterns and coloration with that of the ventral surface, which is fairly uniform among specimens. One unusual color morph (e.g., MCZ A-136827) exhibits a large immaculate white band, just below and posterior to the eye, that extends posterior onto the fore limb along the dorsal surface to just distal to the elbow.

*Habitat and Range.* This typically is a common species that occurs predominantly in lowland forests (e.g., Amiet, 1975). *Arthroleptis variabilis* is known from throughout Central Africa, with localities in Cameroon (e.g., Amiet, 1975; Andersson, 1905; Böhme and Schneider, 1987; Boulenger 1900, 1905, 1906; Gartshore, 1986; Herrmann et al., 2005; Lawson, 1993; Matschie, 1893; Nieden, 1908; Perret, 1966; Perret and Mertens, 1957), Central African Republic (Joger, 1990), Bioko Island (e.g., Boulenger, 1900, 1905), mainland Equatorial Guinea (e.g., De la Riva, 1994), Gabon (e.g., Boulenger, 1905; Burger et al., 2006), eastern Nigeria (Blackburn, unpublished data; Schiötz, 1963), the Democratic Republic of Congo (Kinshasa; e.g., Laurent, 1972; Noble, 1924; de Witte, 1934), and the Republic of Congo (Brazzaville; e.g., Largen and Dowsett-Lemaire, 1991).

*Remarks.* *Arthroleptis variabilis* is sometimes stated to occur in the forests of western Africa (i.e., Global Amphibian Assessment, 2006). However, the western African populations probably correspond to one or several undescribed species ("Arthroleptis sp. 2": Ernst et al., 2008; Rödel and Branch, 2002; Rödel and Ernst, 2004; Rödel et al., 2005). Populations from western Ivory Coast are similar to *A. variabilis*, but smaller (Rödel and Branch, 2002). A specimen from southwestern Ghana (Rödel et al., 2005) was described recently as a new species, *A. krokosua*, by Ernst et al. (2008). Like *A. perreti*, *A. krokosua* also lacks the white gular stripe present in *A. variabilis* and has a

fourth finger shorter than the first and second fingers (Ernst et al., 2008). However, morphological and molecular data indicate that these taxa are neither conspecific nor sister taxa (Blackburn, unpublished data; Ernst et al., 2008). The many taxonomic problems of *Arthroleptis* from western Africa are detailed by Rödel and Bangoura (2004).

*Etymology.* The name derives from the Latin word *varius* meaning different, and in the adjectival form *variabilis*, changeable, presumably in recognition of the wide range of coloration and pattern exhibited by this species.

## DISCUSSION

Differences between *A. perreti* and *A. variabilis* documented in this study are similar to those found by Perret (1966). In general, he found *A. variabilis* to be more robust and to have a relatively shorter snout, relatively shorter crus, relatively larger inner metatarsal tubercle, a prominent white stripe on the midline of the throat, and gray or brown coloration on the posterior surface of the thigh. *Arthroleptis adolfifriederici*, as described by Perret (1966), lacks the white stripe on the throat and has a posterior thigh that is brown with light spots. Perret's (1966) description agrees with *A. perreti* as described here. Although superficially similar, *A. perreti* and *A. variabilis* are morphologically distinct. Molecular phylogenetic data indicates that, while closely related, these two species are not sister taxa (see *Arthroleptis* sp. nov. 1 in Blackburn, 2008a). Guided by the description and redescriptions presented here, future studies should focus on determining or re-evaluating the presence of *A. perreti* at other montane localities in Cameroon.

