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Morphological variation in *Anolis cristatellus*

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Anolis cristatellus was first described by Duméril & Bibron in 1837 based on two syntypes (MNHN 2353, MNHN 2447) erroneously reported to have originated from Martinique. In 1931, Grant proposed to recognize two new subspecies aside from *A. cristatellus cristatellus*: *A. c. wileyae* and *A. c. cooki,* based mostly on differences in dewlap coloration. Gorman et al. in 1968 postulated that *A. cooki* was a species distinct from *A. cristatellus*, based on morphologic and chromosomal evidence. Gorman et al. (1980) found supporting evidence for *A. cooki* being a separate species through electrophoretic analysis, also discovering that *A. desechensis* could not be recognized as a species different from *A. cristatellus.*

Anolis cristatellus is widely distributed on Puerto Rico; it also occurs on the Virgin Islands, in the Dominican Republic, coastal Mexico (Yucatan), Costa Rica, and southeastern Florida.

The collections at the Research Institute Senckenberg include a large series of *A. cristatellus* (350 specimens) from St. Thomas, one of the U.S. Virgin Islands, collected in 1881. It is the purpose of the present paper to summarize the individual variation of this series and test whether differences between males and females could be documented.

According to Heatwhole (1976) and Heatwhole et al. (1981), all *A. cristatellus* populations east of Puerto Rico, including St. Thomas, represent the subspecies *A. c. wileyae*.

We took measurements and scalation data from 50 males and 47 females (see appendix). Nomenclature of scale characters follows that of Köhler (2003). All measurements were made using precision callipers and were rounded to the nearest 0.5 mm. Head length was measured from the tip of the snout to the anterior margin of the ear opening. Snout length was measured from the tip of the snout to the anterior border of the orbit. Head width was identified as the distance between the oral ricti. Snout-vent length was measured from the tip of the snout to the anterior margin of the cloaca, tail length from the anterior end of the cloaca to the tip of the tail. Broken or regrown tails were not measured. Tail height and width were measured at the point reached by the heel of the extended hind leg. The tail fin in males was not included in the measurement. Dorsal scales were counted at the middle portion of the trunk along a paravertebral line, and ventral scales were counted at the middle portion of the trunk along the midline. Subdigital lamellae were counted on phalanges ii to iv of the 4th toe. Abbreviations used are SVL (snout-vent length), HL (head length), HW (head width), A–GD (axilla–groin distance), IP (interparietal plate), SS (supraorbital semicircles), SPL (supralabials) and SBL (sublabials).

Statistics were performed using the computer programs Statistica version 6.1 and GraphPad Prism version 4.0. To assess whether the means of two groups were statistically different we performed t-tests ($p<0.05$).

The largest male (SMF 10762) in our series has a SVL of 69 mm, the largest female (SMF 10491) 58 mm. The variation in morphometric and scalation characters in our series is summarized as follows: tail length / SVL ratio 1.29–1.89 in males, 1.47–1.77 in females; HL / SVL 0.27–0.33 in males, 0.22–0.32 in females; HL / HW 1.42–1.63 in males, 1.09–1.77 in females; shank length / SVL 0.25–0.31 in males, 0.22–0.32 in females; tail slightly to distinctly laterally compressed in cross section, with tail fin in some male specimens, tail height / width ratio 1.10–2.30 in males, 1.00–2.09 in females; SL / SVL 0.12–0.17 in males, 0.12–0.16 in females; SL / HL 0.43–0.51 in males, 0.40–0.71 in females; shank / HL 0.88–1.05 in males, 0.81–1.30; 2–5 postrostrals; 3–6 scales between nasals; supraorbital semicircles well developed, no scales between them; 1–4 rows of scales separating supraorbital semicircles and interparietal at narrowest point; supraorbitals composed of 2–6 distinctly enlarged scales; canthal ridge very prominent, composed of 2–4 large scales; 3–8 scales present between second canthals; 5–12 scales present between posterior canthals; loreal region slightly concave, 18–57 loreal scales in a maximum of 4–8 horizontal rows; mostly keeled subocular scales arranged in a single row; 5–8 supralabials to level below center of eye; suboculars in contact with supralabials in 70% of specimens, in 30% divided by one row of scales; mental bordered posteriorly by 4–10 postmentals; 5–8 sublabials to level below center of eye; ear opening usually vertically oval, size (length x width) ratio ear opening / interparietal 0.67–3.83; dorsum of body with small, nearly uniform, juxtaposed scales, 42–84 dorsal scales in one head length; no median rows enlarged, dorsals gradually grading into the slightly smaller, flattened and homogeneous laterals; ven-

Table 1. Selected measurements, proportions and scale characters of male and female *Anolis cristatellus*. Range is followed by mean value and one standard deviation in parentheses.

