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Source: South American Journal of Herpetology, 26(1) : 11-15

Published By: Brazilian Society of Herpetology

URL: https://doi.org/10.2994/SAJH-D-20-00060.1

South American Journal of HERPETOLOGY

VOLUME 26 | APRIL 2023

SBH
SOCIEDADE BRASILEIRA DE HERPETOLOGIA

South American Journal of Herpetology, 26, 2023, 11–14

Anolis paravertebralis Bernal-Carlo and Roze, 2005 and *A. umbrivagus* Bernal-Carlo and Roze, 2005 are junior synonyms of *A. solitarius* Ruthven, 1916 (Squamata: Dactyloidae)

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Abstract. The Sierra Nevada de Santa Marta of northern Colombia is home to several endemic species. Here we show that the names of two purported endemic lizard species, *Anolis umbrivagus* and *A. paravertebralis,* are junior synonyms of Santa Marta endemic *A. solitarius.* We present morphological evidence for this inference and photographs of *A. solitarius* in life.

Keywords. Colombia; Dactyloidae; Endemic species; Sierra Nevada de Santa Marta; Taxonomy.

Five endemic species of *Anolis* have been described from the Sierra Nevada de Santa Marta (SNSM), Colombia: *A. solitarius* Ruthven, 1916, *A. santamartae* Williams, 1982, *A. menta* Ayala et al., 1984, *A. paravertebralis* Bernal-Carlo and Roze, 2005, and *A. umbrivagus* Bernal-Carlo and Roze, 2005. The two species described by Bernal-Carlo and Roze (2005) were purported to differ from *A. solitarius* in enlarged middorsal scales in the case of *A. paravertebralis* and smaller dewlap and body size in the case of *A. umbrivagus.* Here we show that these traits are not diagnostic for these species, respectively, and recommend that the names *A. paravertebralis* and *A. umbrivagus* be synonymized with *A. solitarius.* In our discussion we consider species to be independently evolving sets of populations (Simpson, 1961).

We have examined the holotype specimens of *Anolis paravertebralis* (Academy of Natural Sciences of Philadelphia, ANSP 19713) and *A. umbrivagus* (Instituto de Ciencias Naturales, Universidad Nacional de Colombia, ICN 6181) and a paratype of *A. solitarius* (Museum of Comparative Zoology, Harvard University, MCZ 12053). Recently we conducted fieldwork on the northwestern slope of the SNSM and collected large series of anoles at the type locality of *A. solitarius* (San Lorenzo, approx. 2,200 m a.s.l.), the type locality of *A. paravertebralis* (Hacienda Cincinnati, approx. 1,600 m a.s.l.), and near the type locality of *A. umbrivagus* (within 15 km of Ciudad Perdida, SNSM). Across each of these localities, we found a single anole species with a large dewlap in males, smaller dewlap in females, and variably enlarged middorsal scales. We infer our collected individuals to be a single species because we observed continuous variation across all traits. Despite dozens of person-hours searching specifically for anoles, we found no evidence of more than one species of anole at any of these sites.

Extreme variation in the size of middorsal scales is uncommon in *Anolis.* Species such as *A. fuscoauratus* d'Orbigny in Duméril and Bibron, 1837 display uniform middorsals, or at most two enlarged scale rows, whereas individuals of *A. auratus* Daudin, 1802 consistently show multiple rows of abruptly enlarged keeled middorsal scales. *Anolis solitarius* is unusual in presenting a variation of levels of middorsal enlargement and keeling within species. Figure 1 shows some of the range of this variation, with comparison between individuals from the type locality of *A. solitarius* to the type specimen of *A. paravertebralis* (so named for its enlarged middorsal scales). Clearly, the level of middorsal variation within *A. solitarius* encompasses the enlargement and keeling evident in the type and only known specimen of *A. paravertebralis.* Given the otherwise indistinguishable morphology of the *A. paravertebralis* type specimen from topotypical *A. solitarius* and accounting for our intense collecting activity at the *A. paravertebralis* type locality, we see no reason to consider the *A. paravertebralis* type specimen as representing a different population than *A. solitarius.* That is, we consider the name *A. paravertebralis* to be a junior synonym of *A. solitarius.*

Anolis umbrivagus was diagnosed from *A. solitarius* as "…having a smaller body size in adults: 37–46 mm ($\bar{x}$ = 42.3 mm), as compared to 46 to 51 ($\bar{x}$ = 48.4 mm) for the latter [i.e., *A. solitarius*]; in having a smaller dewlap

