MORPHOLOGICAL SPECIES VERIFICATION AND GEOGRAPHIC DISTRIBUTION OF *Anolis* (SAURIA: POLYCHROTIDAE) IN FLORIDA

By

BRIAN J. CAMPOSANO

A THESIS PRESENTED TO THE GRADUATE SCHOOL OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

UNIVERSITY OF FLORIDA

2011

To all who dedicated time, effort, patience, and advice throughout my graduate career, in order to make this accomplishment a reality

ACKNOWLEDGEMENTS

I thank the chair of my committee, Dr. Steve Johnson, for believing in me throughout this entire process and helping motivating me through some difficult times while conducting this study. I thank the co-chair of my committee and mentor, Dr. Kenneth Krysko, for the countless hours of scientific and editorial assistance provided throughout my time as a graduate student. I thank the other members of my committee, Drs. Todd Campbell and Jeffrey Hill, for their valuable insight, guidance, and editorial comments enabling me to finish my study. I thank Dr. Kent Vliet, for providing me with a job throughout a significant portion of my graduate career and helping to develop my teaching skills. I thank the University of Florida College of Agriculture and Life Sciences statistical department for advice and guidance on the methodologies and interpretations of my data. I also thank my parents, family and friends who encouraged and supported me throughout this entire process.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Thesis Presented to the Graduate School of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Master of Science

MORPHOLOGICAL SPECIES VERIFICATION AND GEOGRAPHIC DISTRIBUTION OF *Anolis* (SAURIA: POLYCHROTIDAE) IN FLORIDA

By

Brian J. Camposano

December 2011

Chair: Steve Johnson
Major: Interdisciplinary Ecology

Invasive species are recognized as a growing ecological and economic threat worldwide. Reptiles and amphibians, such as the Brown Tree Snake and Cane Toad, are among the most notable species introductions known. In Florida, there are more than 50 introduced established herpetofaunal species; the majority of these are lizards. One group of lizards, the anoles, is represented by nine introduced species plus the state's single native species. The genus *Anolis*, while being one of the most species-rich vertebrate groups, is also extremely variable in morphology, making differentiation among species an arduous task. This has led to misidentification of specimens in both the field and the laboratory, resulting in erroneous records of species and localities being reported and perpetuated in the literature. Additionally, one introduced species, *Anolis porcatus*, is indistinguishable from its native counterpart, *A. carolinensis*, leading to more questions about geographic ranges and identification methods. Proper identification of these species is often difficult and knowledge of proper identification methods for species present in Florida based on characters which do not change in death or preservation (e.g. scales) is lacking. Therefore, I statistically examined the morphology of Florida's *Anolis* species, described and compared morphological characters, developed a

dichotomous key, and compiled distribution maps and historical species accounts of invasion pathways and colonization history in Florida. I compared multiple scale characters for all species with Multiple Analysis of Variance, Analysis of Variance, Multiple Analysis of Covariance, Analysis of Covariance, Discriminate Function Analysis (DFA) and qualitative methods. To attempt to distinguish *A. porcatus* from *A. carolinensis*, I used binomial logistic regression models and DFAs. I found evidence to support characters that allowed for differentiation between each species present in Florida. However, while there was statistical evidence supporting combinations of characters to discern *A. carolinensis* from *A. porcatus*, no such character or characters could differentiate between them with 100% accuracy in every case. The results of this analysis will assist researchers and natural resource managers to identify the different *Anolis* species present in Florida, as well as document further range expansion or introduction of new species into Florida. The species accounts provide insight into the pathways through which these species likely entered the state, as well as where they are currently found.

CHAPTER 1
INTRODUCTION

Transport and release of species to areas outside of their native ranges has been a feature of human culture for thousands of years (Elton 1958). During this time, these activities were largely viewed as beneficial or inconsequential (Kraus 2009). However, a significant percentage of such introduced species ultimately have negative effects on the ecology and economy in their introduced ranges (Simberloff 1997). In 1958, Charles Elton, the "father of invasion ecology," published *The Ecology of Invasions by Animals and Plants*, which introduced ecologists and the general public to invasion problems and provided an introduction to many current themes. Elton (1958) demonstrated that there were severe ecological and human-health related impacts caused by invasive or certain non-indigenous species. One of the best known examples of a catastrophic introduction was the Nile Perch (*Lates niloticus*) into the Lake Victoria basin. Nile Perch dramatically altered the trophic structure of this aquatic system via numerous extinctions of native fish species (Achieng 1990; Ogutu-Ohwayo 1990). Another classic example of a detrimental invasion was the 1859 release of 24 European rabbits (*Oryctolagus cuniculus*) into Australia, which, due to their rapid rate of reproduction and spread, caused profound changes to the structure of flora and fauna throughout the continent (Rolls 1969; Foran 1986). Furthermore, the costs associated with environmental damage and control of some invasive species is exceptionally high. In the United States for example, it is estimated that these costs total approximately 120 billion dollars each year (Pimentel et al. 2005).

More specifically, there have been several notable introductions of non-indigenous amphibian and reptile species that have caused severe environmental damage and economic losses worldwide. Probably the best known example is the introduction of the Brown Tree Snake (*Boiga irregularis*) to the previously snake-free island of Guam in the 1950s (Fritts and

Rodda 1998; Lever 2003; Kraus 2009). These snakes were transported to the island inadvertently in cargo and in the wheel wells of aircraft in the years following the Second World War (Kraus 2009). Brown Tree Snakes decimated Guam's native fauna including the extirpation of 13 bird, two bat, and six lizard species within 40 years of introduction (Savidge 1987). The loss of insectivorous birds has also been linked to loss of agricultural and horticultural crops, causing losses in production, as well as increases in dengue fever carried by increased numbers of insect vectors (Lever 2003). Other negative effects from this introduction include predation upon domesticated animals, snake bites, and electrical power outages caused by the short circuiting of high voltage lines on the island (Lever 2003). Pimentel et al. (2005) estimated that the cost of losses, damage, and control of this species is roughly 12 million dollars annually. The Cane Toad (*Rhinella marina*) in Australia is another well-documented, noteworthy introduction. This introduction was purported to benefit the production of sugarcane by using the toad as a biological control for beetles affecting the success of the crop (Lever 2001; Phillips et al. 2006). However, this species quickly expanded its population and spread throughout Australia, negatively affecting native fauna through predation, competition for food, shelter and breeding sites, and the toxicity of skin secretions (Lever 2001, Phillips et al. 2006).

Invasions of non-indigenous herpetofauna in Florida began more than 145 years ago. In 1863, E. D. Cope documented the first introduced amphibian, the Greenhouse Frog, *Eleutherodactylus planirostris* Cope 1862. This was followed by Garman's (1887) documentation of the first reptile, the Brown Anole, *Anolis sagrei* Duméril and Bibron 1837. These and numerous other reptile and amphibian species have been introduced into Florida through various invasion pathways, including as stowaways in cargo and plant shipments (e.g., Carr 1939), biological control agents (e.g., *Rhinella marina*; Lobdell 1936), and accidental and

illegal deliberate releases via researchers (e.g., *Hemidactylus garnotii*; King and Krakauer 1966) and the pet trade (e.g., *Varanus niloticus*; Enge et al. 2004).

Introduction and successful establishment of herpetofauna in Florida is facilitated by several factors: Florida's subtropical and tropical climates (Simberloff 1997), peninsular geography (Florida is surrounded on three sides by water and has a freeze line to the north (Simberloff 1986; Myers and Ewel 1990b), and multiple seaports and airports as invasion pathways (Simberloff 1997). Additionally, habitat alteration by humans has created available niches for generalist introduced species (Elton 1958; Simberloff 1986), and an abundance of freshwater lakes, ponds and canals have assisted dispersal (Simberloff 1997). The Florida Fish and Wildlife Conservation Commission (FWC 2011) reported 52 herpetofaunal species at one point in time in Florida, although this number does not accurately reflect the most recent information available (Kenneth L. Krysko, pers. comm.). Through 2010, 137 non-indigenous amphibians and reptiles have been verified as introduced in Florida (Krysko et al. 2011). The only other U.S. state with even remotely comparable numbers of established non-indigenous herpetofauna is Hawaii, with at least 31 species (Kraus 2009). Of the species introduced to Florida, 56 (41%) are currently established (Krysko et al. 2011), with the majority (43) being lizards (Krysko and Enge 2005; Krysko et al. 2011.). Furthermore, there are only 16 species of lizards native to Florida, far less than half the number of the established non-indigenous lizard taxa. Among Florida's non-indigenous lizards are nine species of the genus *Anolis*.

Anolis lizards (Family Polychrotidae) are among the most diverse vertebrate groups worldwide with more than 370 recognized extant species (The Reptile Database 2010). Anoles are especially abundant in the New World tropics, ranging from the southeastern U.S. south to Bolivia and Paraguay (Conant and Collins 1998; Schettino 1999; TIGR Reptile Database 2010).

Anoles are generally characterized by several anatomical features. A dewlap (the sometimes colorful flap of skin attached to the throat via a modified hyoid apparatus that can be extended by cartilage), which aids in communication, courtship, territoriality displays, and defense, is present in males of all species as well as females in few species. Another character of anoline lizards is the ability to change color in response to external stimuli. This feature is well-developed in anoles and is the result of pigment granule movement within skin cells (Hadley 1931; Weber 1983). Additionally, sub-digital lamellae, the expanded digital pads on the underside of all anole toes having many microscopic spinules, spines, spikes, prongs and setae (Ruibal and Ernst 1965; Peterson and Williams 1981), enable both arboreal and terrestrial movement. Males of most anole species also exhibit enlarged post-cloacal scales, conspicuous coloration patterns, and larger heads, bodies and tails in relation to females within a species (Schettino 1999). However, anoles are highly variable in morphology (Conant and Collins 1998; Schettino 1999), which makes species diagnoses difficult due to overlap of many morphological characteristics with other sympatric anole species.

Only one species, the Green Anole, *Anolis carolinensis* (Voigt 1832), is native to the continental United States, whereas to date at least 10 additional West Indian anole species have been introduced into Florida, and nine have become established. For the purposes of my study, an established non-indigenous species must have a specimen or photographic voucher deposited in a systematic collection to document its identification, occurrence, and evidence of reproduction for at least one generation (with a generation defined as the length of time from birth to maturity for that particular species). In Florida, these established, non-indigenous anoles include: Hispaniolan Green Anole, *A. chlorocyanus* Duméril and Bibron 1837; Puerto Rican Crested Anole, *A. cristatellus* Duméril and Bibron 1837; Large-headed Anole, *A. cybotes* Cope

1862; Bark Anole, *A. distichus* Cope 1861; Knight Anole, *A. equestris* Merrem 1820; Jamaican Giant Anole, *A. garmani* Stejneger 1899; Cuban Green Anole, *A. porcatus* Gray 1840; Brown Anole, *A. sagrei* Duméril and Bibron 1837; and Saint Vincent's Bush Anole, *A. trinitatis* Reinhardt and Lütken 1862.

