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Article in *Zootaxa* · January 2017

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The type localities of *Anolis aequatorialis* Werner, 1894 (Sauria: Iguania: Dactyloidae) and *Pristimantis appendiculatus* (Werner, 1894) (Amphibia: Anura: Craugastoridae)

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The eminent Austrian zoologist Franz Werner described several new species of amphibians and reptiles from America, including *Anolis aequatorialis* Werner, 1894 and *Hylodes appendiculatus* Werner, 1894. Both species were described based on single specimens, with no more specific type localities than “Ecuador” (Werner 1894a,b). After its description, *A. aequatorialis* remained unreported until Peters (1967) and Fitch *et al.* (1976) published information on its distribution and natural history. *Anolis aequatorialis* is currently known to inhabit low montane and cloud forest on the western slopes of the Andes from extreme southern Colombia to central Ecuador, between 1300 and 2300 m elevation (Ayala-Varela & Velasco 2010; Ayala-Varela *et al.* 2014; Lynch *et al.* 2014; D.F. Cisneros-Heredia pers. obs.). Likewise, *Hylodes appendiculatus* (now *Pristimantis appendiculatus*) remained only known from its type description until Lynch (1971) and Miyata (1980) provided certain localities and information on its natural history. *Pristimantis appendiculatus* is currently known to occur in low montane, cloud, and high montane forests on the western slopes of the Andes from extreme southern Colombia to northern Ecuador between 1460 and 2800 m elevation (Lynch 1971; Miyata 1980; Lynch & Burrowes 1990; Lynch & Duellman 1997; Frost 2016). To this date, the type localities of both species remain obscure. The purpose of this paper is to restrict the type localities of *Hylodes appendiculatus* Werner, 1894 and *Anolis aequatorialis* Werner, 1894 based on analyses of the travel journals of their original collector.

The type specimen of *Anolis aequatorialis* (Fig. 1) was originally deposited at the collection of the *Zoologisches Institut, Universität Wien* (Institute of Zoology, University of Vienna) under number 184. In 1929, it was transferred to the *Naturhistorisches Museum Wien* (Natural History Museum Vienna), where it is currently accessed under number NMW 16233 (Werner 1894a; Tiedemann & Häupl 1980; Tiedemann *et al.* 1994; G. Gassner in litt. 18 August 2016). The type specimen of *Hylodes appendiculatus* (Fig. 2) was also originally deposited at the *Zoologisches Institut* under number 68. Werner (1894b: 411) reported finding it “together with *H. surdus*, *conspicillatus*, *vertebralis* and *unistrigatus* in a glass jar in the collection of the Institute of Zoology and Comparative Anatomy of the University of Vienna” (free translation from German). In 1922, the type specimen of *H. appendiculatus* was transferred to the *Naturhistorisches Museum Wien*, where it is now deposited as NMW 16507 (Werner 1894b; Lynch 1971; Häupl & Tiedemann 1978; Häupl *et al.* 1994; H. Grillitsch in litt. 13 July 2015). Although Werner (1894b) only reported the type locality of *H. appendiculatus* as “Ecuador”, it is filed as “Ecuador, Cordilleren” (Ecuador, mountain range) in the NMW catalogue (Häupl & Tiedemann 1978; Häupl *et al.* 1994; H. Grillitsch in litt. 13 July 2015). L. K. Schmarda collected both type specimens.

Austrian zoologist Ludwig Karl Schmarda (born 23 August 1819, died 07 April 1908) studied in Vienna, and later became a professor at the universities of Graz, Prague and Vienna (Salvini-Plawen & Mizzaro 1999; Riedl-Dorn 2007). He was Head of the *Naturhistorisches Museum, Universität Wien* (Natural History Museum, University of Vienna), which subsequently became the *Zoologisch-vergleichend-anatomisches Institut* (Institute of Zoology and Comparative Anatomy) and the *Zoologisches Institut, Universität Wien* (Institute of Zoology, University of Vienna) (Salvini-Plawen & Mizzaro 1999; Riedl-Dorn 2007). L. K. Schmarda is considered as the founder of ecological zoogeography (Riedl-Dorn 2007). Between 1853 and 1857, L. K. Schmarda travelled around the world (Egypt, Sri Lanka, South Africa, Australia, New Zealand, and across America) collecting primarily invertebrates, but also vertebrates and plants (Werner 1894a,b; Karsten 1858-1861; Häupl & Tiedemann 1978; Tiedemann & Häupl 1980; Häupl *et al.* 1994; Tiedemann *et al.*

1994). He published an account of his travels in a three-volume journal entitled “*Reise um die Erde in den Jahren 1853–1857*” (Journey around the World in the years 1853–1857) (Schmarda 1861).