How to cite this article: Poe S., Pérez-González J.L., Barnett J., Rueda-Solano L.A. 2023. *Anolis paravertebralis* Bernal-Carlo and Roze, 2005 and *A. umbrivagus* Bernal-Carlo and Roze, 2005 are junior synonyms of *A. solitarius* Ruthven, 1916 (Squamata: Dactyloidae). *South American Journal of Herpetology* 26: 11–14. http://doi.org/10.2994/SAJH-D-20-00060.1

Submitted: 10 December 2020
Accepted: 27 April 2022
Available Online: 10 April 2023

Handling Editor: Omar Torres-Carvajal
DOI: http://doi.org/10.2994/SAJH-D-20-00060.1
ZooBank: urn:lsid:zoobank.org:pub:F70823D1-44ED-4AF4-A4A5-23C61BB454CE

in males that begins at the level of the orbit and in having no dewlap or a rudimentary white fold in females." Bernal-Carlo and Roze further noted that "The new species has the tail more than twice the length of the body (2.11−2.35), while *A. solitarius* has the tail less than twice the length of the body (1.62−2.00)." In their dichotomous

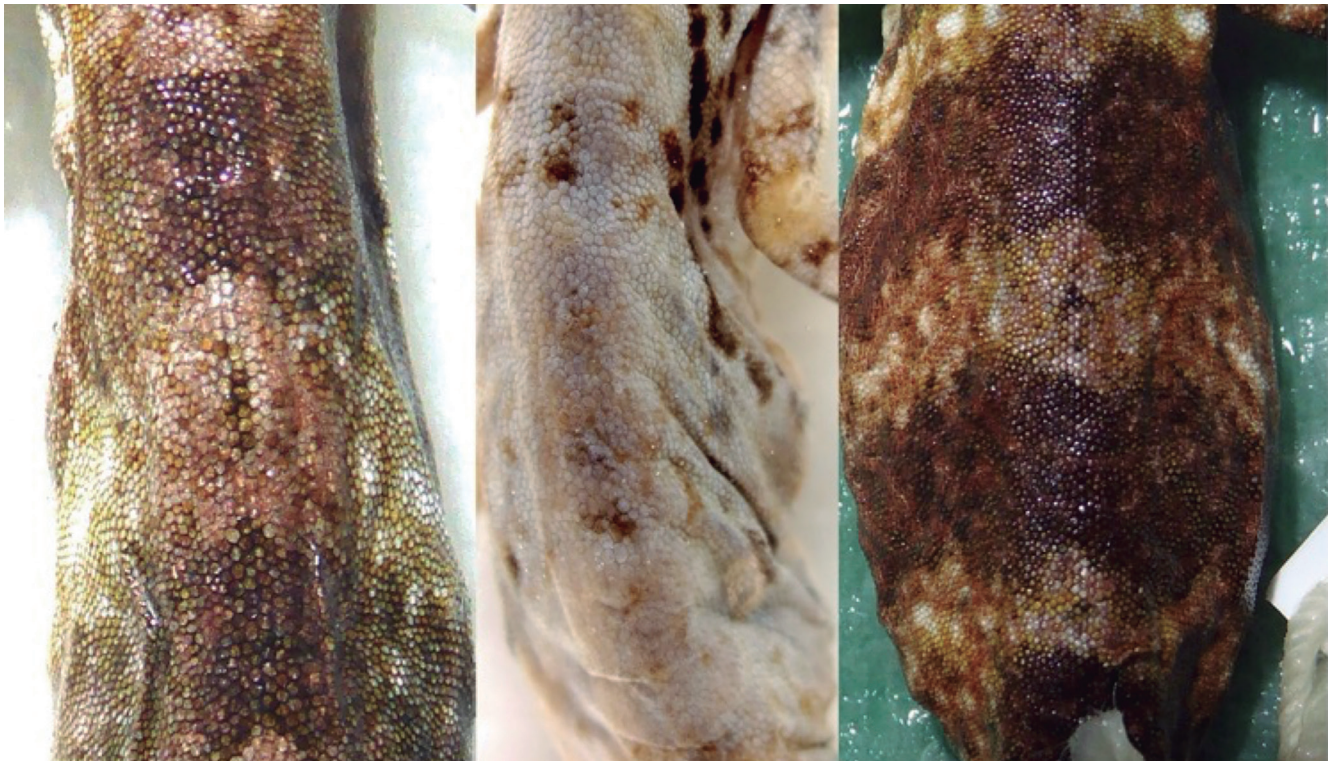

Figure 1. Dorsal scales of the holotype of *Anolis paravertebralis* (ANSP 19713; center) and specimens of *A. solitarius* collected at its type locality of San Lorenzo, Sierra Nevada de Santa Marta.