The past four decades have witnessed a dramatic increase in the described amphibian diversity in Cameroon and neighboring

countries (e.g., Amiet, 1971a,b, 1972a,b, 1973, 1977, 1980a,b, 1981, 2000, 2001, 2004a,b; Blackburn, 2008b; Herrmann et al., 2004; Kobel et al., 1980; Lawson, 2000; Loumont and Kobel, 1991; Rödel et al., 2004). This region is a hotspot of amphibian diversity within sub-Saharan Africa (Global Amphibian Assessment, 2006), and the Cameroonian amphibian fauna is one of the most diverse in the world, with nearly 200 described species. Much of this diversity is concentrated in the mountains of the Cameroon Volcanic Line, especially Mt. Manengouba (Amiet, 1971a,b, 1973, 1977, 1980a; Blackburn, 2008b; Kobel et al., 1980). This mountain is an important center of diversity within Cameroon, especially of amphibians (e.g., Amiet, 1975; Blackburn, 2008b; Gartshore, 1986), but has received only limited conservation attention (e.g., Gartshore, 1986; Gonwouo et al., 2006). Description of *A. perreti* from Mt. Manengouba highlights the need for conservation measures focused on the preservation of the unique biodiversity found on this and other mountains of the Cameroon Volcanic Line.

## MATERIAL EXAMINED

Type material, sex, and SVL (in mm) indicated in parentheses. *Arthroleptis affinis*: Tanzania: MCZ A-13145–146 (females, 37.2, 37.6), A-13150–151 (males, 23.4, 25.3), A-13152–153 (females, 35.8, 40.5), A-13157–160 (females, 32.8, 33.7, 34.7, 36.6), A-13162–163 (females, 36.6, 35.7), A-13165 (female, 35.6), A-13167 (male, 27.8), A-13169 (male, 29.2), A-25400–401 (females, 35.5, 30.5), A-138241–244 (female, 36.2, 33.8, 42.9, 37.4); TNHC 38577 (female, 38.8); ZMB 23093 (holotype; female, 35.6). *Arthroleptis francei*: Malawi: BMNH 1954.1.13.74 (paratype; female, 32.4); MCZ A-27474–476 (paratypes; males, 25.4, 28.2, 28.0), A-27477–478 (paratypes; females,

38.7, 41.0), A-27479 (holotype; female, 41.9), A-137038 (female, 37.3); TMP 48089 (female, 43.0), 48092 (male, 27.8). *Arthroleptis krokosua*: Ghana: SMNS 12555 (holotype; male, 43.3). *Arthroleptis nikaee*: Tanzania: BMNH 2002.101 (holotype; female, 52.5), 2002.102 (paratype; female, 53.7). *Arthroleptis stenodactylus*: Malawi: MMB HA2002.1.13 (female, 37.0), HA2002.1.60 (male, 32.7), HA2002.4.17 (female, 38.4). Tanzania: BMNH 2002.596 (female, 33.0); CAS 168455 (male, 35.6); MCZ A-21715 (male, 27.6), A-25387 (female, 28.6), A-27447 (female, 39.5). Kenya: NMK A/4251 (male, 33.0), A/4251/3 (female 40.0), A/4251/4 (male, 31.0), A/4401/3 (female, 25.7), A/4401/6 (female, 26.2). *Arthroleptis tanneri*: Tanzania: CAS 168823 (male; 41.9), 168825 (female; 54.7); MCZ A-13166 (paratype; female; 36.5). *Arthroleptis variabilis* (specimens not included in PCA): Equatorial Guinea: CAS 207817–819 (females, 34.0, 30.6, 35.4), 207820 (female?, 26.2), 207821–822 (female, 33.3, 36.1), 207823 (juvenile, 25.3), 207824–826 (females, 32.7, 33.4, 31.0), 207827 (female?, 26.9), 207828 (female, 35.9). *Arthroleptis* sp.: Tanzania: MCZ A-16952 (female, 44.4).