Disagreement exists as to how many non-indigenous *Anolis* species have actually been introduced into Florida, predominantly due to a lack of evidence (i.e. voucher specimens or photographs) of purported species. In addition to the non-indigenous anoles that have become established in Florida, several other species have reportedly been introduced, but have either failed to establish, not yet become established, or possibly were never introduced. For example, two anoles (*Anolis extremus and A. ferreus*) were reported to be introduced (not reproducing) in Fort Myers, Lee County, during the 1990s (Bartlett and Bartlett 1999), however no voucher exists to support this claim. Furthermore, since the initial report, no *A. extremus* or *A. ferreus* have been found despite extensive searches by many individuals (Todd Campbell, pers. comm.), casting doubt that these species were ever introduced. (These two anoles are considered in this study only for the purpose of documenting failed or illegitimately reported introductions and to consider the potential future establishment.) Multiple examples exist of other unverified species, which leads to perpetuation of erroneous invasions in the literature (for some accounts *see* Bartlett and Bartlett 1999; Engeman et al. 2005; Kraus 2009; and "species of uncertain status" *in* Meshaka et al. 2004). Additionally, two voucher specimens of *A. coelestinus* (UF 157133 and UF 164359) were collected from vegetation surrounding a pet dealer's business in Broward County, Florida, in 2009 and 2010. However, these adult specimens were likely recent escapees from the store, and no other individuals were seen in subsequent visits to the site. Thus, this

species did not appear to have established a breeding population at the time this study was conducted (Krysko et al. 2011). Therefore, *A. coelestinus* is not considered further in this study.

A special case exists in Florida between two very closely related species which are very difficult to distinguish from each other. *Anolis carolinensis* and *A. porcatus* are part of a larger group known as the "*carolinensis* series" (Burnell and Hedges 1990:44) or "*carolinensis* subgroup" (Glor et al 2005: 2419), which consists of *A. carolinensis* in the southeastern United States; *A. lerneri*, *A. brunneus*, and *A. smaragdinus* in the Bahamas; *A. fairchildi* on Cay Sal; *A. longiceps* on Navassa; *A. maynardi* on Little Cayman; and *A. porcatus* and *A. allisoni* on Cuba, all of which are hypothesized to have descended from Cuban *A. porcatus* (Ruibal and Williams 1961; Glor et al. 2005). Lizards within this group are generally described as having long snouts, the nostril scale median to the canthal ridge separated from the rostral by three scales, rostral scale bordered by five scales on the posterior dorsal margin, loreal scales numbering three to four, supra-digital scales multicarinate, ventral and dorsal scales keeled, ventral scales larger than dorsal and lateral scales, and a round tail in cross section (Ruibal and Williams 1961; Schwartz and Henderson 1991). Coloration is variable, from green with some isolated white scales, to brown with black vermiculations (Schettino 1999), and there is pronounced sexual dimorphism. Males are larger with prominent frontal and/or canthal ridges, enlarged post-cloacal scales, and a reddish-mauve dewlap, all of which are reduced or absent in females (Ruibal and Williams 1961; Schwartz and Henderson 1991). Because of extensive morphological similarities and overlap among *A. carolinensis* and *A. porcatus*, Williams (1969) hypothesized that *A. carolinensis* was derived from Cuban *A. porcatus* during interglacial low sea levels in the Pleistocene (1.8 to 0.01 million years ago [Ma]), an Epoch when other members of the complex are also believed to have dispersed from Cuba to surrounding Caribbean islands.

However, Glor et al. (2005) hypothesized that portions of the Cayman Islands have likely been constantly emergent since the Pliocene (5.3–2.58 Ma), and Navassa Island may have been above water for the last 5 million years. Furthermore, Buth et al. (1980) used an arbitrary molecular-clock based analysis of allozyme data and suggested a Pliocene (5.3–2.5 Ma) divergence between *A. carolinensis* and Cuban populations of *A. porcatus*. In Florida, lizard fossils are rare from the late Miocene (7.2–5.3 Ma) and early Pliocene (5.3–3.6 Ma); however a small iguanian, most likely *Anolis*, is known from the early Pliocene (5.3–3.6 Ma, Willacoochee Creek in Gadsden County), with the earliest presumed *A. carolinensis* occurring in the middle Pleistocene (0.781–0.126 Ma), suggesting that speciation of *A. carolinensis* occurred on the United States mainland (Hulbert 2001).

Many non-indigenous lizards in Florida are misidentified by researchers and layman because of morphological similarities among species, and a lack of known morphological characters that distinguish each species (*see* Krysko and Daniels 2005; Smith and Krysko 2007). For example, Seigel et al. (1999) reported *Anolis cristatellus* from Brevard County, Florida, 150 km north of its most northern known locality in Miami-Dade County (also *see* Meshaka et al. 2004). However, this voucher specimen (LSUMZ 80413) was misidentified and is actually an *A. sagrei* (Brian J. Camposano and Kenneth L. Krysko, pers. obs.), hence emphasizing the need for vouchers. Additionally, *A. porcatus* was first reported from the Florida Keys in 1904 (Barbour 1904) and subsequently reported in Key West in 1937 (Allen and Slatten 1945). Although Vance (1987) believed that *A. porcatus* from Key West was probably erroneous, Meshaka et al. (1997) reported this species in Florida from northern Miami, Miami–Dade County in 1991 based on arbitrary differences in skull characteristics and relative sub-digital lamellae counts compared to *A. carolinensis*. Glor et al. (2004) used mitochondrial DNA to show that members of the

carolinensis group (*A. porcatus* and *A. allisoni*) hybridize in their native Cuban range, though both remain as distinct lineages. *Anolis carolinensis* is highly variable in morphology throughout its range (Chun 2001) and may appear indistinguishable from introduced *A. porcatus*, though distinct genomes for each species (and hybrids) have been shown to occur in southern Florida (Kolbe at al. 2007). Kolbe et al. (2007) also implies that the source of *A. carolinensis* in the United States is derived from Western Cuba populations of *A. porcatus,* and that native *A. carolinensis* do in fact hybridize with non-native *A. porcatus*, making differentiation near impossible. *Anolis porcatus* has been described to have a rugose skull with two prominent frontal ridges on the snout that run lengthwise and are higher than the canthal ridges (Powell et al. 1998). Although not numerically specific, Collette (1961) distinguished *A. porcatus* as having more sub-digital lamellae on the third and fourth toes of the front limbs than *A. carolinensis*. However, because *A. carolinensis* is extremely morphologically similar to *A. porcatus*, hybridization and/or niche shifting may be occurring between these two taxa resulting in an intermediate number of sub-digital lamellae as well as other characters. Additionally, because anoles are easily misidentified in the field and laboratory by both experts and non-professionals, this suggests that proposed geographic distributions of Florida's anoles (excluding *A. carolinensis*) are also questionable and continued misidentifications will likely occur.

Proper identification of anoles can be difficult, especially when metachromatic changes occur or in examination of preserved specimens where relying on coloration or patterns does not allow for definitive identification. As the pet trade in Florida continues to thrive, high potential exists for additional anoles to become established in Florida's permanent herpetofauna, making it important to be able to identify species presently established. Although anoles have very similar scalation, both within and among species, subtle differences in scale characters serve as the best

way of identifying anoles. Herein, I 1) examine morphology of Florida's established *Anolis* species, 2) describe and compare morphological characteristics statistically that diagnose each species through the creation of a dichotomous key, and 3) provide geographic distribution maps and detailed species accounts of invasion pathways and colonization history for each species in Florida.

CHAPTER 2
MATERIALS AND METHODS

Specimens

Twenty-five preserved specimens were obtained for each of Florida's 10 *Anolis* species (nine introduced species and the native Green Anole) from systematic collections throughout the United States (Appendix A; Table 2-1) and scored for 23 meristic and nine morphometric characters (Table 2-2), except *A. trinitatis*, for which a limited number of specimens were available (N=18). Source acronyms follow Leviton et al. (1985), with the addition of Everglades National Park (EVER) from which the entire fluid-preserved collection is now accessioned and curated within the UF collection. Characters chosen for this study were among those used classically and most commonly in the morphological description of anoline systematics (Collette 1961; Buden and Schwartz 1968; Lee 1980; Chun 2001). With the use of preserved specimens, it was not always possible to record complete counts for each individual, as specimens were often damaged (e.g., damaged scales, limbs missing, tails broken, etc.). Therefore, specimens with undamaged characters were used whenever possible.

Morphological Characters and Counts

All of the characters used in this study, with defining measurements, are listed in Table 2-2. Although most of the counts, descriptions and measurements are standard in morphological analyses, clarifications on several characters are provided. Character 1 (Figure 2-1) was assessed by counting lamellae from the tip of the digit until lamellae become uniform (i.e. no longer change in width). Character 2 (Figure 2-2) consisted of the number of scales on the raised ridge on either side of the head, from the nostril to socket of the eye. Character 3 (Figure 2-2) was counted from the mental scale to the scale or scale margin below the center of the eye. Character 4 (Figure 2-2) was counted from the rostral scale to the scale or scale margin below the center of

the eye. Character 6 (Figure 2-3) consisted of counting the number of scales in the shortest distance between the interparietal scale and any part of the supra-orbital semicircles. Character 7 (Figure 2-3) consisted of counting the number of scales across the top of the snout, at the level of the second canthal scale from the eye. Character 8 (Figure 2-2) was assessed by counting the number of scales or scale margins in a vertical line from the middle of the second canthal scale down to the supra-labial scales. Character 9 (Figure 2-2) was assessed as the number of enlarged adjacent keeled scales surrounding the orbit of the eye, ending to the posterior in contact with supra-labials. Character 10 (Figure 2-4) was counted at mid-body, from the posterior insertion of the arm to the anterior insertion of the leg. Character 11 (Figure 2-4) was counted at mid-body, between imaginary vertical lines at the insertion of each arm. Character 12 (Figure 2-3) was counted as the fewest scales between the supra-orbital semicircles; the enlarged scales in half moon shape surrounding the supra-ocular scales and eye.