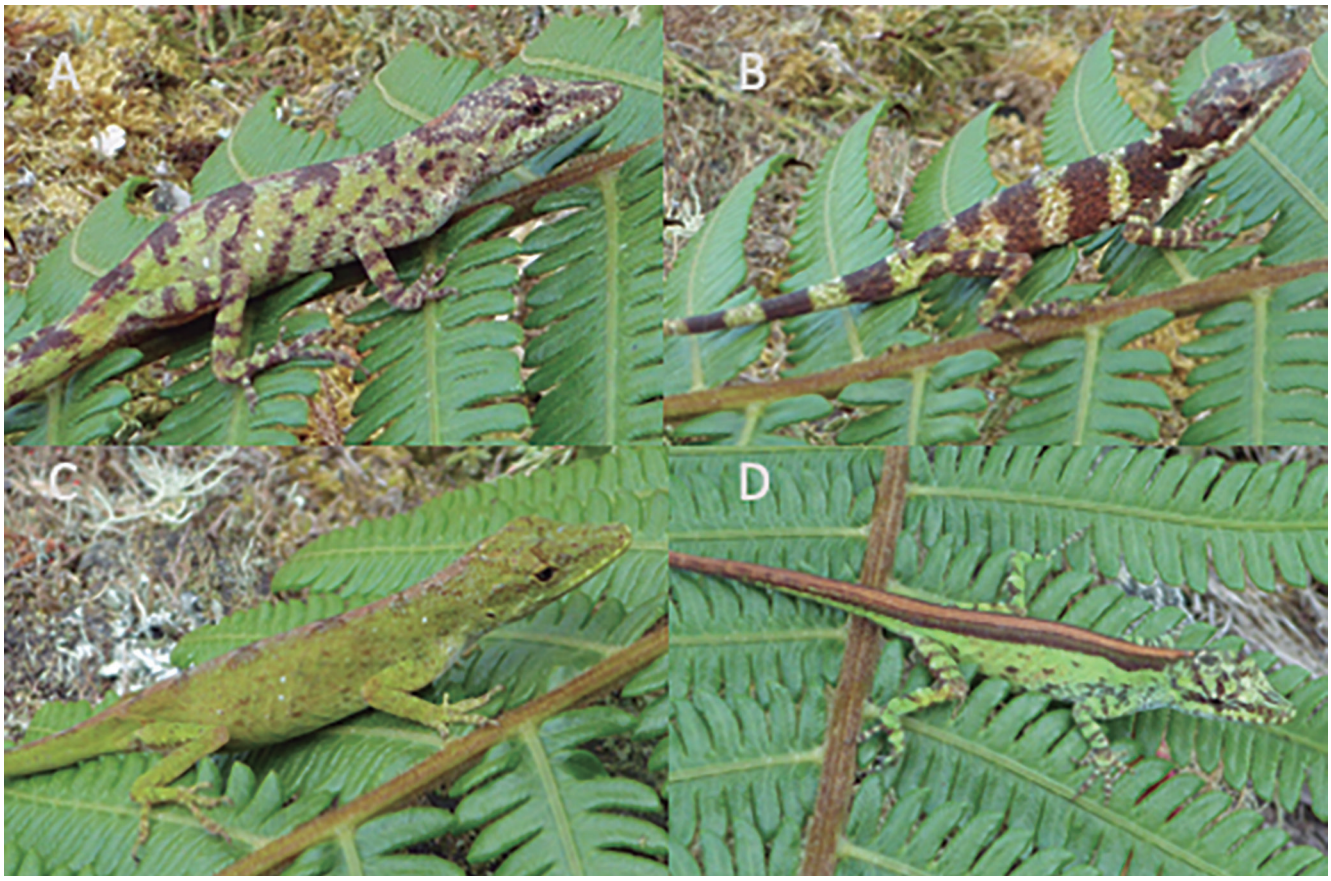

Figure 2. Pattern variation in adult male **(A, B)** and female **(C, D)** *Anolis solitarius* from the type locality of San Lorenzo, Sierra Nevada de Santa Marta.