#### ACKNOWLEDGMENTS

Many people assisted with the fieldwork, logistics, or both needed to collect specimens for this study: K. S. Blackburn, M. Che, V. Che, J. L. Difo, D. Fotibu, N. Gawani, P. Huang, M. LeBreton, and M. T. Kouete. The people of Nsong and the Fulbe-speaking community in the Mt. Manengouba crater deserve our sincere gratitude for their hospitality and allowing use of their buildings. The Cameroon ministry of forestry and wildlife (MINFOF, formerly MINEF) supplied research and collection permits (0173PR/MINEF/SG/DFAP, 0588/PRBS/MINFOF/SG/DFAP/SDVEF/SC) and permissions to export specimens (0850–54/

CO/MINEF/SG/DFAP/SAN, 0512–16/PRBS/MINFOF/SG/DFAP/SDVEF/SC). DCB was funded by the Department of Organismic and Evolutionary Biology (Harvard University), Goelet Summer Research Funds, a Putnam Expeditionary Grant from the Museum of Comparative Zoology (Cambridge, Massachusetts, U.S.A.), NSF grant EF-0334939 (AmphibiaTree) to D. Cannatella and J. Hanken, and Project Exploration, a not-for-profit educational organization (Chicago, Illinois, U.S.A.). LNG was supported by Conservation International (Washington, DC, U.S.A.). D. Hewitt provided assistance with translations from German, and C. Bonneaud translated the abstract into French. C. S. Walker (Harvard Map Collection) created Figure 1. J. Hanken and R. C. Drewes provided valuable comments on a draft of this manuscript.

#### LITERATURE CITED

- AHL, E. 1939 "1938". Beschreibung neuer afrikanischer Frösche der Gattung *Arthroleptis*. Sitzungsberichte der Gesellschaft naturforschender Freunde Berlin, **1938**: 303–310.
- AMIET, J.-L. 1971a. Espèces nouvelles ou mal connues de *Leptodactylodon* (Amphibiens Anoures) de la Dorsale camerounaise. Annales de la Faculté des Sciences du Cameroun, **5**: 57–81.
- . 1971b. *Leptodactylodon* nouveaux du Cameroun (Amphibiens Anoures). Annales de la Faculté des Sciences du Cameroun, **7–8**: 141–172.
- . 1972a. Description de cinq nouvelles espèces camerounaises de *Cardioglossa* (Amphibiens Anoures). Biologia Gabonica, **8**: 201–231.
- . 1972b. Description de trois Bufonidés orophiles du Cameroun appartenant au groupe de *Bufo preussi* Matschie (Amphibiens Anoures). Annales de la Faculté des Sciences du Cameroun, **11**: 121–140.
- . 1973. Caractères diagnostiques de *Petropedetes perreti*, nov. sp. et notes sur les autres espèces camerounaises. Bulletin de l'Institut Français Afrique Noire, **35**: 462–474.
- . 1975. Ecologie et distribution des amphibiens anoures de la région de Nkongsamba (Cameroun). Annales de la Faculté des Sciences de Yaoundé, **20**: 33–107.