A secondary comparison was made to explore additional traits to better distinguish *Anolis carolinensis* from *A. porcatus*. Preserved specimens of *A. carolinensis* collected in northern Florida, Alabama and Georgia and *A. porcatus* collected in Cuba (Appendix A; Table 2-3) were scored for the original 23 meristic characters and 11 additional meristic characters (Tables 2-2 and 2-4), and specimens from the first analysis were rescored for the new meristic characters. All specimens were analyzed by sex due to known dimorphic differences between these two species (Collette 1961, Chun 2001). Additional characters chosen for this supplemental analysis included scalation of digits; maintaining particular importance to the presumed characters historically used by Collette (1961) in diagnosing true United States *A. carolinensis* from Cuban *A. porcatus,* and as a potential feature of ecomorphological differences between these species. Additionally, putative *A. carolinensis* or *A. porcatus* collected in Miami-Dade County, Florida,

were also scored as above to search *a posteriori* for differences between both species within their established overlapping range (Kolbe et al. 2007), with both species being treated as a singular "unknown" group in order to determine if a distinction could be made for each species.

In all comparisons specimens were measured to the nearest mm (± 0.01 mm) using digital calipers (Fisher Scientific, Inc.). A binocular dissecting microscope (Bausch and Lomb, Inc.) was used to aid in very small distance measurements and all scale counts, except where scales (e.g. in *Anolis equestris*) were easily counted with the naked eye. Bilateral characters were recorded from the right side of a lizard when possible for consistency and to facilitate comparisons with other studies (*see* Chun 2001). Specimen selection and analysis in the first comparison was random with regard to age and sex, as the purpose of this study is dependent on species differentiation regardless of these two features, although there may be sexually dimorphic differences in some other measured characteristics. In the first comparison, an effort was made to include a sample of both sexes, while in the second (i.e., *A. carolinensis* versus *A. porcatus*), it was necessary to score and analyze sexes independently in light of known sexually dimorphic differences in supra- and sub-digital scale characteristics (Collette 1961). Specimens were then sexed by the presence or absence of enlarged post-cloacal scales (*see* Schettino 1999; Chun 2001), which are evident in even the smallest males of species exhibiting this trait, presence or absence of a dewlap (except in *A. equestris*), and by internal examination where needed. I measured and scored all characters myself, thus reducing the amount of variation associated with inter-observer variability (Lee 1990), and multiple counts were made until I was confident my scale counts were correct.

Statistical Analyses

In the first comparison, I analyzed both meristic and morphometric for each of Florida's *Anolis* species using univariate and multivariate techniques for both meristic and morphometric data. Statistical analyses were carried out using JMP statistical software version 8 (SAS Institute) and PASW Statistics version 18 (SPSS, Inc., Chicago). Due to small sample size of available voucher specimens, *A. trinitatis* was not included in any statistical analyses and was evaluated solely by raw meristic data. Verification of the difference between each species for meristic data was first carried out in multivariate fashion by multiple analysis of variance (MANOVA), with species included as a factor, to search for an overall difference between species. Sex was not used in this overall analysis because the ultimate goal of my research is to find differences in scale characters among species without having to first determine a lizard's gender. Subsequent verification was carried out in a univariate fashion by single classification analysis of variance (ANOVA), with species included as a factor (Lee 1985; Van Rooijen and Vogel 2009). Where the assumptions of an ANOVA were violated, a non-parametric equivalent Kruskal-Wallis test was used to examine the data. Qualitative variables were analyzed qualitatively using contingency table analysis (χ^2 test). Data were then analyzed using a stepwise discriminant function analysis (DFA), which was used to determine which variables discriminate between two or more naturally occurring groups. Additionally, DFA calculates the percentage of correctly classified individuals relative to their origin (Chun 2001). This was performed to determine which characters were the most important in discriminating each species.

Since all morphological variables increase with size (Irschick and Losos 1996), all transformed variables were first analyzed in a multiple analysis of covariance (MANCOVA), with species as a factor and snout-vent length (SVL) as a covariate, thereby removing the effect

of length from the analysis (Lee 1987; Van Rooijen and Vogel 2009). Morphometric data were analyzed by examining the descriptive statistics for each log transformed (ln) variable for data trends and conformity to assumptions of parametric testing, as most biological data can be transformed in this fashion to better fit the assumptions of parametric tests. Each variable was analyzed *post hoc* in univariate fashion by analysis of covariance (ANCOVA) to test for differences between species for each character. This method was chosen over a residual analysis due to more statistically sound results of the ANCOVA (*see* Garcia-Berthou 2001; Green 2001).

My second comparison analyzed additional meristic data scored for *A. carolinensis* and *A. porcatus* specimens in addition to the continuous meristic characters used in the initial analysis from outside the assumed range overlap. All specimens for these taxa used in the original analysis were also used in the second analysis, but additional specimens were added to increase the sample size (Table 2-3). This analysis followed the above procedure for meristic data, because no morphometric data were scored. However, unlike the overall analysis, specimens were analyzed separately by sex to account for any dimorphic differences since no single character could differentiate these species in the overall analysis. Characters of specimens from outside the assumed range overlap were first compared in multivariate fashion (MANOVA), with species and sex included as factors, to determine if a difference existed between these species in the characters tested. Each character was then compared in univariate fashion to determine if any single character could differentiate between the two species and also to determine which characters represented significant differences between the two species. The initial comparison examined statistical differences between the two species from outside of the presumed range overlap. All continuous variables (Tables 2-2 and 2-4) were subjected to a two-way ANOVA to determine which characters differed significantly between species and sex, and

whether there was a single character able to differentiate between both species and sex. All characters were subsequently verified for adherence to assumptions of parametric testing. Significant characters were then examined in a series of maximum-likelihood binomial logistic regression analyses to determine the best set of predictors to differentiate the two groups, using the formula:

$$\ln [p/(1-p)] = (\alpha + \beta_1 X_1 + \beta_2 X_2 \ldots),$$

where p is the probability of predicting the correct species, α is the intercept of the model, β is the coefficient for each particular character, and X is the value of the particular character being tested. Potential logistic regression equation models were selected for comparison of the unknown data based on the ability to classify the most individual taxa correct relative to their origin (e.g., either *A. carolinensis* or *A. porcatus*). All selected models were run against the putative "unknown" *Anolis* specimens (e.g., specimens collected from Miami-Dade County) in order to determine the best characters for prediction of a particular unknown species, using the formula:

$$\text{Prediction} = e^{(\alpha + \beta_1 X_1 + \beta_2 X_2 \ldots)} / [1 - e^{(\alpha + \beta_1 X_1 + \beta_2 X_2 \ldots)}],$$

where the prediction is number between 0 and 1, with 0 (0 to 0.05) being assigned to *A. porcatus* and (0.95 to 1) assigned to *A. carolinensis*, α is the intercept of the model, β is the coefficient for each particular character, and X is the value of the particular character being tested. After inputting the unknown specimens into each of the trial models, specimens from within the range of overlap were assigned to one of the two known groups, with partial predictions (e.g., prediction = 0.5) either representing incomplete differentiation or some degree of hybridization

between each species. Results of all models were compared with one another to determine which models most often resulted in similar predictions.

In addition to using logistic regression to create potential models to predict each unknown *Anolis carolinensis* and *A. porcatus*, a stepwise DFA was run for each sex on all continuous variables that were examined for potential use in the logistic regression to further look at any potential characters for discerning these two species. Only data for *A. carolinensis* and *A. porcatus* from outside of the known range overlap was used as an input for the model, testing *a posteriori* where each specimen from the unknown group was assigned. Unknown specimens were plotted on the same axes produced by the data for the two known groups. A combination of the logistic regression analysis and the DFA were compared to suggest characters for discerning each species where their ranges have been shown to overlap. Two different statistical tests were used for this data set to attempt to determine which test provided the most accurate results.

The results from this secondary comparison, in conjunction with the results from the first comparison, were used to ultimately produce a dichotomous key separating each species by distinct characteristics. In order to verify the accuracy of the selected characters for use in the key, I examined 1192 *Anolis* specimens comprising 10 different species from Florida (Appendix A), including 185 *A. carolinensis*, 100 *A. chlorocyanus*, 121 *A. cristatellus*, 106 *A. cybotes*, 149 *A. distichus*, 153 *A. equestris*, 68 *A. garmani*, 79 *A. porcatus*, 213 *A. sagrei*, and 18 *A. trinitatis*.

In order to determine each species' current geographic distribution in Florida, historical records and accounts were obtained from the literature and field-collected specimens. All *Anolis* (N = 5377) records from Florida with locality data from available collections (Appendix B) were

geo-referenced to obtain spatial coordinates for each record in the collection, and subsequently plotted using ArcGIS ver. 9.3 (ESRI). Detailed species accounts of invasion pathways, colonization, and natural history in Florida were obtained from literature reviews of each species and are summarized in the Discussion.

Table 2-1. Collection locality of *Anolis* specimens for statistical analysis of morphological characters.

Species	Country	County	N
A. carolinensis	United States	Leon	10
		St. Johns	5
		Wakulla	10
A. chlorocyanus	United States	Broward	8
		Palm Beach	9
	Dominican Republic		1
	Haiti		7
A. cristatellus	United States	Miami-Dade	25
A. cybotes	United States	Broward	6
		Miami-Dade	7
		Martin	7
	Haiti		5
A. distichus	United States	Broward	2
		Collier	3
		Miami-Dade	19
		Monroe	1
A. equestris	United States	Collier	5
		Lee	3
		Martin	1
		Miami-Dade	16
A. garmani	United States	Miami-Dade	25
A. porcatus	Cuba		25
A. sagrei	United States	Alachua	2
		Lee	4
		Palm Beach	5
		Pinellas	4
		Volusia	10
A. trinitatis	United States	Miami-Dade	1
	Saint Vincent		17

Table 2-2. Morphological characters and measurements used for *Anolis* specimens in first analysis. See text for certain character descriptions and figures.

Character Number	Character Description
Meristic	
1	Number of expanded sub-digital lamellae on third anterior digit
2	Number of scales comprising the canthalus rostralis
3	Number of infra-labial scales
4	Number of supra-labial scales
5	Number of pairs of postmental scales
6	Minimum number of scales between the supra-orbital semicircles and interparietal scale
7	Number of snout scales
8	Number of loreal scales
9	Number of sub-ocular scales
10	Number of longitudinal ventral scales
11	Number of transverse ventral scales
12	Minimum number of scales between the supra-orbital semicircles
13	Dorsal scales keeled (+) or flat (-)
14	Mid-dorsal scales expanded (+) or uniform (-)
15	Overlapping rostral suture present (+) or absent (-)
16	Tail whorls on anterior one-third of tail present (+) or absent (-)
17	Ventral scales keeled (+) or flat (-)
18	Ventral scales imbricate (+) or non-imbricate (-)
19	Ventral scales distally pointed (+) or rounded (-)
20	Tail base laterally compressed (+) or round (-)
21	Post cloacal scales enlarged (+) or uniform (-)
22	Supra-ocular scales multicarinate (++), singly keeled (+) or flat (-)
23	Supra-orbital semicircles multicarinate (++), singly keeled (+) or flat (-)
Morphometric	
24	Snout-vent length (SVL) (mm)
25	Axilla-groin distance (AGD) (mm)
26	Head length (HL) (mm)
27	Head width (HW) (mm)
28	Internarial distance (IND) (mm)
29	Ear-eye distance (EED) (mm)
30	Naris-rostrum distance (NRD) (mm)
31	Snout length (SNL) (mm)
32	Tibia length (TIB) (mm)

Table 2-3. Collection locality of additional specimens examined for morphological analysis between *Anolis carolinensis* and *A. porcatus*.