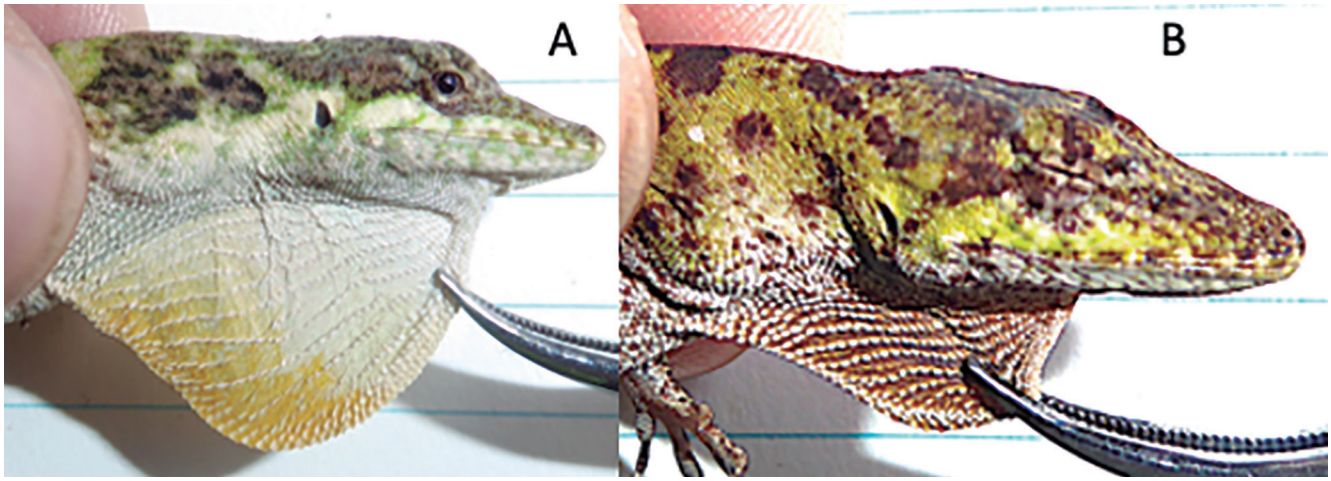

Figure 3. Dewlaps of male **(A)** and female **(B)** *Anolis solitarius* from the type locality of San Lorenzo, Sierra Nevada de Santa Marta.

key, Bernal-Carlo and Roze (2005) separated *A. umbrivagus* from *A. solitarius* and *A. menta* based on details of color pattern: "Not or poorly developed dark dorsal spots in males, or longitudinal dorsal stripes; females without or poorly marked white dewlaps" in *A. umbrivagus,* versus "Black dorsal crossbands clearly distinct, extending laterally to belly; males and females with dark dewlaps in *A. solitarius* and *A. menta*." The diagnosis and description of *A. umbrivagus* were based on one holotype male (SVL = 41.5 mm) and 10 paratype females. We address the five stated diagnostic traits, body size, male dewlap size, female dewlap size, tail length, and body pattern, in turn below.

A complicating factor in evaluating body size, and the status of *Anolis umbrivagus* in general, is that it is not clear which specimens were assigned to which species during scoring by Bernal-Carlo and Roze. This lack of clarity is due to the fact that the entire type series of *A. umbrivagus,* including the holotype (ICN 5797–5800, 6180–6186), is also listed by Bernal-Carlo and Roze as "specimens examined" for *A. solitarius* (Bernal-Carlo and Roze, 2005:21). If we assume that Bernal-Carlo and Roze considered the type series of *A. umbrivagus* to be *A. umbrivagus* rather than *A. solitarius,* that leaves four additional specimens that were considered to be *A. solitarius* (the type and paratypes of *A. solitarius,* and an uncataloged ICN specimen). Obviously, body size varies ontogenetically. Without corroborating evidence, it is not clear why the smaller specimens among those examined were considered to be a distinct species. In particular, it is unclear why the single male specimen known from Ciudad Perdida of length 41.5 mm was taken as evidence that the population in Ciudad Perdida has especially small body size.