In the last volume of his journal, L. K. Schmarda detailed his journey in Ecuador between 1855 and 1856 (Schmarda 1861).

He arrived in Guayaquil on 30 December 1855, and travelled across the south of Ecuador to the city of Cuenca before heading to the north, passing through the cities of Azogues, Alausí, Guamote, Ambato, and Latacunga (all of which are located in inter-Andean valleys or *hoyas* of Paute, Cañar, Chanchán, Chambo, and Patate). Afterwards, he reached the inter-Andean valley of Quito (or *hoya de Guayllabamba*), where the city of San Francisco de Quito is located. He stayed in Quito between 2 April and 24 May 1856. During his time in Quito, he hiked the highlands and lower slopes of the Pichincha volcano. Subsequently, he went towards the cities of Ibarra and Tulcán, and thereafter to the Republic of New Granada (nowadays Colombia). During his travels in Ecuador, L. K. Schmarda only visited two areas in the western Andean slopes (Pacific versant) of Ecuador: on his way from Guayaquil to Cuenca on southern Ecuador, and around the Pichincha volcano on northern Ecuador. Based on the known distributions of *Anolis aequatorialis* and *Pristimantis appendiculatus*, L. K. Schmarda could have collected the type specimens only on the slopes of the Pichincha volcano.

L. K. Schmarda was curious about all aspects of natural history, and his journal provides abundant and passionate comments about the flora and fauna of the surroundings of Quito, showing a very good knowledge of Neotropical biodiversity. With a travel writing style that was popular in the XIX century, L. K. Schmarda’s journal provides valuable information in Chapter VIII to re-construct his journeys and determine the most probable areas where he would have collected the type specimens of *Anolis aequatorialis* and *Hylodes appendiculatus* (free translation from German, translator’s notes in square brackets):

“Chapter VIII. The surrounding area of Quito. —The slopes of Pichincha. —Machangara. —Plants and animals. —Climate of Quito.” (Schmarda 1861: 244).

“During my first trip to one of the peaks of Pichincha, I saw only fleetingly the mountain slopes, but I noticed the beauty of the shrub vegetation, awakening in me the desire to get to know closer this part of the mountain. There was an excursion, which I often repeated, because I easily reach from the city to this region in two hours and I could be back always before it rained, but prevented me from visiting the crater of the volcano that has developed a pernicious activity in recent times” (Schmarda 1861: 245).

“At the Plaza de San Francisco [*sic* Francisco] the busy life had already begun, because of the vegetable and fruit market. The Barrio San Francisco with its steep roads was reached, and following one of its water inflows, I was soon beyond the town. I continued my walk through a quebrada, which is one of the narrower canyons. [...] At approximately 10,000 feet high, where the last house is located (*Catuna* 10,360 feet) with its cornfields and vegetable patches, in which some large *Datura* trees stand (*Datura arborea*) [now *Brugmansia arborea*], with white funnel-shaped flowers, the footpath makes a turn at the edge of the canyon and in front of me there was a chorrera, as the waterfalls are called here, continuing into a mountain creek” (Schmarda 1861: 246).

“But we also take a look at the landscape facing us and at our feet. The city [Quito] remains hidden, and even the flat top of the Panecillo, which reveals deeper down her position, is no longer visible; to the south lies the green valley of Quito; in the southeast, a high snowy mountain lifts in the blue sky [...] that in the imagination of the natives looks like heart-shaped and therefore call it Corazon” (Schmarda 1861: 251).

