

Introductions of *Anolis* Species to the  
Island of St. Lucia, West Indies: Testing  
for Hybrids Using Multivariate  
Morphometrics

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Of the 27 islands in the Lesser Antilles, 17 contain a single species, whilst ten islands have two species. The solitary lizards on 16 of the 17 are classified as intermediate in size relative to the body sizes of *Anolis* species in sympatry (the exception is *A. ferreus* on Marie Galante). On nine of the two-species islands, one species is larger than the other by a factor of 1.5 or more (on the tenth island, St. Maarten, the difference is 1.45).

A considerable amount of interest has recently been given to this phenomenon (Roughgarden and Pacala, 1989; Losos, 1990; Miles and Dunham, 1996), particularly in the Northern Lesser Antilles. Losos (1990) considered two fundamentally different hypotheses to explain differences in body size among island populations of *Anolis*. The first hypothesis suggests that species of roughly equivalent size colonize an island and evolve in different directions (character displacement). Alternatively, he suggested that body size differences may have evolved in allopatry, and only species sufficiently different in body size could invade and coexist on an island (size assortment). For the Northern Lesser Antillean species, Losos (1990) demonstrated character displacement, although an alternative hypothesis (Roughgarden and Pacala, 1989) exists to explain the patterns of body size. Miles and Dunham (1996) presented a critical discussion of these alternative hypotheses.

However, in the Southern Lesser Antilles character displacement cannot be demonstrated, but Losos (1990) was unable to reject the alternative hypothesis of size assortment. Theoretically, there are two plausible causes which could be responsible for the pattern of size assortment, namely competitive exclusion or hybridization of closely-related taxa (Gorman and Kim, 1976; Losos, 1990). Using a null model, Losos (1990) was unable to reject the latter hypothesis.

In this paper we use the island of St. Lucia (140°N, 610°W) in the Southern Lesser Antilles to investigate potential processes that have been proposed to explain the patterns of body size for anoles of this island chain. The recorded reptile fauna of the island includes five species of snakes and twelve species of lizards (Schwartz and Henderson, 1991). The most common reptile is the endemic iguanid *Anolis luciae* (Schwartz and Henderson, 1991). However, two introduced species of *Anolis*, *A. extremus* from Barbados and *A. watsi watsi* from Antigua, also occur in the north west of the island around the capital city, Castries (Underwood, 1962; Corke, 1987; Schwartz and Henderson, 1991). In this study we test for hybridization between *A. extremus* and *A. luciae* using multivariate morphometrics. These species are both members of the monophyletic *roquet* species group and are classified as intermediate-sized anoles (Roughgarden, 1995). Hence, the presence of hybrids would support the hypothesis of occasional hybridization being a potential cause of size assortment in the Southern Lesser Antilles. Analysis was not performed on *A. watsi* since it has substantial karyotypic differences from *A. luciae* (Gorman and Atkins, 1969) rendering hybridization very unlikely.

Ten adult male lizards were sampled from each of three localities on St. Lucia where both *A. luciae* and *A. extremus* have been recorded (Schwartz and Henderson, 1991). Specimens sampled were not *A. luciae*

but may have been *A. extremus* or *A. luciae* / *A. extremus* hybrids. In addition five adult male *A. luciae* were also collected from each of 47 localities from across the rest of the island, whilst 10 adult male *A. extremus* were collected from Crane Point, Barbados. Lizards were weighed and anaesthetized with sodium pentobarbitone. After body measurements (measured to 0.01 mm using digital calipers) and scale counts (using a 5× stereoscopic microscope) were made the lizards were allowed to recover, then returned to the site of capture. The following precisely defined characters were recorded: (1) snout-vent length (SVL) measured from the anterior tip of the snout to the anterior edge of the vent; (2) jaw length (JAWL) measured from the angle of the jaw to the tip of the snout; (3) head length (HEADL) measured from the anterior edge of the tympanum to the tip of the snout; (4) head depth (HEADD) measured at a point just posterior to the eyes; (5) head width (HEADW) measured at the widest part of the head; (6) snout width (SNOUTW) measured at a point just posterior to the eyes; (7) upper leg length (UPLEGL) measured from the angle of the knee joint to the midline between the hind limbs; (8) lower leg length (LOWLEGL) measured from the angle of the knee joint to the angle of the ankle joint; (9) length of the fourth toe of the hind foot (TOEL) measured from the webbing between the third and the fourth toes to the tip of the pad on the fourth phalanx; (10) width of the fourth toe of the hind foot (TOEW) measured at its widest point; (11) tail depth (TD) measured at a point half the snout-vent distance from the vent; (12) dewlap area (DEWSIZE) measured by drawing round the edge of the extended dewlap onto graph paper and counting the number of 1 mm squares enclosed. For computational purposes this was reduced to a linear measurement by the formula square root (2× area); (13) the number of scales around the body (BSC) at its widest point; (14) the number of ventral scale rows (VENTSC) counted between the limb axillae; (15) the number of supralabials (SUPLAB); (16) the number of sublabials (SUBLAB); (17) the number of scales from the first parietal scale in a straight line down the back to the point directly between the illial processes (PSC); (18) the number of subdigital lamellae (LAM) on the second and third phalanges of the fourth toe of the hind foot, beginning at the lamella level with the webbing between the third and fourth toes; (19) the number of scales between the interparietal and supraorbital semicircles (SCBISS); (20) the number of postrostral scales (PRSC); (21) the number of postmental scales (PMSC).