- . 1977. Les *Astylosternus* du Cameroun (Amphibia Anura, Astylosterninae). Annales de la Faculté des Sciences de Yaoundé, **23-24**: 99–227.
- . 1980a. Révision du genre *Leptodactylodon* Andersson (Amphibia, Anura, Astylosterninae). Annales de la Faculté des Sciences de Yaoundé, **27**: 69–224.
- . 1980b. Un *Hyperolius* nouveau du Cameroun: *Hyperolius endjami* n. sp. (Amphibia Anura, Hyperoliidae). Revue Suisse de Zoologie, **87**: 445–460.
- . 1981. Une nouvelle *Cardioglossa* orophile de la Dorsale camerounaise: *C. schioetzi* nov. sp. (Amphibia, Anura, Arthroleptinae). Annales de la Faculté des Sciences de Yaoundé, **28**: 117–131.
- . 1987. Aires disjointes et taxons vicariants chez les Anoures du Cameroun: implications paléoclimatiques. Alytes, **6**: 99–115.
- . 2000. Les *Alexteroon* du Cameroun (Amphibia, Anura, Hyperoliidae). Alytes, **17**: 125–164.
- . 2001. Un nouveau *Leptopelis* de la zone forestière camerounaise (Amphibia, Anura, Hyperoliidae). Alytes, **19**: 29–44.
- . 2004a. Une nouvelle espèce d'*Hyperolius* du Cameroun (Amphibia, Anura, Hyperoliidae). Revue Suisse de Zoologie, **11**: 567–583.
- . 2004b. A propos de deux *Leptopelis* nouveaux pour la faune du Cameroun (Anura, Hyperoliidae). Alytes, **21**: 111–170.
- ANDERSSON, L. G. 1905. Batrachians from Cameroon collected by Dr. Y. Sjöstedt in the years 1890–1892. Arkiv för Zoologie, **2**: 1–29, 1 plate.
- BARBOUR, T., AND A. LOVERIDGE. 1928. A comparative study of the herpetological faunae of the Uluguru and Usambara Mountains, Tanganyika Territory with descriptions of new species. Memoirs of the Museum of Comparative Zoology, **50**: 87–265, 4 plates.
- BLACKBURN, D. C. 2005. *Cardioglossa liberiensis* Barbour & Loveridge 1927 is a junior synonym of *Phrynobatrachus fraterculus* (Chabanaud 1921). African Journal of Herpetology, **54**: 171–179.
- . 2008a. Biogeography and evolution of body size and life history of African frogs: phylogeny of squeakers (*Arthroleptis*) and long-fingered frogs (*Cardioglossa*) estimated from mitochondrial data. Molecular Phylogenetics and Evolution, **49**: 806–826.
- . 2008b. A new species of *Cardioglossa* (Amphibia: Anura: Arthroleptidae) endemic to Mount Manengouba in the Republic of Cameroon, with an analysis of morphological diversity in the genus. Zoological Journal of the Linnean Society, **54**: 611–630.