Character	males	females	p-value
max. SVL [mm]	69	58	–
tail length / SVL	1.288–1.891 (1.683 ± 0.158)	1.466–1.773 (1.560 ± 0.120)	0.0926 (ns)
tail diameter vertical / horizontal	1.095–2.286 (1.589 ± 0.247)	1.0–2.091 (1.409 ± 0.247)	0.0052 (**)
HL/HW	1.417–1.627 (1.511 ± 0.044)	1.09–1.775 (1.576 ± 0.100)	<0.0001 (***)
HL/SVL	0.175–0.224 (0.192 ± 0.001)	0.165–0.214 (0.183 ± 0.011)	<0.0001 (***)
axilla–groin distance / SVL	0.331–0.484 (0.402 ± 0.032)	0.363–0.531 (0.421 ± 0.035)	0.0064 (**)
snout length / SVL	0.116–0.165 (0.134 ± 0.009)	0.115–0.158 (0.134 ± 0.009)	0.9427 (ns)
snout length / HL	0.425–0.506 (0.462 ± 0.019)	0.397–0.711 (0.468 ± 0.042)	0.4145 (ns)
shank length / SVL	0.248–0.313 (0.276 ± 0.014)	0.222–0.319 (0.260 ± 0.016)	<0.0001 (***)
shank length / HL	0.878–1.045 (0.952 ± 0.039)	0.808–1.303 (0.907 ± 0.072)	0.0002 (***)
subdigital lamellae of 4th toe	29–39 (32.560 ± 2.140)	27–36 (29.956 ± 2.088)	<0.0001 (***)
number of scales between IP and SS	1–4 (2.180 ± 0.691)	1–4 (2.511 ± 0.804)	0.0320 (*)
number of SPL to level below centre of eye	5–8 (6.640 ± 0.749)	5–8 (6.756 ± 0.609)	0.4148 (ns)
number of SBL to level below centre of eye	5–8 (6.460 ± 0.646)	6–8 (6.511 ± 0.589)	0.6888 (ns)
total number of loreals	21–51 (34.040 ± 7.714)	18–57 (30.844 ± 6.755)	0.0352 (*)
number of horizontal loreal scale rows	5–8 (5.980 ± 0.820)	4–7 (5.556 ± 0.693)	0.0080 (**)
number of postrostrals	2–5 (3.511 ± 0.748)	2–5 (3.349 ± 0.686)	0.2893 (ns)
number of postmentals	6–10 (7.060 ± 0.978)	4–9 (6.682 ± 0.959)	0.0621 (ns)
number of scales between nasals	3–6 (4.367 ± 0.636)	4–6 (4.605 ± 0.791)	0.1144 (ns)
number of scales between 2nd canthals	4–8 (5.480 ± 0.863)	3–8 (5.409 ± 0.897)	0.6973 (ns)
number of scales between posterior canthals	5–11 (7.840 ± 1.131)	6–12 (7.682 ± 1.052)	0.4863 (ns)
number of medial dorsal scales in one head length	42–72 (58.120 ± 7.233)	42–84 (63.957 ± 8.094)	0.0003 (***)
number of medial ventral scales in one head length	32–60 (46.820 ± 6.336)	30–54 (39.277 ± 4.871)	<0.0001 (***)
number of medial dorsal scales between levels of axilla and groin	64–119 (87.633 ± 13.435)	67–120 (90.711 ± 12.650)	0.2568 (ns)
number of medial ventral scales between levels of axilla and groin	40–76 (57.02 ± 7.23)	40–60 (50.96 ± 4.50)	<0.0001 (***)

trals at midbody larger and smooth; 30–60 ventral scales in one head length; 27–39 lamellae under phalanges ii–iv of 4th toe.

We found highly significant morphological differences between males and females in relative head width, relative trunk length, and in the relative size of ventral scales. Males have relatively broader heads than females as indicated by ratios of head length to head width as well as head width to SVL (Tab. 1). Males have a relatively shorter axilla–groin distance, and in consequence a relatively larger head than females, but more ventral scales between levels of axilla and groin (Tab. 1). Also the average adult size of males is greater than in females. The largest male specimen measured 69 mm in SVL, whereas the largest female reached a SVL of 58 mm. Counting dorsal scales turned out to be another distinctive means for separating males from females, since female specimens had a significantly higher number of medial dorsal scales in one head length than males (Tab. 1).