A canonical variate analysis (CVA) was performed with *A. luciae* from St. Lucia (47 groups representing 47 localities) and *A. extremus* from Barbados (a single group). The 30 unknown specimens were then plotted on the canonical variates (*a posteriori*) in order to reveal whether they belonged to either species or were intermediate, indicating hybrid status.

The loadings for the first two canonical variates are shown in Table 1. The first canonical variate discriminates between the two species (*A. luciae* and *A. extremus*), while the second expresses geographic variation of *A. luciae* for St. Lucia (Fig. 1). The first canonical variate therefore provides an axis discriminating between the two species. It is also apparent that the unknown specimens from the potential hybrid area

TABLE 1. Canonical variate loadings for all morphological variables.

Character	CV1	CV2
SVL	0.64	2.71
JAWL	-0.17	0.11
HEADL	-0.24	-0.03
HEADD	0.10	0.62
HEADW	0.40	-1.34
SNOUTW	-0.24	0.47
UPLEGL	0.06	-0.58
LOWLEGL	-0.09	-0.92
TOEL	-0.17	-0.53
TOEW	0.01	-0.29
TD	-0.02	0.05
DEWS	-0.16	-0.29
BSC	0.47	0.14
VENTSC	0.12	0.24
SUPLAB	0.21	0.03
SUBLAB	0.16	-0.24
PSC	-0.21	-0.37
LAM	-0.87	0.27
SCBISS	0.30	0.07
PRSC	-0.01	0.24
PMSC	0.04	0.01

group with *A. extremus* from Barbados and are not hybrids. Hence, this preliminary study suggests that *A. luciae* and *A. extremus* are behaving as biological species on the island of St. Lucia and hybrids are not common.

This has implications for the explanation of patterns of body size for the anoles of the Southern Lesser Antilles in terms of size assortment (Losos, 1990), namely

that this sample does not provide evidence that inter-specific hybridization is the mechanism by which size assortment arose for at least part of the southern Lesser Antilles. On the other hand the evidence does not allow us to reject the alternative explanation of size assortment by competitive exclusion.

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LITERATURE CITED

- CORKE, D. 1987. Reptile conservation on the Maria Islands (St. Lucia, West Indies). *Biol. Conserv.* 40: 263–270.
- GORMAN, G. C., AND L. ATKINS. 1969. The zoogeography of Lesser Antillean *Anolis* lizards— an analysis based upon chromosomes and lactic dehydrogenases. *Bull. Mus. Comp. Zool.* 38:53–80.
- \_\_\_\_\_, AND Y. J. KIM. 1976. *Anolis* lizards of the eastern Caribbean: a case study in evolution. II. Genetic relationships and genetic variation of the *bimaculatus* group. *Syst. Zool.* 25:62–77.
- LOSOS, J. B. 1990. A phylogenetic analysis of character displacement in Caribbean *Anolis* lizards. *Evolution* 44:558–569.
- MILES, D. B., AND A. E. DUNHAM. 1996. The paradox of the phylogeny: character displacement of analyses of body size in island *Anolis*. *Evolution* 50: 594–603.
- ROUGHGARDEN, J. 1995. *Anolis* lizards of the Caribbean. Ecology, evolution and plate tectonics. Oxford Univ. Press, Oxford.

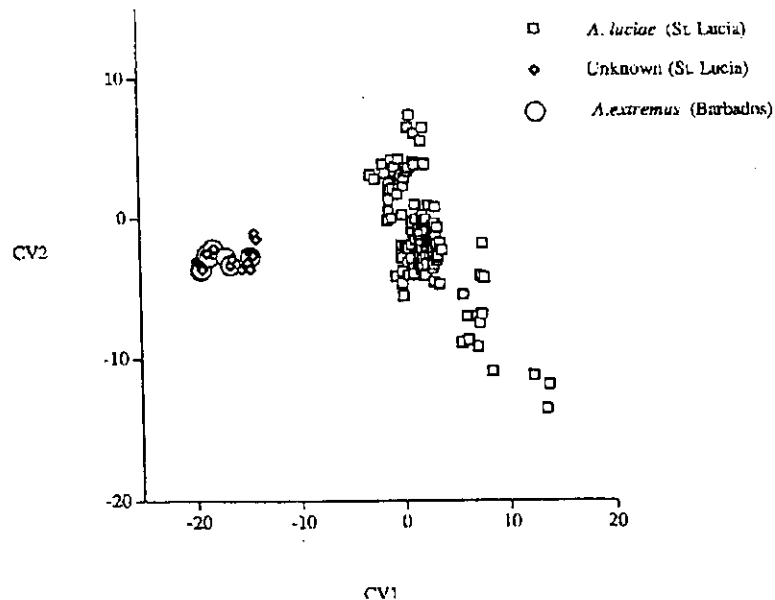


FIG. 1. Scatterplot of the first two canonical variable scores for overall morphology (summarizing 80% of total variation). CV1 discriminates between the two species, whilst CV2 represents geographic variation of *A. luciae* for St. Lucia.