- . In press. Diversity and evolution of male secondary sexual characters in African squeakers and long-fingered frogs. Biological Journal of the Linnean Society.
- BOULENGER, G. A. 1900. A list of the batrachians and reptiles of the Gaboon (French Congo), with descriptions of new genera and species. Proceedings of the Zoological Society, London, **1900**: 433–456, 6 plates.
- . 1905. Descriptions of new tailless batrachians in the collection of the British Museum. Annals and Magazine of Natural History, **16**: 180–184.
- . 1906. Descriptions of new batrachians discovered by Mr. G. L. Bates in South Cameroon. Annals and Magazine of Natural History, **17**: 317–323.
- BÖHME, W., AND B. SCHNEIDER. 1987. Zur Herpetofaunistik Kameruns (III) mit Beschreibung einer neuen *Cardioglossa* (Anura: Arthroleptidae). Bonner Zoologische Beiträge, **38**: 241–263.
- BURGER, M., O. S. G. PAUWELS, W. R. BRANCH, E. TOBI, J.-A. YOGA, AND E.-N. MIKOLO. 2006. An assessment of the amphibian fauna of the Gamba Complex of protected areas, Gabon, pp. 297–307. In Gamba, Gabon: Biodiversité d'une forêt équatoriale africaine. A. Alonso, M. E. Lee, P. Campbell, O. S. G. Pauwels, & F. Dallmeier (eds.), Bulletin of the Biological Society of Washington no. 12. 436 pp.
- CHANNING, A., AND K. M. HOWELL. 2006. Amphibians of East Africa. Ithaca, New York, Cornell University Press. 418 pp.
- DE LA RIVA, I. 1994. Anfíbios anuros del Parque Nacional de Monte Alén, Río Muni, Guinea Ecuatorial. Revista Espanola Herpetologie, **8**: 123–139.
- DREWES, R. C., AND J. V. VINDUM. 1994. Amphibians of the Impenetrable Forest, southwest Uganda. Journal of African Zoology, **108**: 55–70.
- ERNST, R., A. C. AGYEI, AND M.-O. RÖDEL. 2008. A new giant species of *Arthroleptis* (Amphibia: Anura: Arthroleptidae) from the Krokosua Hills Forest Reserve, south-western Ghana. Zootaxa, **1697**: 58–68.
- FROST, D. R. (ED.) 1985. Amphibian Species of the World: A Taxonomic and Geographical Reereence. Lawrence, Kansas, Association of Systematics Collections and Allen Press. 732 pp.
- FROST, D. R. (ED.) 2007. Amphibian species of the world: an online reference [Internet]. Version 5.1. New York, American Museum of Natural History [cited 1 August 2008]. Available from: <http://research.amnh.org/herpetology/amphibia/index.php>.
- FROST, D. R., T. GRANT, J. FAIVOVICH, R. H. BAIN, A. HAAS, C. F. B. HADDAD, R. O. DE SÁ, A. CHANNING, M. WILKINSON, S. C. DONNELLAN, C. J. RAX-WORTHY, J. A. CAMPBELL, B. L. BLOTTO, P. MOLER,