Species	Country	State	County	N
A. carolinensis	United States	Florida	Marion	3
			Jefferson	2
			Leon	1
		Georgia		9
		Alabama		16
A. porcatus	Cuba			31
Unknown	United States	Florida	Miami-Dade	57

Table 2-4. Additional meristic morphological characters used for analysis of *Anolis carolinensis* and *A. porcatus*.

Character Number	Character Description
33	Gender (F = female; M = male)
34	Total number of sub-digital lamellae on third anterior digit
35	Total number of sub-digital lamellae on fourth anterior digit
36	Total number of sub-digital lamellae on third posterior digit
37	Number of supra-digital scales on third anterior claw
38	Number of supra-digital scales on fourth anterior claw
39	Number of supra-digital scales on third posterior claw
40	Number of sub-digital scales on third anterior claw
41	Number of sub-digital scales on fourth anterior claw
42	Number of sub-digital scales on third posterior claw
43	Supra-digital scales multicarinate (++), singly keeled (+), or flat (-)

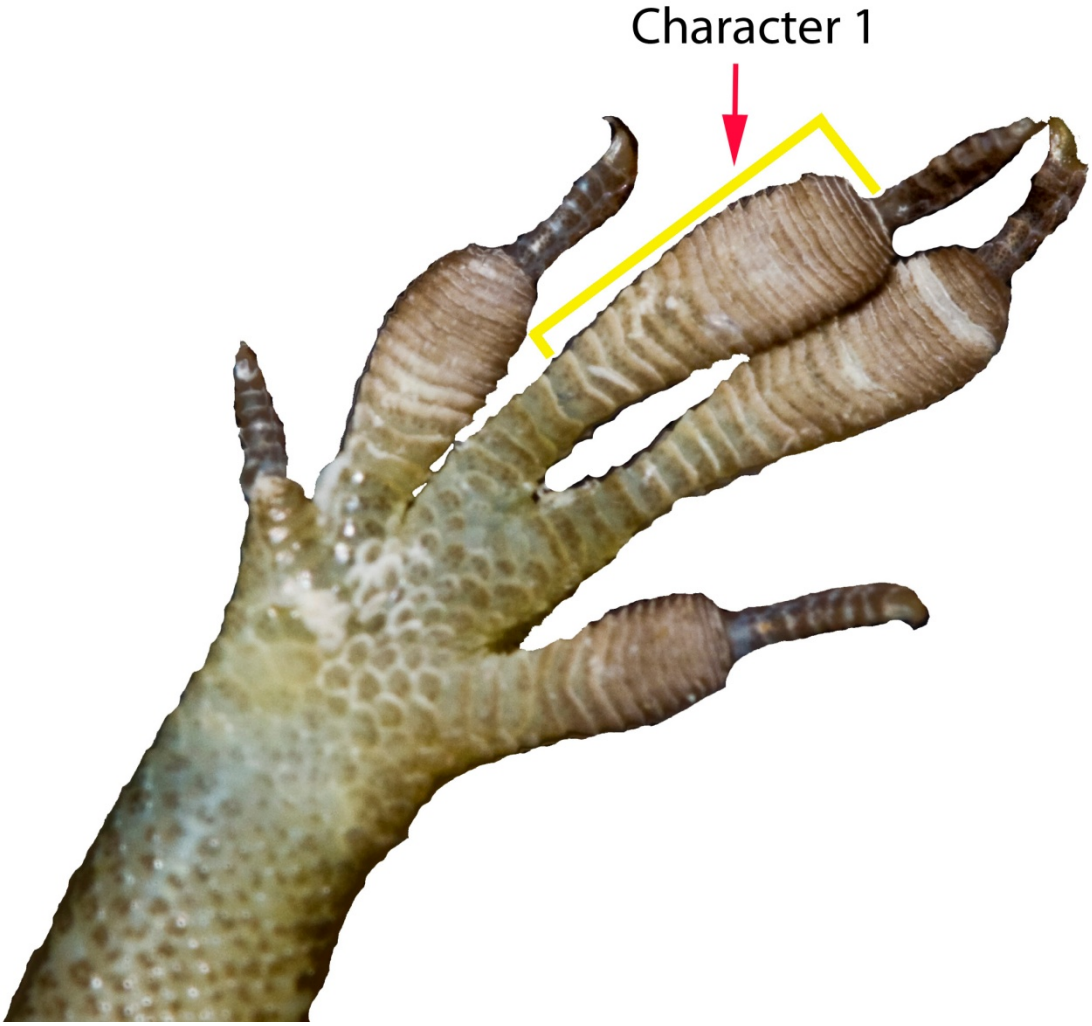

Figure 2-1. Illustration of a representative *A. chlorocyanus* (UF 157424) demonstrating Character 1: expanded sub-digital lamellae counted from the tip of the digit until the scales become uniform in width.

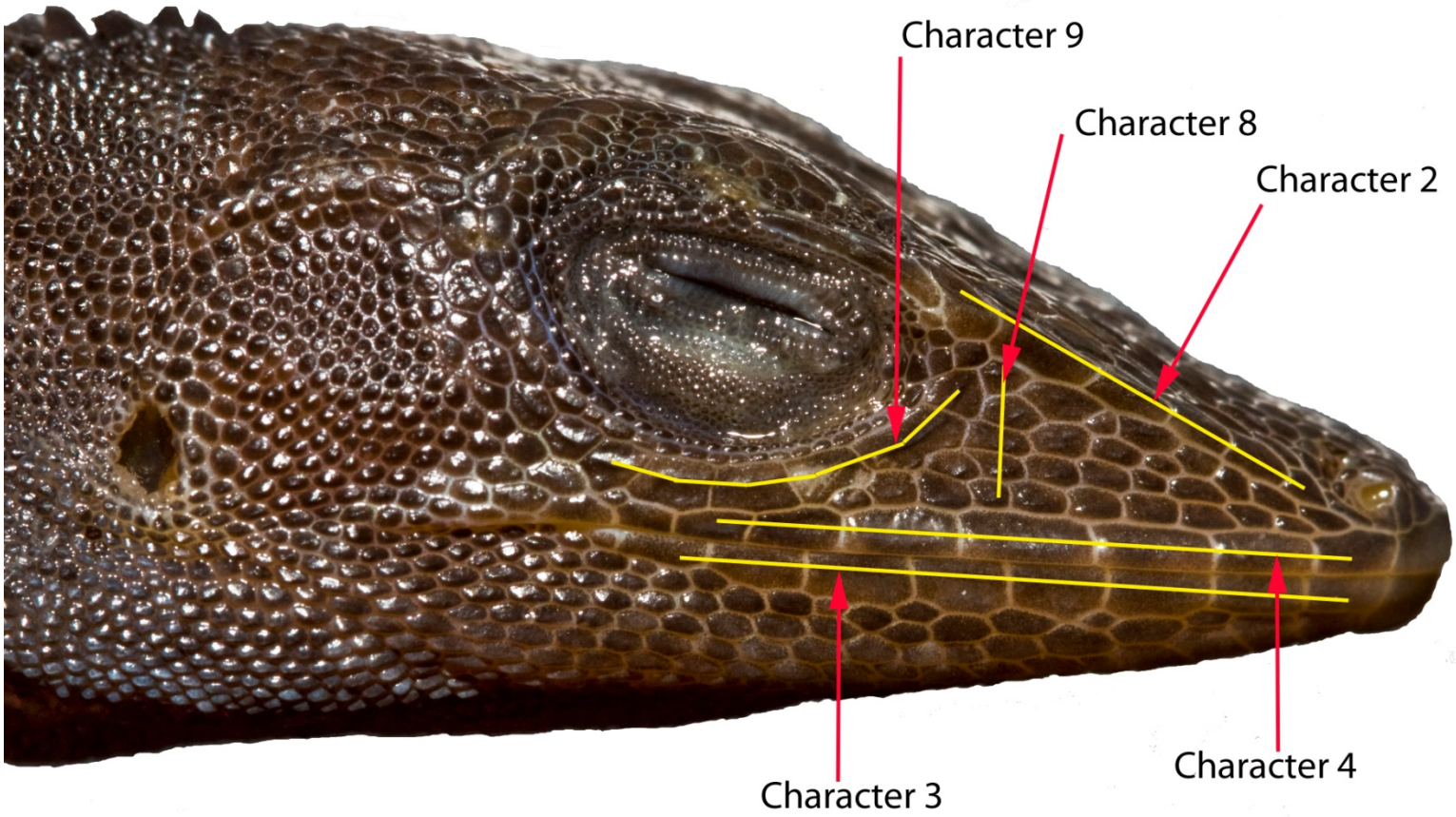

Figure 2-2. Illustration of a representative *A. garmani* (UF 121443) demonstrating Character 2: the scales comprising the canthalus rostralis; Character 3: the scales comprising the infra-labial scales; Character 4: the scales comprising the supra-labial scales; Character 8: the scales comprising loreal scale rows; and Character 9: the scales comprising the sub-ocular scales.