Like body size, male dewlap size changes during ontogeny. It is well established in *Anolis* that smaller male individuals have proportionately smaller dewlaps (Echelle et al., 1978). We agree with Bernal-Carlo and Roze that the dewlap of the holotype of *A. umbrivagus* is proportionately slightly smaller than the dewlap of typical large male *A. solitarius* (i.e., SVL > 50 mm), although this comparison is difficult given the compressed nature of the dewlap in the preserved *A. umbrivagus* holotype. However, based on our collections of dozens of *A. solitarius* of a variety of body sizes, we find the dewlap size of the holotype of *A. umbrivagus* to be appropriate for an *A. solitarius* of SVL 41.5 mm. To summarize, based on body size and dewlap size, we cannot distinguish the holotype of *A. umbrivagus* from subadult males of *A. solitarius.*

Female dewlap size also varies ontogenetically in *Anolis* (personal observation), although the allometry of dewlap change in females has not, to our knowledge, been studied. Our own observations are that females of *A. solitarius* in the size range of the smaller individuals of the paratypes of *A. umbrivagus* have a dewlap that is barely noticeable. Such dewlaps may appear absent in preserved individuals, which is to say, the dewlap sizes in the paratype series of *A. umbrivagus* appear appropriate for comparably sized (i.e., subadult) female *A. solitarius.*

Relative tail length, the fourth trait listed to diagnose *A. umbrivagus,* also may vary ontogenetically. Regardless, our measurement of the MCZ paratype of *Anolis solitarius* gives a relative tail length of 2.12 (SVL 52 mm, tail length 110 mm), and relative tail lengths of our collected adult *A. solitarius* is 1.2–2.3. That is, the range of tail lengths in topotypical *A. solitarius* encompasses the values Bernal-Carlo and Roze considered to be diagnostic for *A. umbrivagus.*

Color pattern varies significantly in life and patterns fade over time in preserved *Anolis solitarius,* as in most anole species. We find the range of patterns we have observed in our collections of *A. solitarius* and older preserved material of *A. solitarius* to encompass the variation listed by Bernal-Carlo and Roze as diagnostic for *A. umbrivagus.* For example, note that the MCZ paratype of *A. solitarius* (MCZ 12053; https://mczbase.mcz.harvard.edu/guid/MCZ:Herp:R-12053) does not obviously display the "Black dorsal crossbands, clearly distinct" claimed to distinguish *A. solitarius* from *A. umbrivagus* in the dichotomous key. In general, individuals of *A. solitarius* are quite variable in color pattern. Males and females tend to display green flanks and an abdomen with some dark transverse points or bands. Many female individuals have a tan middorsal stripe bordered by darker brown. Males often show a dark butterfly-shaped pattern in the verte-

bral region (a pattern that is present but often weaker in some females) or broad bands of green and dark brown; they may possess a cream stripe above the mouth extending through the ear to the level of the axilla and a dark blotch posterior to the ear. Individuals of either sex may appear patternless green or brown (Fig. 2). The only color trait listed by Bernal-Carlo and Roze that we have not observed is the "dark" dewlap of male *A. solitarius.* However, this trait was scored incorrectly by Bernal-Carlo and Roze. Males of *A. solitarius* have a pale white and yellow dewlap (Fig. 3). Possibly Bernal-Carlo and Roze ascribed the dewlap color of the female to that of the male based on Ruthven's (1916:3) color description of his female holotype specimen: "skin of the gular region black."

We observed no differences in the type specimen of *Anolis umbrivagus* that cannot be attributed to ontogenetic stage or normal intraspecific variation. That is, the few specimens collected by Juan Manuel Renjifo at Ciudad Perdida appear to be subadult specimens of *A. solitarius.* Therefore, we recommend that the name *A. umbrivagus* be considered a junior synonym of *A. solitarius.*

Here we have shown that the holotype specimens of *Anolis umbrivagus* and *A. paravertebralis* are conspecific with *A. solitarius.* This work reduces the number of endemic species of Santa Marta anole to three: *A. solitarius* from the northwestern slope of the SNSM, *A. menta* from the western slope, and *A. santamartae* from the south slope. The southern and eastern regions of the area remain understudied, and we expect that our ongoing work on Santa Marta anoles will result in taxonomic additions to the endemic fauna of the area.

ACKNOWLEDGMENTS

We thank two reviewers and the editorial staff of SAJH for helpful reviews of this paper.

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APPENDIX

Additional specimens examined

Anolis solitarius (*n* = 12): COLOMBIA: **Magdalena:** Cuchilla de San Lorenzo, Estacion Experimental: Reptile Collection of the Centro de Colecciones de la Universidad del Magdalena, CBUMAG:REP:00325-00336.