- R. C. DREWES, R. A. NUSSBAUM, J. D. LYNCH, D. M. GREEN, AND W. C. WHEELER. 2006. The amphibian tree of life. *Bulletin of the American Museum of Natural History*, **297**: 1–291.
- GARTSHORE, M. 1986. The status of the montane herpetofauna of the Cameroon highlands, pp. 204–240. *In* Stuart, S. N. (ed.), *Conservation of Cameroon Montane Forests*. London, International Council for Bird Preservation. 263 pp.
- GLOBAL AMPHIBIAN ASSESSMENT. 2006. Washington, D.C., IUCN/SSC-CI/CABS; c2006 [cited 1 August 2008] Available from: <http://www.globalamphibians.org>.
- GONWOUO, L. N., M. LEBRETON, C. WILD, L. CHIRIO, P. NGASSAM, AND M. N. TCHAMBA. 2006. Geographic and ecological distribution of the endemic montane chameleons along the Cameroon mountain range. *Salamandra*, **42**: 213–230.
- GRANDISON, A. G. C. 1983. A new species of *Arthroleptis* (Anura: Ranidae) from the West Usambara Mountains, Tanzania. *Bulletin of the British Museum of Natural History (Zoology)*, **45**: 77–84.
- HERRMANN, H.-W., P. A. HERRMANN, A. SCHMITZ, AND W. BÖHME. 2004. A new frog species of the genus *Cardioglossa* from the Tchabal Mbabo Mtns, Cameroon. *Herpetozoa*, **17**: 119–125.
- , W. BÖHME, P. A. HERRMANN, M. PLATH, A. SCHMITZ, AND M. SOLBACH. 2005. African biodiversity hotspots: the amphibians of Mt. Nlonako, Cameroon. *Salamandra*, **41**: 61–81.
- IUCN. 2001. IUCN red list categories and criteria [Internet]. Version 3.1. Gland, Switzerland, IUCN [cited 1 August 2008]. Available from: <http://www.ucnredlist.org>.
- JÖGER, U. 1990. The herpetofauna of the Central African Republic, with description of a new species of *Rhinotyphlops* (Serpentes: Typhlopidae), pp. 85–102. *In* G. Peters, & R. Hutterer (eds.), *Vertebrates of the Tropics*. Berlin, Museum Alexander Koenig.
- KOBEL, H. R., L. DU PASQUIER, M. FISCHBERG, AND H. GLOOR. 1980. *Xenopus amieti* sp. nov. (Anura: Pipidae) from the Cameroons, another case of tetraploidy. *Revue Suisse de Zoologie*, **87**: 919–926.
- LARGEN, M. J., AND F. DOWSETT-LEMAIRE. 1991. Amphibians (Anura) from the Kouilou River basin, République du Congo. *Tauraco Research Report*, **4**: 145–168.
- LAURENT, R. F. 1940. Contribution à l'ostéologie et à la systématique des ranides africains – Première note. *Revue de Zoologie et de Botanique Africaines*, **34**: 74–97, 3 plates.
- . 1954. Remarques sur le genre *Schoutedenella* Witte. *Annales du Musée Royal du Congo Belge, Tervuren*, **1**: 34–40.
- . 1957. Notes sur les Hyperoliidae. *Revue de Zoologie et de Botanique Africaines*, **56**: 274–282.
- . 1972. Amphibians. Exploration du Parc National des Virunga, Institut National Conservation de la Nature de la République du Zaïre, **22**: 3–125, 11 plates.
- . 1973. The natural classification of the Arthroleptinae (Amphibia, Hyperoliidae). *Revue de Zoologie et de Botanique Africaines*, **87**: 666–678.
- LAWSON, D. P. 1993. The reptiles and amphibians of Korup National Park Project, Cameroon. *Herpetological Natural History*, **1**: 27–90.
- . 2000. A new caecilian from Cameroon, Africa (Amphibia: Gymnophiona: Scolecomorphidae). *Herpetologica*, **56**: 77–80.
- LEVITON, A. E., R. H. GIBBS, JR., E. HEAL, AND C. E. DAWSON. 1985. Standards in herpetology and ichthyology: part I. Standard symbolic codes for institutional resource collections in herpetology and ichthyology. *Copeia*, **1985**: 802–832.
- LOUMONT, C., AND H. R. KOBEL. 1991. *Xenopus longipes* sp. nov., a new polyploid pidid from western Cameroon. *Revue Suisse de Zoologie*, **98**: 731–738.
- LOVERIDGE, A. 1942. Scientific results of a fourth expedition to forested areas in East & Central Africa. *Bulletin of the Museum of Comparative Zoology*, **41**: 377–436, 4 plates.
- . 1953. Zoological results of a fifth expedition to East Africa. IV. Amphibians from Nyasaland and Tete. *Bulletin of the Museum of Comparative Zoology*, **110**: 325–406, 4 plates.
- . 1957. Check list of the reptiles and amphibians of East Africa (Uganda; Kenya; Tanganyika; Zanzibar). *Bulletin of the Museum of Comparative Zoology*, **117**: 153–362, i–xxxvi.
- MATSCHIE, P. 1893. Einige anscheinend neue Reptilien und Amphibien aus West-Afrika. *Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin*, **1893**: 170–175.
- MATSUI, M. 1984. Morphometric variation analysis and revision of the Japanese toads (genus *Bufo*, Bufonidae). *Contributions from the Biological Laboratory, Kyoto University*, **26**: 209–428.
- MYERS, N., R. A. MITTERMEIER, C. G. MITTERMEIER, G. A. B. DA FONSECA, AND J. KENT. 2000. Biodiversity hotspots for conservation priorities. *Nature*, **403**: 853–858.
- NIEDEN, F. 1908. Die Amphibienfauna von Kamerun, mit einer Bestimmungstabelle. *Mitteilungen aus dem Zoologischen Museum in Berlin*, **1908**: 491–518.