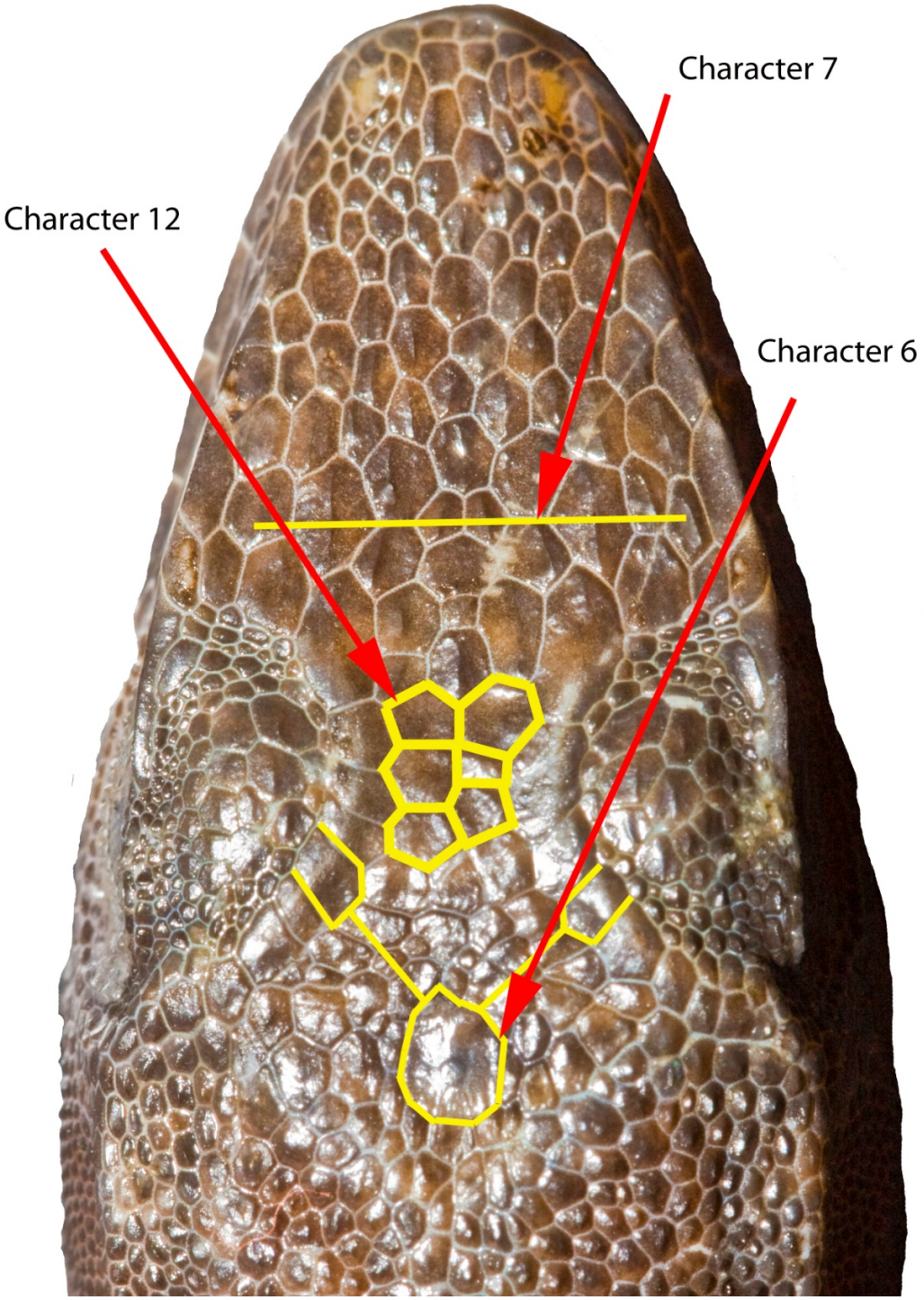

Figure 2-3. Illustration of a representative *A. garmani* (UF 121443) demonstrating Character 6: the minimum number of scales between the interparietal scale and the supra-orbital semicircles; Character 7: the scales comprised in the count of snout scales; and Character 12: the minimum number of scales between the supra-orbital semicircles.

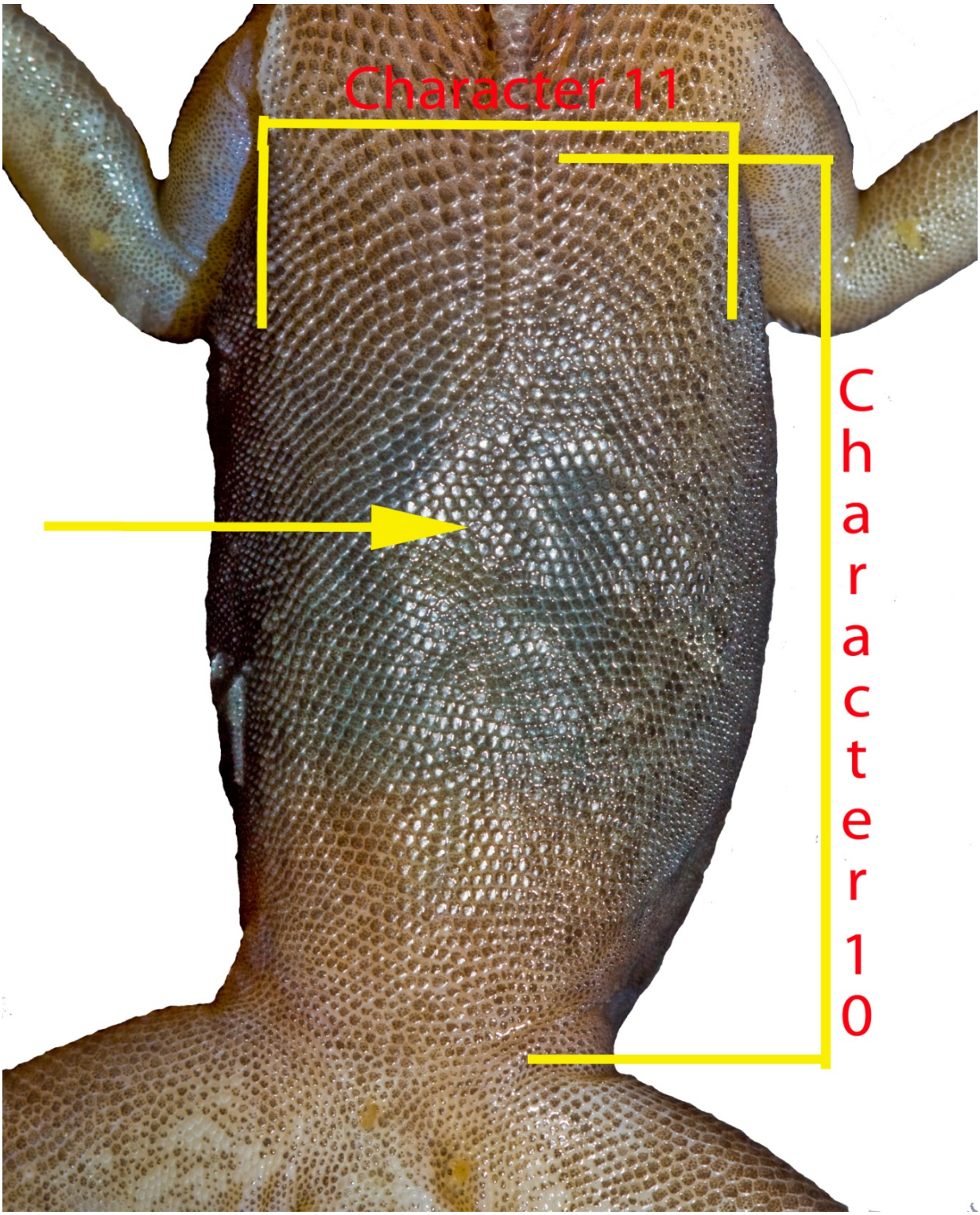

Figure 2-4. Illustration of a representative *A. cristatellus* (UF 155409) demonstrating Character 10: the beginning and ending locations to count longitudinal ventral scales; and Character 11: the beginning and ending locations to count the transverse ventral scales. Note that all counts are made at mid-body, indicated by the yellow arrow.

CHAPTER 3
RESULTS

Meristic Data Comparisons

The overall MANOVA was significant for intercept (Wilks' Lambda; $F_{13, 204}$ = 12366.654; $P < 0.001$) and species (Wilks' Lambda; $F_{104, 1415.781} = 63.090$; $P < 0.001$), indicating that significant differences exist between each of the characters examined. Twenty-two of the 23 characters tested in this analysis, excluding character 16, showed significant variation ($P <$ 0.0001) among two or more species (Table 3-1). None of the characters tested violated assumptions of parametric testing and therefore were all tested using ANOVA. Although most of the characters demonstrated significant differences in mean values, not all characters were significant in distinguishing differences between species, either due to a lack of a distinct range of values for a given character (the "restriction of range" problem in statistics) or a more informative character existed. Therefore, only characters 1, 6, 10, 12, 13, 14, 17, 20 and 22 (Table 3-2) are discussed in greater detail.

The ANOVA for Character 1 (expanded lamellae on front right digit) was highly significant ($F_{8, 216} = 764.57$, $P < 0.0001$, $r^2 = 0.97$). *Anolis equestris* had the highest mean value ($\bar{x} = 31.56$) and was distinct from all other species. *Anolis chlorocyanus* (Figure 3-1) and *A. porcatus* were grouped together ($\bar{x} = 20.88$, $\bar{x} = 20.32$, respectively) and distinct from the remaining species except *A. garmani* ($\bar{x} = 19.24$), which was not significantly different from *A. porcatus*. *Anolis carolinensis* was distinct from all other species ($\bar{x}$ =15.92), providing evidence of a distinction from *A. porcatus*, though overlap of raw values between both species occurred, and given that males and females were analyzed together from populations far outside the purported range overlap (e.g., Cuba and Northern Florida), prevented definitive differentiation.

Anolis distichus, *A. cristatellus* (Figure 3-2) and *A. cybotes* were grouped together ($\bar{x}$ =12.44, $\bar{x}$ = 12.24, $\bar{x}$ = 11.36, respectively) and distinct from other species. *Anolis sagrei* had the lowest mean value ($\bar{x}$ = 10.12) and was significantly different from all other species. Measurement ranges by species for all characters are presented in Table 3-2.

The ANOVA for Character 6 (scales between the supra-orbital and interparietal scales) was highly significant ($F_{8, 216}$ = 55.45, $P < 0.0001$, R^2 = 0.67) among species. *Anolis equestris* had the highest mean value ($\bar{x}$ = 3.92) and was distinct from the remaining species. *Anolis garmani* and *A. sagrei* were not significantly different ($\bar{x}$ =3.04, $\bar{x}$ = 2.76); *A. sagrei* and *A. chlorocyanus* (Figure 3-3) were not significantly different ($\bar{x}$ =2.76, $\bar{x}$ = 2.44); *A. chlorocyanus*, *A. cybotes*, and *A. cristatellus* were not significantly different ($\bar{x}$ = 2.44, $\bar{x}$ = 2.12, $\bar{x}$ = 2.04); *A. cybotes*, *A. cristatellus* and *A. carolinensis* were not significantly different ($\bar{x}$ = 2.12, $\bar{x}$ = 2.04, $\bar{x}$ = 1.68, respectively); and *A. cristatellus*, *A. carolinensis* and *A. porcatus* were not significantly different ($\bar{x}$ = 2.04, $\bar{x}$ =1.68, $\bar{x}$ = 1.52, respectively). *Anolis distichus* had the lowest mean value ($\bar{x}$ =0.76) and was significantly different from all other species. Although there was considerable among-species overlap for this character, it remains important as a diagnosable character for *A. trinitatis* ($\bar{x}$ = 0.00), which does not have any scales between the supra-orbital semicircles and the interparietal scale (Figure 3-4).