“At 12000 feet high, the small, creeping bamboo disappears; the shrubs are dwarf [...] The pajonal carries a sea of golden panicles and deserves his name due to the dry, straw-like appearance of its grasses. Still higher up the grasses are small and consist predominately of *Carex*... *Homantis pungens* [*sic* *Homanthis*, now *Perezia pungens*], an herbaceous composite, comes to more than 13,000 feet high” (Schmarda 1861: 252–253).

“After the visits to the higher parts a look at the lower parts will contribute significantly to the understanding. Below Quito, the vegetation changes at 8000 feet high. Individual bushes stretch the streams along the lower shrub region [...] Even a Mimose [*Mimosa*] rises from the hot valleys up the river to a few hundred feet below Quito” (Schmarda 1861: 254–255).

“Below 8000 feet, arboreal orchids are fairly common [...] The lower shrub region is not particularly rich in insects, the streams have a small Andean catfish (*Pimelodes*) [now *Astroblepus*], snakes do not reach high elevations; I saw the first in the forested region, about 1000 feet below Quito, frogs go up to 10500 feet” [only mention of frogs in his travel accounts in Ecuador] (Schmarda 1861: 255–256).

“Quito is very uneven, the house, which I inhabited, is the Convent of St. Augustine” (Schmarda 1861: 259).

“Lizards are still numerous at 9000 feet high, as well as some genera of spiders.” [only mention of lizards in his travel accounts in Ecuador] (Schmarda 1861: 259).



FIGURE 1. Dorsal (A), ventral (B) and lateral (C) views, and dewlap (D) of the holotype of *Anolis aequatorialis* Werner, 1894. Bar = 10 mm. Photos courtesy of Georg Gassner (Natural History Museum Vienna).

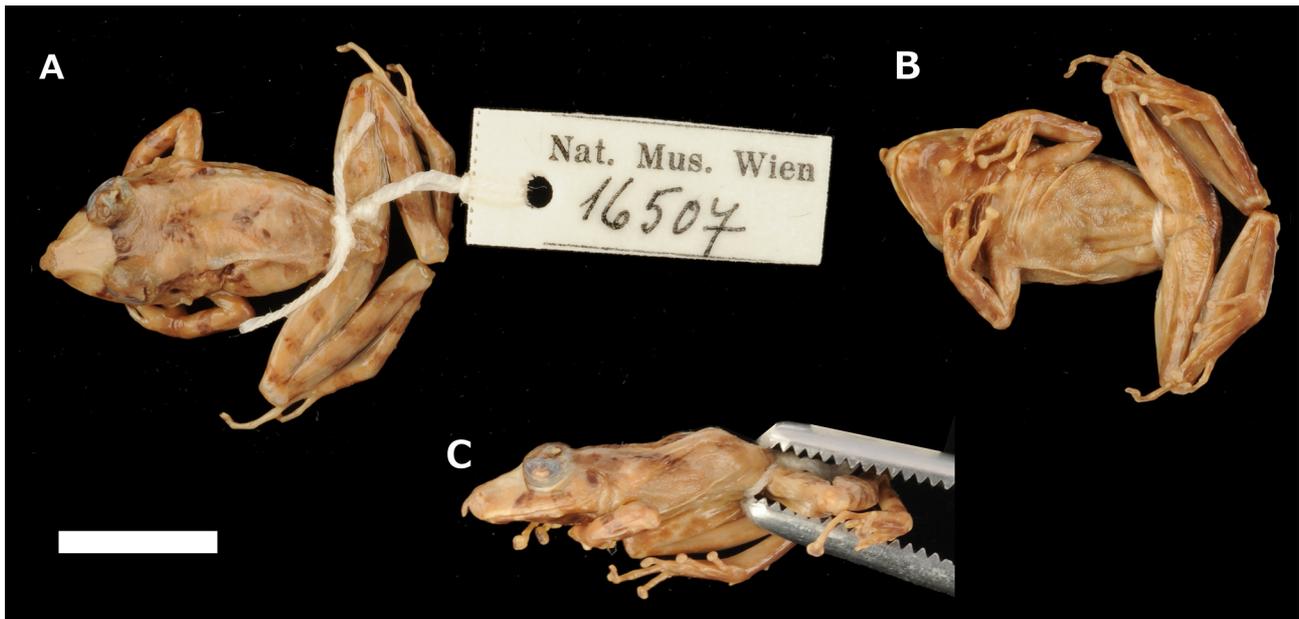


FIGURE 2. Dorsal (A), ventral (B) and lateral (C) views of the holotype of *Hylodes appendiculatus* Werner, 1894. Bar = 10 mm. Photos courtesy by Georg Gassner (Natural History Museum Vienna).