Counting the 4th toe lamellae on a hind limb showed another highly significant difference between the genders (Tab. 1). The number of lamellae is higher in males, with a maximum of 39 lamellae, than in females, with a maximum of 36 lamellae.

The shank length, both in relation to SVL and HL is shown to be significantly larger in male specimens (Tab. 1).

A little less significant, with a p-value of 0.0052 (**), is the ratio of vertical to horizontal tail diameter (Tab. 1), which indicates that males have slightly more laterally compressed tails than females.

We noticed ontogenetic and sexual variation in tail morphology. While in juveniles the tails are only slightly compressed laterally (Fig. 1a) and not very different from one another, that changes with age. With maturity comes a stronger lateral compression. Adult males develop a more or less distinct dorsal crest on their tails which range from hardly noticeable (Fig. 1b) to about twice the diameter of the measured tail (Fig. 1c). In females no tail crest was ever apparent (Fig. 1d). Due to the irregular occurrence of tail crests, we did not include them in the measurements.

The present data lead to the conclusion that differences between sexes become evident when comparing HW, HL, SVL, shank length, axilla–groin distance, and 4th toe lamellae count.

Similar results were obtained by Butler et al. (2007). By using analysis of variance (ANOVA) and multivariate analysis of variance (MANOVA), they found that sexual dimorphism was significant regarding SVL, mass, hind and fore limb in some, and 4th toe lamellae count in almost all ecomorph (habitat specialist) classes.

In a slightly different context, Knox et al. (2001) found that among other measurements, SVL, hind and fore limb length, and 4th toe lamellae count were highly significant in establishing which kind of ecomorph class an anole belongs to.

In addition, the somewhat paradox observation that males have smaller relative body sizes than females was also made by Butler et al. (2007) and Butler (2007).

The results we obtained largely support the data published by Schwartz & Henderson (1991). Their largest male had a SVL of 75 mm, the largest female one of 73 mm