The ANOVA for Character 10 (longitudinal ventral scale rows) was highly significant ($F_{8, 216}$ = 312.91, $P < 0.0001$, R^2 = 0.92) among species. *Anolis equestris* had the highest mean value ($\bar{x}$ = 93.2) followed by *A. garmani* ($\bar{x}$ = 88.64), and both were significant from one another and all other species. *Anolis carolinensis*, *A. distichus* and *A. chlorocyanus* did not differ significantly from one another ($\bar{x}$ =83.68, $\bar{x}$ = 82.72, $\bar{x}$ = 79.88, respectively), and *A.*

chlorocyanus and *A. porcatus* did not differ significantly from each other ($\bar{x}$ = 79.88, $\bar{x}$ = 77.6, respectively). *Anolis sagrei* ($\bar{x}$ = 68.28), *A. cristatellus* ($\bar{x}$ = 56.28) (Figure 3-5) and *A. cybotes* ($\bar{x}$ =44.28) (Figure 3-6) were each significantly different from one another and all other species.

The ANOVA for Character 12 (number of scales between the supra-orbital semicircles) was highly significant ($F_{8, 216}$ = 117.49, $P < 0.0001$, R^2 = 0.81). *Anolis equestris* and *A. garmani* (Figure 3-7) had the highest score means ($\bar{x}$ = 205.8, $\bar{x}$ = 190.2, respectively). The next grouping of score means included *A. sagrei*, *A. carolinensis*, *A. chlorocyanus* (Figure 3-8), and *A. porcatus* ($\bar{x}$ =130.1, $\bar{x}$ = 117.72, $\bar{x}$ = 117.7, $\bar{x}$ = 100.38, respectively). The final group, with the lowest score means, included *A. cybotes*, *A. distichus* and *A. cristatellus* ($\bar{x}$ = 61.6, $\bar{x}$ = 51.7, $\bar{x}$ = 41.8, respectively).

Character 13 qualitatively compared specimens with keeled or flat dorsal scales. With the exception of *A. equestris*, all species, including *Anolis trinitatis*, had small, round dorsal scales with a keel (Figure 3-9). *Anolis equestris* has flat, smooth dorsal scales, even in the smallest individuals (Figure 3-10).

Character 14 qualitatively compared specimens with mid-dorsal scales that were either uniform in size or expanded in relation to surrounding scales. *A. carolinensis*, *A. distichus*, *A. equestris*, and *A. porcatus* were always scored as having uniform mid-dorsal scales (Figure 3-11). *A. cristatellus*, *A. cybotes*, and *A. garmani* were always scored as having expanded mid-dorsal scales (Figure 3-12). *A. chlorocyanus* and *A. sagrei* were the only two species to have a variety of each, with five *A. chlorocyanus* specimens having uniform mid-dorsal scales and 24 *A. sagrei* having uniform mid-dorsal scales.

Character 17 qualitatively compared whether ventral scales were flat or with a single keel. *A. carolinensis*, *A. porcatus* and *A. sagrei* always had ventral scales with a single keel. The remaining species, including *A. trinitatis*, always had flat ventral scales.

Character 20 qualitatively compared whether a specimen's tail base was laterally compressed or rounded in cross-section. *A. cristatellus*, *A. equestris* and *A. sagrei* always had tail cross-sections that were laterally compressed. All remaining species had rounded tail cross sections.

Character 22 qualitatively compared whether supra-ocular scales were multicarinate, with a single keel, or flat. *A. carolinensis* and *A. porcatus* always had multicarinate supra-ocular scales (Figure 3-13). *A. chlorocyanus*, *A. cristatellus*, *A. cybotes*, *A. garmani*, and *A. sagrei* always had supra-ocular scales with a single keel (Figure 3-14). The remaining species always had flat supra-ocular scales.

The stepwise DFA was significant for all 12 continuous variables (Wilks' Lambda = 0.0000090; $F_{96,1391.2} = 66.79$; $P < 0.0001$; Table 3-3). Character 1 was the most informative in separating species, correctly classifying 66.56% of specimens. Sequential additions of characters 10, 8 and 7 correctly classified 85.33%, 90.22%, and 93.78% of specimens, respectively. Character 4 was the final and least important (albeit significant) addition to the model, correctly classifying 99.55% of specimens.

The combined characters only misclassified one individual, predicting an *A. porcatus* as *A. chlorocyanus*. Only four of the remaining 224 classifications were misclassified, all of which were between *A. porcatus* and *A. chlorocyanus*. One *A. chlorocyanus* specimen had a 34% chance of predicting *A. porcatus*, while *three A. porcatus* had a chance (24%, 22%, and 22%,

respectively) of predicting *A. chlorocyanus*, likely due to the similar outward appearance of the scale characters measured. However, despite the fact that DFA cannot analyze qualitative data, character 17 (ventral scales keeled or flat) quickly and easily distinguishes these two species apart from one another. All other species were correctly identified relative to their origin (Figure 3-15).

No misclassifications were made between *A. carolinensis* and *A. porcatus*. While the results from this DFA appear to support that these two taxa are distinct when using multiple characters to differentiate each species, no character existed which did not overlap between species. Additionally, this analysis did not include specimens of these taxa from within the purported range overlap. Therefore, there is only limited support of accurate diagnosis in Florida as these species have demonstrated the ability to hybridize where their ranges overlap (Kolbe et al. 2007). The relationship between these species in southern Florida is considered further in the second analysis. The results of this analysis further demonstrate that the continuous characters chosen from the ANOVA analyses are significant in discriminating species.

Morphometric Data Comparisons

The overall multivariate model for *Anolis* species was highly significant for intercept (Wilks' lambda; $F_{8, 208} = 179.508$, $P < 0.001$), the covariate SVL (Wilks' lambda; $F_{8, 208} = 1176.022$, $P < 0.001$), and species (Wilks' lambda; $F_{64, 1206.208} = 23.760$, $P < 0.001$), indicating that significant differences exist between each of the characters examined. Subsequently, each univariate ANCOVA test was also highly significant with regard to species (Table 3-4).

Character 25, axilla-groin distance, was significant among species ($F_{8, 215} = 3.496$, $P = 0.001$). *Anolis equestris* had the largest relative axilla-groin distance, though only significantly

different from *A. cristatellus*, *A. cybotes* and *A. porcatus*. *Anolis cristatellus* had the smallest relative axilla-groin distance, though only significantly different from *A. carolinensis*, *A. equestris*, *A. garmani*, and *A. sagrei* (Table 3-5).

Character 26, head length, was significant among species ($F_{8, 215} = 41.460$, $P < 0.001$). *Anolis porcatus* had the longest relative head length, significantly different from all other species. *Anolis distichus* had the shortest relative head length, also significantly different from all other species (Table 3-5).

Character 27, head width, was significant among species ($F_{8, 215} = 21.957$, $P < 0.001$). *Anolis cybotes* had the widest relative head size, significantly different from all other species except *A. cristatellus*. *Anolis chlorocyanus* had the narrowest relative head size, significantly different from all other species except for *A. carolinensis* (Table 3-6).

Character 28, internarial distance, was significant among species ($F_{8, 215} = 23.558$, $P < 0.001$). *Anolis equestris* had the widest relative internarial distance, significantly different from all species except *A. cybotes*. *Anolis chlorocyanus* had the narrowest relative internarial distance, significantly different from all other species (Table 3-6).

Character 29, ear-eye distance, was significant among species ($F_{8, 215} = 16.691$, $P < 0.001$). *Anolis cybotes* had the longest relative ear-eye distance, significantly different from all other species. *Anolis distichus* had the shortest relative ear-eye distance, significantly different from all other species except for *A. chlorocyanus* and *A. equestris* (Table 3-7).

Character 30, naris-rostrum distance, was significant among species ($F_{8, 215} = 106.234$, $P< 0.001$). *Anolis porcatus* had the longest relative naris-rostrum distance, significantly different

from all other species. *Anolis distichus* has the shortest relative naris-rostrum distance, significantly different from all species except for *A. cristatellus* and *A. garmani*. (Table 3-7).

Character 31, snout length, was significant among species ($F_{8, 215}$ = 49.704, P< 0.001). *Anolis porcatus* had the longest relative snout length, significantly different from all species except for *A. equestris*. *Anolis distichus* had the shortest relative snout length, significantly different from all other species (Table 3-8).

Character 32, tibia length, was significant among species ($F_{8, 215}$ = 60.815, P< 0.001). *Anolis cristatellus* had the longest relative tibia length, significantly different from all other species. *Anolis equestris* had the shortest relative tibia length, significantly different from all species except for *A. carolinensis*, *A. chlorocyanus* and *A. porcatus* (Table 3-8).

Anolis carolinensis* and *Anolis porcatus

The overall MANOVA was significant for intercept (Wilks' Lambda; $F_{21,84}$ = 4808.587; P < 0.001), species (Wilks' Lambda; $F_{21, 84}$ = 49.211; P < 0.001) and sex (Wilks' Lambda; $F_{21, 84}$ = 2.473; P = 0.002). Although the interaction of species and sex was not significant (Wilks' Lambda; $F_{21, 84}$ = 1.507; P = 0.097), both species were still analyzed by sex. After testing each character univariately for each sex, no characters were identified in which raw data did not overlap between both species and sex. However, characters 1, 3, 7, 8, 10, 11, 12, 34, 35, and 36 were significantly different (P < 0.05) for both sexes, while character 4 was significantly different for females and character 2 was significantly different for males between species. No qualitative characters were significantly different between species, and therefore were not considered hereafter. All characters with significant differences were subjected to the same variance testing as in the initial analysis, and all met the assumptions of parametric tests.

Characters 1, 10, 34, 35 and 36 were selected for incorporation into logistic regression model testing as a result of their larger mean differences between species, whereas those left out of analysis exhibited differences that were often less than one (Tables 3-9 and 3-10). Characters 1, 34, 35 and 36 were directly related to digit morphology, whereas character 10 represented differences in longitudinal ventral scalation.

Thirteen different character combinations were selected into a binomial logistic regression to test independently for each sex and compared to examine which combination of characters most frequently predicted the correct species (Table 3-11). Based on the previously established criteria (see chapter 2), combinations of characters 1 and 10 (model 1) and characters 1, 35 and 36 (model 3) resulted in only three incorrect classifications, with the next closest groups including characters 10, 35, and 36 (model 2) and characters 1 and 34 (model 4), with only 5 incorrect classifications. The combinations of characters 1 and 10, and characters 1, 35 and 36 misclassified two of three of the same individuals, whereas the other misclassification was a different specimen for both. Only one similar misclassification occurred between the other two models. In all cases, statistical evidence of perfect fit for all data points was detected, indicating a possible complete separation of the data (e.g. correctly classifying known species correctly), which was evidenced by the high percentage of correct predictions by the model. This result is supported further by the results from the DFA in the first analysis, which was able to differentiate between each species using multiple characters from non-overlapping populations. These four groups performed the best in predicting each group from outside of the range overlap (Tables 3-12 and 3-13).