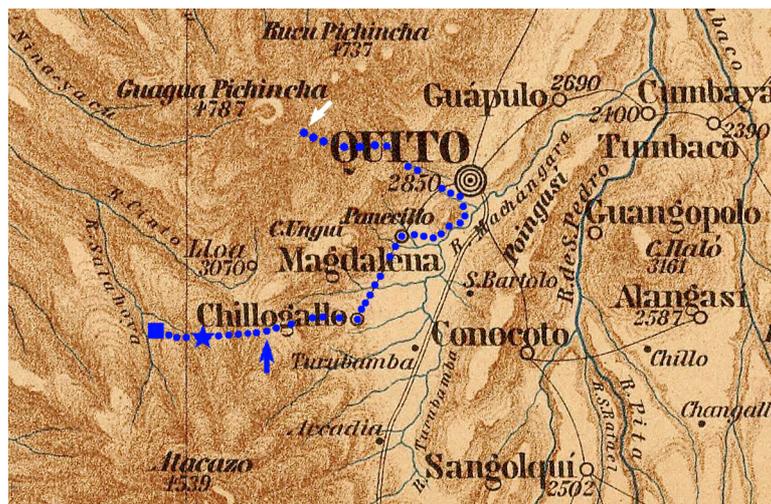


FIGURE 3. Section of the *Carta Geográfica del Ecuador* by Theodore Wolf (1892) indicating the most probable areas for the type localities of *Anolis aequatorialis* Werner, 1894 (square) and *Hylodes appendiculatus* Werner, 1894 (star), along the mountain pass between the south-western slopes of the Pichincha volcano and the northern slopes of the Atacazo volcano area. Blue dots mark the routes that Ludwig Karl Schmarda took to hike to the highlands (white arrow) and lower slopes (blue arrow) of the Pichincha volcano. Dark lines indicate roads.

Based on this information, it is evident that L. K. Schmarda hiked several times towards the highlands of the Pichincha volcano. His excursions started from his residence in the *Convento de San Agustín*, continued to the *Plaza de San Francisco*, one of the major public squares of Quito, and through the steep streets of the *Barrío de San Roque*, neighbourhood located on the eastern foothill of the Pichincha volcano. The streets of *San Roque* led him to the ravine *Quebrada de Jerusalén* and to the waterfall *Chorrera de Jatuna*. The ravine that he hiked was called *Jatuna* during precolonial (pre-incasic?) times; its name changed to *Ullaguanga-huayco*, *Ullaguangayacu* or *Quebrada de los Gallinazos* during the XVI century, and to *Quebrada de Jerusalén* or *Quebrada de La Cantera* during the XVII–XIX centuries. It was filled and transformed into the avenue *Avenida 24 de Mayo* in the early XX century (Andrade Marín 1964a-d; Stübel 2004; 1875 map of Quito by Juan Bautista Menten). L. K. Schmarda reached at least 4000 m elevation on the Pichincha volcano—based on his observation of *Perezia pungens* at more than 13,000 feet high. This same route was used by Alexander von Humboldt to reach the highlands of the Pichincha volcano (Stübel 2004).