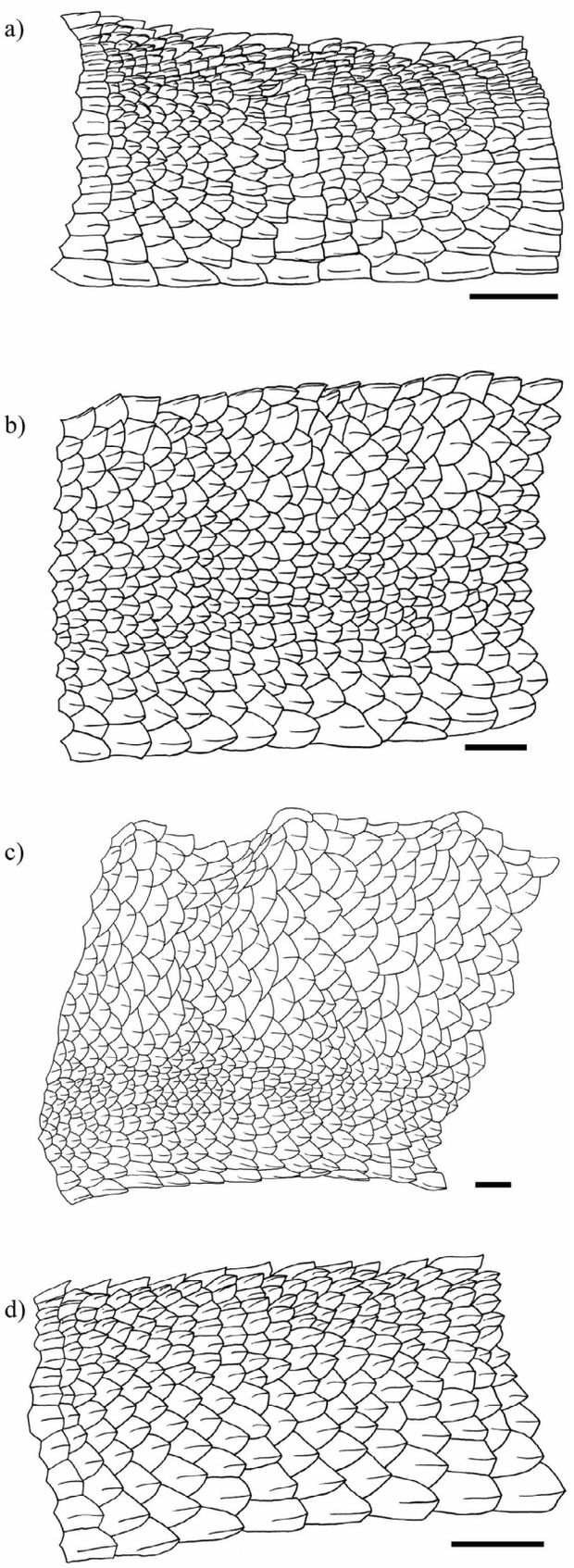

Figure 1. Lateral view of tail in *Anolis cristatellus* (at the point reached by the heel of the extended hind leg) in a) juvenile (SMF 10750); b) adult male (SMF 10609); c) adult male (SMF 10720); d) adult female (SMF 10521). Scale bars equal 1.0 mm

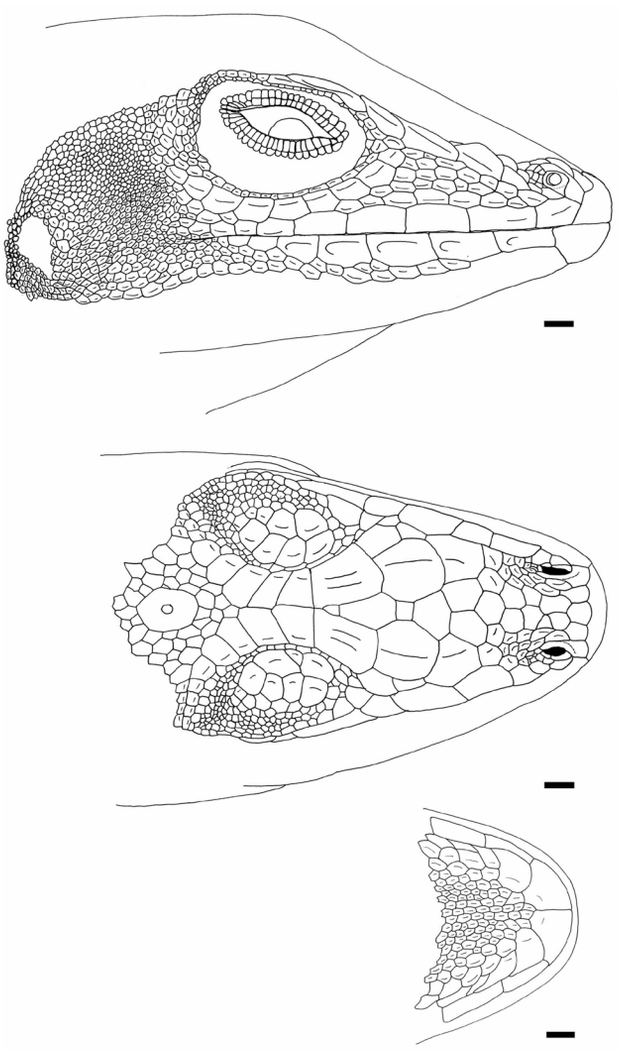

Figure 2. Head of *Anolis cristatellus* (SMF 10695). Scale bar equals 1.0 mm

in contrast to 69 and 58 mm, respectively, in our collection.

Schwartz & Henderson (1991) found 5–7 rows of loreals, 6–8 postmentals, and the subocular scales were never in contact with supralabial scales in any specimen. In our specimens we documented 4–8 rows of loreals and 4–10 postmentals, and subocular scales were in contact with one supralabial scale in almost 30% of the specimens.

Acknowledgements

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Appendix
Specimens examined

USA: Virgin Islands: St. Thomas: SMF 10459, 10468, 10485–89, 10491, 10493, 10497, 10499, 10501, 10505–07, 10513–14, 10517–18, 10520–21, 10525–29, 10544, 10550, 10553, 10557, 10562–63, 10565, 10567–68, 10572, 10575, 10584, 10588, 10590, 10593, 10598, 10606–07, 10609, 10613–14, 10624, 10626–27, 10630–31, 10635–36, 10638, 10642–43, 10648, 10651, 10655–56, 10659–62, 10664–65, 10668, 10676, 10679–80, 10686, 10688, 10690–92, 10694–96, 10698–99, 10708, 10714, 10720–21, 10725, 10743–44, 10750, 10762, 10764, 10769, 10771, 10774, 10779, 40690–91, 40694, 40697.