For each of the character combinations, regression coefficients (β) were obtained from the initial tests on the two species from outside of the range overlap for each sex for prediction

modeling of the unknown group (Tables 3-14 and 3-15). These values were used in the second formula for prediction of each individual unknown specimen. All responses were rounded to four decimal places, with values of 0.9500 and above indicating *A. carolinensis*, and values of 0.0500 or less indicating *A. porcatus*. Partial values indicated that a particular specimen was not properly predicted. All models were compared to each other in order to discern whether a particular model was predicting similarly to the other models (Table 3-16).

Each model agreed in predicting 40 of the 56 (71%) unknown specimens, of which all unknown specimens labeled as *A. carolinensis* were scored as such, whereas two females labeled as *A. porcatus* were scored as *A. carolinensis*. There were two instances where model 1 did not agree with the other models, one instance where model 3 did not agree with the other models, four instances where model 4 did not agree with the other models, and nine instances where two or more models either disagreed or produced intermediate responses. From the nine instances that models did not agree, there were three instances where models 2 and 3 agreed, two instances when models 3 and 4 agreed, and one instance where models 1 and 2 agreed. The remaining three instances had non-agreement for all four models. Since model 3 had no instances of disagreements with the remaining three models, and when two or models disagreed, model three agreed with at least one other model five out six times, this evidence suggests that model 3 may contain the best set of predictors of *A, carolinensis* and *A. porcatus* where their ranges have been shown to overlap.

The stepwise DFA for females was significant for five out of 15 possible continuous characters (Wilks' Lambda = 0.075778, $F_{5,35} = 85.3754$, $P < 0.0001$), correctly classifying 100% of the species from outside of the known range overlap (Table 3-17, Figure 3-16). Character 34 was the most informative in species diagnosis, correctly classifying 97.62% of specimens

correctly. The next addition, Character 1, classified 100% of specimens correctly. Characters 10, 35 and seven, respectively, were also significant to the model, though not explaining any additional data. Using this classification data for known specimens, 13 of the 16 unknown females were classified as *A. carolinensis*, whereas only 2 were classified as *A. porcatus*. The final unknown specimen was classified as *A. carolinensis*, with a 29% chance of being *A. porcatus*.

The stepwise DFA for males was significant for six out of 15 possible continuous characters (Wilks' Lambda = 0.102551, $F_{6, 61} = 88.9710$, $P < 0.0001$), correctly classifying 100% of the species from outside of the known range overlap (Table 3-18, Figure 3-17). Character 35 was the most informative in species diagnosis, correctly classifying 94.12% of specimens correctly. The next addition, Character 10, classified 98.53% of specimens correctly. With the next addition, character 1, 100% of specimens were correctly classified. Characters 8, 36 and 3, respectively, were also significant to the model, though not explaining any additional data. Using these classification data for known specimens, 22 of the 39 unknown male specimens were classified as *A. carolinensis*, and 17 of the 39 were classified as *A. porcatus*. Two of the predicted *A. carolinensis* had probabilities of 0.13 and 0.20 as being predicted as *A. porcatus*, whereas three of the predicted *A. porcatus* had probabilities of 0.14, 0.25 and 0.32 of being predicted as *A. carolinensis*.

A Key to the Anoles of Florida

Based on the results of both analyses, a dichotomous key was produced to identify each *Anolis* species established in Florida (Figure 3-18). Data from the first analysis provided non-overlapping characters that were suitable to discern all species except *A. carolinensis* from *A.*

porcatus. While the first and second analyses were able to statistically demonstrate that differences exist between these species, no single character was able to discern each taxa. As a result, this key will fail to differentiate between *A. carolinensis* and *A. porcatus*.

Table 3-1. Interspecific variation for each of 23 meristic characters of *Anolis* species in Florida. ANOVA testing was used to analyze characters 1 to 12. Characters 13 to 23 were qualitative in nature and subjected to a χ^2 contingency analysis test.

Character	Mean of Response	*F*-ratio or χ^2	Degrees of Freedom	R^2
1	17.12	764.57*	8, 216	0.97
2	6.07	43.80*	8, 216	0.62
3	6.92	131.05*	8, 216	0.83
4	7.21	91.34*	8, 216	0.77
5	2.86	23.72*	8, 216	0.47
6	2.25	55.45*	8, 216	0.67
7	6.86	41.03*	8, 216	0.60
8	4.61	77.88*	8, 216	0.74
9	6.63	47.34*	8, 216	0.64
10	74.95	312.91*	8, 216	0.92
11	25.30	94.58*	8, 216	0.77
12	1.04	117.49*	8, 216	0.81
13	-	156.97*	8	1.00
14	-	273.64*	8	0.89
15	-	148.79*	8	0.49
16	-	0.00	0	-
17	-	286.43*	8	1.00
18	-	92.89*	8	0.32
19	-	106.17*	8	0.76
20	-	238.37*	8	1.00
21	-	89.89*	8	0.30
22	-	447.762*	8	1.00
23	-	286.43*	8	1.00

Table 3-2. Descriptive statistics in regards to the most significant diagnostic characters for Florida's *Anolis* species. Characters were chosen in response to results from statistical analyses and examination of raw character scores. *Anolis trinitatis* is included based solely on raw character scores. Continuous characters (1, 6, 10 and 12) display mean values and ranges for each character. Qualitative characters display percentages of individuals exhibiting a particular trait.

Character	*A. carolinensis* n =25	*A. chlorocyanus* n =25	*A. cristatellus* n = 25	*A. cybotes* n = 25	*A. distichus* n=25
1	15.92 (14-18)	20.88 (19-23)	12.24 (10-14)	11.36 (10-13)	12.44 (10-14)
6	1.68 (1-3)	2.44 (1-3)	2.04 (0-3)	2.12 (1-3)	0.76 (0-3)
10	83.68 (76-92)	79.88 (75-86)	56.28 (52-68)	44.28 (37-49)	82.72 (72-90)
12	1 (0-2)	0.96 (0-1)	0.04 (0-1)	0.28 (0-1)	0.16 (0-1)
13	Keeled: 100% Unkeeled: 0%	Keeled: 100% Unkeeled: 0%	Keeled: 100% Unkeeled: 0%	Keeled: 100% Unkeeled: 0%	Keeled: 100% Unkeeled: 0%
14	Expanded: 0% Uniform: 100%	Expanded: 80% Uniform: 20%	Expanded: 100% Uniform: 0%	Expanded: 100% Uniform: 0%	Expanded: 0% Uniform: 100%
17	Keeled: 100% Unkeeled: 0%	Keeled: 0% Unkeeled: 100%	Keeled: 0% Unkeeled: 100%	Keeled: 0% Unkeeled: 100%	Keeled: 0% Unkeeled: 100%
20	Compressed: 0% Round: 100%	Compressed: 0% Round: 100%	Compressed: 100% Round: 0%	Compressed: 0% Round: 100%	Compressed: 0% Round: 100%
22	Multicarinate: 100% Single Keel: 0% Unkeeled: 0%	Multicarinate: 0% Single Keel: 100% Unkeeled: 0%	Multicarinate: 0% Single Keel: 100% Unkeeled: 0%	Multicarinate: 0% Single Keel: 100% Unkeeled: 0%	Multicarinate: 0% Single Keel: 0% Unkeeled: 100%

Table 3-2. Continued.

Character	*A. equestris* n =25	*A. garmani* n =25	*A. porcatus* n = 25	*A. sagrei* n = 25	*A. trinitatis* n=18
1	31.56 (30-35)	19.24 (17-21)	20.32 (17-23)	10.12 (8-12)	16.88 (15-19)
6	3.92 (3-5)	3.04 (2-4)	1.52 (1-3)	2.76 (2-4)	0.0 (0)
10	93.2 (83-102)	88.64 (78-100)	77.6 (70-90)	68.28 (61-75)	73.27 (70-78)
12	2.76 (2-3)	2.24 (2-3)	0.76 (0-2)	1.16 (0-2)	0.0 (0)
13	Keeled: 0% Unkeeled: 100%	Keeled: 100% Unkeeled: 0%	Keeled: 100% Unkeeled: 0%	Keeled: 100% Unkeeled: 0%	Keeled: 100% Unkeeled: 0%
14	Expanded: 0% Uniform: 100%	Expanded: 100% Uniform: 0%	Expanded: 0% Uniform: 100%	Expanded: 04% Uniform: 96%	Expanded: 100% Uniform: 0%
17	Keeled: 0% Unkeeled: 100%	Keeled: 0% Unkeeled: 100%	Keeled: 100% Unkeeled: 0%	Keeled: 100% Unkeeled: 0%	Keeled: 0% Unkeeled: 100%
20	Compressed: 100% Round: 0%	Compressed: 0% Round: 100%	Compressed: 0% Round: 100%	Compressed: 100% Round: 0%	Compressed: 0% Round: 100%
22	Multicarinate: 0% Single Keel: 0% Unkeeled: 100%	Multicarinate: 0% Single Keel: 100% Unkeeled: 0%	Multicarinate: 100% Single Keel: 0% Unkeeled: 0%	Multicarinate: 0% Single Keel: 100% Unkeeled: 0%	Multicarinate: 06% Single Keel: 94% Unkeeled: 0%

Table 3-3. Significant characters in stepwise DFA analysis in order of model importance. *F* ratio was recorded at the time each character was added to the model. -2 Log Likelihood is minus two times the natural log of the likelihood function evaluated at the best-fit parameter estimates.

Character	Prob>*F*	*F* Ratio	Number Misclassified	Percent Misclassified	-2 Log Likelihood
1	0.0000000	764.556	100	44.44	408.3
10	0.0000000	173.599	33	14.67	164.0
8	0.0000000	54.362	22	9.778	106.3
7	0.0000000	39.446	14	6.222	77.65
11	0.0000000	33.258	10	4.444	54.38
3	0.0000000	33.002	8	3.556	48.75
9	0.0000000	30.004	7	3.111	43.24
12	0.0000000	21.899	6	2.667	36.10
2	0.0000000	16.289	5	2.222	19.90
6	0.0000000	8.683	1	0.444	11.94
5	0.0000001	6.590	2	0.889	10.75
4	0.0000006	6.015	1	0.444	8.043

Table 3-4. Mean responses for natural log size corrected morphometric features examined in this analysis appear in the top row for each species. Note that the covariate appearing in this model is ln Character 24 = 4.145. See Table 2-2 for explanation of the acronyms. Size corrected measurements back-transformed from natural log appear in the second row for each species. All back-transformed measurements are in millimeters.