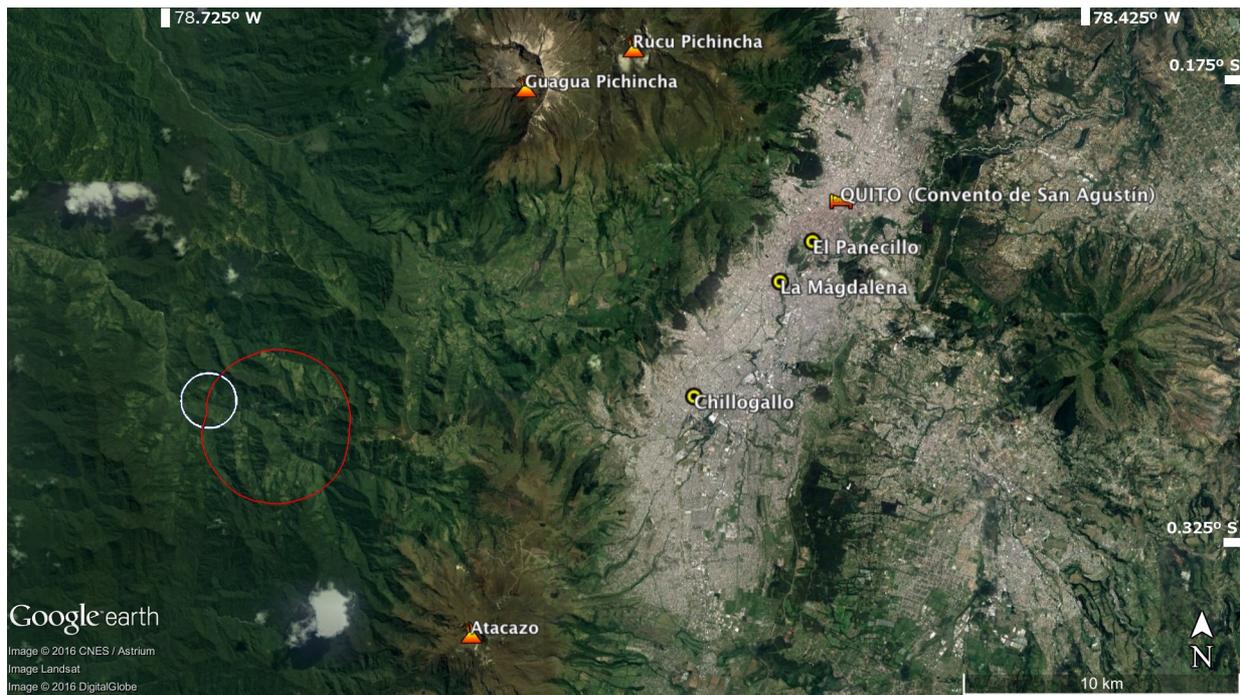


FIGURE 4. Map of Quito and surrounding areas showing several localities mentioned in the text and in Figure 3, and the type localities of *Anolis aequatorialis* Werner, 1894 (white circle, coordinates focus point: -0.278660° -78.709697° , radius: 1 km) and *Hylodes appendiculatus* Werner, 1894 (red circle, coordinates focus point: -0.285367° , -78.679366° , radius: 2.71 km.). Each locality is described as a circle, with a focus point and a radius. KMZ files showing both type localities are available here: <https://dx.doi.org/10.6084/m9.figshare.3753387.v1> Map images: Google, CNES/Astrium (2016), Landsat, Digital Globe (2016).