- . 1911 "1910". Neue ostafrikanische Frösche aus dem Kgl. Zool. Museum in Berlin. Sitzungsberichte Gesellschaft Naturforschender Freunde Berlin, **1910**: 436–441.
- . 1913. Amphibia. Wissenschaftliche Ergebnisse der Deutschen Zentral-Afrika-Expedition, **4**: 165–195.
- NOBLE, G. K. 1924. Contributions to the herpetology of the Belgian Congo based on the collection of the American Museum Congo Expedition, 1909–1915. Part III. Amphibia. Bulletin of the American Museum of Natural History, **49**: 147–347, 20 plates.
- PERRET, J.-L. 1966. Les amphibiens du Cameroun. Zoologische Jahrbucher (Systematik), **8**: 289–464.
- . 1991. Le statut d'*Arthroleptis bivittatus* F. Müller (Anura, Arthroleptidae). Bulletin de la Société neuchateloise des Sciences naturelles, **114**: 71–76.
- , AND R. MERTENS. 1957. Étude d'une collection herpétologique faite au Cameroun de 1952 à 1955. Bulletin de l'Institut Français Afrique Noire, **49**: 548–601.
- PETERS, W. 1875. Über die von Hrn. Professor Dr. R. Buchholz in Westafrika gesammelten Amphibien. Monatsberichte der Königlichen Preussische Akademie des Wissenschaften zu Berlin, **1875**: 196–212, 3 plates.
- PLATH, M., M. SOLBACH, AND H.-W. HERRMANN. 2004. Anuran habitat selection and temporal partitioning in a montane and submontane rainforest in Southwestern Cameroon—first results. Salamandra, **40**: 239–260.
- POYNTON, J. C. 1976. Classification and the Arthroleptinae. Revue de Zoologie Africaine, **90**: 215–220.
- . 2003a. *Arthroleptis troglodytes* and the content of *Schoutedenella* (Amphibia: Anura: Arthroleptidae). African Journal of Herpetology, **52**: 49–51.
- . 2003b. A new giant species of *Arthroleptis* (Amphibia: Anura) from the Rubeho Mountains, Tanzania. African Journal of Herpetology, **52**: 107–112.
- , AND D. G. BROADLEY. 1985. Amphibia Zambesiaca I. Scolecomorphidae, Pipidae, Microhylidae, Hemisidae, Arthroleptidae. Annals of the Natal Museum, **26**: 503–553.
- , AND S. P. LOADER. 2008. Clinal variation and its taxonomic consequences in the common Tanzanian forest frog, *Arthroleptis affinis*. Copeia, **2008**: 517–526.
- RÔDEL, M.-O., AND M. A. BANGOURA. 2004. A conservation assessment of amphibians in the Forêt Classée du Pic de Fon, Simandou Range, south-eastern Republic of Guinea, with the description of a new *Ammirana* species (Amphibia Anura Ranidae). Tropical Zoology, **17**: 201–232.
- , AND W. R. BRANCH. 2002. Herpetological survey of the Haute Dodo and Cavally forests, western Ivory Coast, Part I: amphibians. Salamandra, **38**: 245–268.
- , AND R. ERNST. 2004. Measuring and monitoring amphibian diversity in tropical forests. I. An evaluation of methods with recommendations for standardization. Ecotropica, **10**: 1–14.
- , M. GIL, A. C. AGYEI, A. D. LEACHÉ, R. E. DIAZ, M. K. FUJITA, AND R. ERNST. 2005. The amphibians of the forested parts of south-western Ghana. Salamandra, **41**: 107–127.
- , A. SCHMITZ, O. S. G. PAUWELS, AND W. BÖHME. 2004. Revision of the genus *Werneria* Poche, 1903, including descriptions of two new species from Cameroon and Gabon (Amphibia: Anura: Bufonidae). Zootaxa, **720**: 1–28.
- SCHJØTZ, A. 1963. On a collection of Amphibia from Nigeria. Videnskabelige meddelelser fra Dansk naturhistorisk forening i Kjøbenhavn, **129**: 43–48.
- SCHMIDT, K., AND R. F. INGER. 1959. Amphibians, exclusive of the genera *Afrixalus* and *Hyperolius*. Exploration du Parc National de l'Upemba, Mission G.F. de Witte, Institut des Parcs Nationaux du Congo Belge, **56**: 1–264, 9 plates.
- SIMMONS, J. E. 2002. Herpetological collecting and collections management. Herpetological Circular, **31**: 1–153.
- SKELTON-BOURGOIS, M. 1961. Reptiles et batraciens d'Afrique orientale. Revue de Zoologie et de Botanique Africaines, **63**: 309–338.
- STUART, S. N. 1984. Conservation recommendations and conclusions, pp. 241–245. In Stuart, S. N. (ed.), Conservation of Cameroon Montane Forests. London, International Council for Bird Preservation. 263 pp.
- DE WITTE, G.-F. 1934. Batraciens récoltés au Congo Belge par le Dr. H. Schouteden et par M. G.-F. de Witte. Annales du Musée Royal du Congo Belge, Tervuren, C. – Zoologie, Série I, **3**: 157–188, 7 plates.