While Schmarda's route to the highlands is fairly clear, his route to the lower slopes of the Pichincha volcano is less evident due to the scarce information provided in the journal. This is further complicated by the fact that in the mid XIX century, major roads that connected Quito to the south-western lower slopes of the Pichincha volcano were largely abandoned, and several trails and bridle paths were used to connect the estates, hamlets, and towns on the lower slopes. However, these trails were never mapped and are nowadays poorly known (Villavicencio 1858; Wolf 1892; Andrade Marín 1964c; Lozano Castro 1991; Salomon 1997; 1875 map of Quito by Juan Bautista Menten; C. Freile in litt. 17 July 2015). It could be suggested that L.K. Schmarda continued his way from the *Chorrera de Jatuna* to Lloa and then went down to the western lower slopes of the Pichincha volcano, through the trail leading to Mindo. However, I find unlikely that he went to Lloa. He never mentioned Lloa in his journal, and it was a reference-point frequently indicated by contemporary explorers. Besides, the trail between Lloa and Mindo was largely neglected during the 1850s (Solomon 1997; C. Freile in litt. 17 July 2015). Instead, I think that L. K. Schmarda left the centre of Quito (crossing over the *Quebrada de Jerusalén*) to explore the basin of the river *Río Machángara*. He explicitly cited this river in the titles of Chapter VIII, and while he did not write the name of this river in the text of his journal, the narrations presented in the chapter match the sequence of titles, suggesting that on page 254 he is describing his expeditions across the *Río Machángara*. Furthermore, he described the flatworm *Polycladus andicola* (now *Pseudogeoplana andicola*) from specimens collected on bushes at Machángara (Schmarda 1859). Following the river, he probably went towards the towns of La Magdalena and Chillogalli, and then took a trail to San Juan and across the mountain pass between the south-western slopes of the Pichincha volcano and the northern slopes of the Atacazo volcano, the only available and nearby sector to reach the lower slopes. Another trail also departed from Chillogalli, but went towards Lloa and it would have taken him to the highlands again, which makes this path unlikely. L. K. Schmarda descended to the lower slopes of the Pichincha volcano, below 2400 m elevation—based on his observations of orchids below 8000 feet, and snakes ca. 1000 feet below Quito (i.e., ca. 8350 feet). Actually he must have reached at least 2300 m, the maximum known altitude for *Anolis aequatorialis*. This area roughly corresponds nowadays to the Quito–San Juan–Chiriboga–Las Palmas highway.

The correct definition of a type locality is important because it is the geographical place of collection of the name-bearing type; thus the International Code for Zoological Nomenclature recommends “a statement of a type locality that is found to be erroneous should be corrected” (ICZN 2000). In restricting and accurately localising a type locality, it is

recommended to re-examine data accompanying the original material, properly identify the original collector, review direct evidence from the collector's notes, and understand the collector's itinerary and related personal communications (Dunn 1934; Dunn & Stuart 1951; Peters 1955; Axtell 1981; ICZN 2000). Thus, based on the geographic and historic analyses of the expeditions of L. K. Schmarida herein presented, the known distribution of the species, and personal experience with both taxa and with the areas explored by L. K. Schmarida, I herein restrict the type localities as follows:

Type locality of *Anolis aequatorialis* Werner, 1894: The mountain pass between the south-western slopes of the Pichincha volcano and the northern slopes of the Atacazo volcano, at 2300 m elevation, province of Pichincha, Ecuador. Coordinates focus point: -0.278660° -78.709697° , radius: 1 km.

Type locality of *Hylodes appendiculatus* Werner, 1894: The mountain pass between the south-western slopes of the Pichincha volcano and the northern slopes of the Atacazo volcano, between 2300 and 2800 m elevation, province of Pichincha, Ecuador. Coordinates focus point: -0.285367° , -78.679366° , radius: 2.71 km.

Each locality is described as a circle, with a focus point and a radius to describe the associated uncertainty as a maximum distance from that point within which the locality is expected to occur (i.e., point-radius method, Wieczorek *et al.* 2004). KMZ files showing both type localities are available here: <https://dx.doi.org/10.6084/m9.figshare.3753387.v1>.

Acknowledgements

I am thankful to Georg Gassner and Heinz Grillitsch, Herpetological Collection, *Naturhistorisches Museum Wien* (Natural History Museum Vienna) for providing information and photographs of the type specimens of *Anolis aequatorialis* and *Hylodes appendiculatus*; to the historian Carlos Freile, Universidad San Francisco de Quito USFQ, for his comments on the status of roads in the surroundings of Quito in the XIX century; and to Jonathan Guillemot, Luciano Javier Avila and two anonymous reviewers for comments on the manuscript. I acknowledge support from the Programa "Becas de Excelencia", Secretaría de Educación Superior, Ciencia, Tecnología e Innovación (SENESCYT); Universidad San Francisco de Quito USFQ (Collaboration Grants); and María Elena Heredia and Laura Heredia. I am grateful to the Biodiversity Heritage Library BHL, Google Books, UNESCO, Flacso Andes, and Biblioteca Virtual Miguel de Cervantes for making freely available important literature.

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