Species	AGD	HL	HW	IND	EED	NRD	SNL	TIB
A. carolinensis	3.243	2.881	2.352	0.825	1.972	0.850	2.374	2.380
	(25.610)	(17.832)	(10.507)	(2.282)	(7.185)	(2.340)	(10.740)	(10.805)
A. chlorocyanus	3.229	2.826	2.326	0.555	1.928	0.235	2.336	2.355
	(25.254)	(16.878)	(10.237)	(1.742)	(6.876)	(1.265)	(10.340)	(10.538)
A. cristatellus	3.198	2.815	2.475	0.725	2.026	0.134	2.248	2.629
	(24.484)	(16.693)	(11.882)	(2.065)	(7.584)	(1.143)	(9.469)	(13.860)
A. cybotes	3.217	2.888	2.490	0.952	2.111	0.331	2.293	2.585
	(24.953)	(17.957)	(12.061)	(2.591)	(8.256)	(1.392)	(9.905)	(13.263)
A. distichus	3.223	2.742	2.441	0.670	1.921	0.109	2.147	2.527
	(25.103)	(15.518)	(11.485)	(1.954)	(6.828)	(1.115)	(8.559)	(12.516)
A. equestris	3.286	2.886	2.399	1.019	1.942	0.479	2.478	2.352
	(26.736)	(17.921)	(11.012)	(2.770)	(6.973)	(1.614)	(11.917)	(10.507)
A. garmani	3.261	2.873	2.393	0.859	2.016	0.146	2.376	2.545
	(26.076)	(17.690)	(10.946)	(2.361)	(7.508)	(1.157)	(10.762)	(12.743)
A. porcatus	3.201	2.999	2.411	0.824	2.031	1.091	2.526	2.378
	(24.557)	(20.065)	(11.145)	(2.280)	(7.622)	(2.977)	(12.503)	(10.783)
A. sagrei	3.269	2.774	2.361	0.778	1.964	0.409	2.206	2.558
	(26.285)	(16.023)	(10.602)	(2.177)	(7.128)	(1.505)	(9.079)	(12.910)

Table 3-5. Intraspecific mean differences in morphometric pairwise comparisons. Axilla-groin distance (Character 26) is represented above the diagonal and head length (Character 27) is represented below. Vertical column made in comparison with horizontal column. Numbers with * are significant at 0.05, ** are significant at 0.01, and *** are significant at 0.001. A negative value indicates the character for the species in question is smaller than the species it's being compared to.

Species	*A. carolinensis*	*A. chlorocyanus*	*A. cristatellus*	*A. cybotes*	*A. distichus*	*A. equestris*	*A. garmani*	*A. porcatus*	*A. sagrei*
A. carolinensis	-	0.013	0.045*	0.026	0.020	-0.043	-0.018	0.042*	-0.026
A. chlorocyanus	-0.055***	-	0.032	0.013	0.007	-0.057	-0.032	0.028	-0.039
A. cristatellus	-0.066***	-0.011	-	-0.019	-0.025	-0.088**	-0.063**	-0.003	-0.071***
A. cybotes	0.007	0.062***	0.073***	-	-0.006	-0.069*	-0.044*	0.016	-0.052*
A. distichus	-0.139***	-0.084***	-0.073***	-0.146***	-	-0.063	-0.038	0.022	-0.046*
A. equestris	0.005	0.060*	0.071**	-0.002	0.144***	-	0.025	0.085**	0.017
A. garmani	-0.008	0.047**	0.058***	-0.015	0.131***	0.013	-	0.060**	-0.007
A. porcatus	0.118***	0.173***	0.184***	0.111***	0.257***	0.113***	0.126***	-	-0.068*
A. sagrei	-0.107***	-0.052***	-0.041**	-0.114***	0.032*	-0.112***	-0.099***	-0.225***	-

Table 3-6. Intraspecific mean differences in morphometric pairwise comparisons. Head width (Character 28) is represented above the diagonal and internarial distance (Character 29) is represented below. Vertical column made in comparison with horizontal column. Numbers with * are significant at 0.05, ** are significant at 0.01, and *** are significant at 0.001. A negative value indicates the character for the species in question is smaller than the species it's being compared to.

Species	*A. carolinensis*	*A. chlorocyanus*	*A. cristatellus*	*A. cybotes*	*A. distichus*	*A. equestris*	*A. garmani*	*A. porcatus*	*A. sagrei*
A. carolinensis	-	0.026	-0.123***	-0.138***	-0.088***	-0.047	-0.041*	-0.059***	-0.009
A. chlorocyanus	-0.270***	-	-0.149***	-0.163***	-0.114***	-0.073**	-0.067***	-0.085***	-0.035*
A. cristatellus	-0.100**	0.170***	-	-0.014	0.035*	0.077**	0.082***	0.064***	0.114***
A. cybotes	0.127***	0.397***	0.227***	-	0.049**	0.091***	0.097***	0.078***	0.128***
A. distichus	-0.155***	0.115**	-0.055	-0.282***	-	0.042	0.048*	0.029	0.079***
A. equestris	0.194***	0.465***	0.294***	0.067	0.349***	-	0.006	-0.012	0.038
A. garmani	0.034	0.304***	0.134***	-0.093*	0.189***	-0.161***	-	-0.018	0.032
A. porcatus	-0.001	0.269***	0.099**	-0.128***	0.154***	-0.195***	-0.035	-	0.050**
A. sagrei	-0.047	0.224***	0.053	-0.174***	0.108**	-0.241***	-0.080*	-0.046	-

Table 3-7. Intraspecific mean differences in morphometric pairwise comparisons. Ear-eye distance (Character 30) is represented above the diagonal and naris-rostrum distance (Character 31) is represented below. Vertical column made in comparison with horizontal column. Numbers with * are significant at 0.05, ** are significant at 0.01, and *** are significant at 0.001. A negative value indicates the character for the species in question is smaller than the species it's being compared to.

Species	*A. carolinensis*	*A. chlorocyanus*	*A. cristatellus*	*A. cybotes*	*A. distichus*	*A. equestris*	*A. garmani*	*A. porcatus*	*A. sagrei*
A. carolinensis	-	0.044*	-0.054*	-0.139***	0.050*	0.029	-0.044	-0.059**	0.007
A. chlorocyanus	-0.616***	-	-0.098***	-0.183***	0.006	-0.015	-0.088***	-0.103***	-0.037
A. cristatellus	-0.716***	-0.101***	-	-0.085***	0.104***	0.084**	0.010	-0.005	0.061**
A. cybotes	-0.519***	0.096*	0.197***	-	0.189***	0.169***	0.095***	0.080***	0.146***
A. distichus	-0.742***	-0.126*	-0.026	-0.222***	-	-0.021	-0.094***	-0.109***	-0.043*
A. equestris	-0.372***	0.244***	0.344***	0.148*	0.370***	-	-0.074**	-0.089**	-0.022
A. garmani	-0.704***	-0.089	0.012	-0.185***	0.037	-0.333***	-	-0.015	0.051*
A. porcatus	0.241***	0.857***	0.957***	0.760***	0.983***	0.613***	0.945***	-	0.066**
A. sagrei	-0.441***	0.175***	0.275***	0.078	0.301***	-0.069	0.263***	-0.682***	-

Table 3-8. Intraspecific mean differences in morphometric pairwise comparisons. Snout length (Character 32) is represented above the diagonal and tibia length (Character 33) is represented below. Vertical column made in comparison with horizontal column. Numbers with * are significant at 0.05, ** are significant at 0.01, and *** are significant at 0.001. A negative value indicates the character for the species in question is smaller than the species it's being compared to.

Species	*A. carolinensis*	*A. chlorocyanus*	*A. cristatellus*	*A. cybotes*	*A. distichus*	*A. equestris*	*A. garmani*	*A. porcatus*	*A. sagrei*
A. carolinensis	-	0.038	0.126***	0.082***	0.227***	-0.104**	-0.002	-0.151***	0.168***
A. chlorocyanus	-0.025	-	0.088***	0.043*	0.189***	-0.142***	-0.040	-0.190***	0.130***
A. cristatellus	0.249***	0.275***	-	-0.044*	0.101***	-0.230***	-0.128***	-0.278***	0.042*
A. cybotes	0.205***	0.231***	-0.044*	-	0.145***	-0.186***	-0.084***	-0.233***	0.087***
A. distichus	0.147***	0.172***	-0.102***	-0.059**	-	-0.331***	-0.229***	-0.379***	-0.059**
A. equestris	-0.028	-0.003	-0.277***	-0.234***	-0.175***	-	-0.102***	-0.047	0.272***
A. garmani	0.165***	0.190***	-0.085***	-0.041*	0.018	0.193***	-	-0.149***	0.170***
A. porcatus	-0.002	0.024	-0.251***	-0.207***	-0.148***	0.027	-0.166***	-	0.320***
A. sagrei	0.178***	0.203***	-0.071***	-0.028	0.031	0.206***	0.013	0.179***	-

Table 3-9. Characters tested with statistically significant differences between female *A. carolinensis* and *A. porcatus* in the second analysis. Note that all mean values were counts of scales for that particular character.

Character	Mean (*A. porcatus*)	Mean (*A. carolinensis*)	Mean Difference	F Ratio	Probability > F
1	20.25	15.9091	3.3409	142.1015	<0.0001
3	8.0	6.8	1.2	31.4286	<0.0001
4	7.25	8.04545	0.79545	18.0319	0.0001
7	7.15	7.81818	0.66818	7.2452	0.0103
8	3.05	4.18182	1.13182	52.5110	<0.0001
10	75.9474	82.9545	7.0071	25.9646	<0.0001
11	24.3	26.5455	2.2455	25.2570	<0.0001
12	0.75	1.18182	0.43182	7.0889	0.0111
34	24.45	20.4545	3.9955	150.6497	<0.0001
35	25.65	22.0909	3.5591	138.3472	<0.0001
36	25.2	21.5	3.7	122.8429	<0.0001

Table 3-10. Characters tested with statistically significant differences between male *A. carolinensis* and *A. porcatus* in the second analysis. Note that all mean values were counts of scales for that particular character.

Character	Mean (*A. porcatus*)	Mean (*A. carolinensis*)	Mean Difference	F Ratio	Probability > F
1	20.3333	16.6667	3.6666	136.8445	<0.0001
2	5.75	6.39394	0.64394	11.2209	0.0013
3	7.27778	8.21212	0.93434	37.6649	<0.0001
7	6.77778	7.96970	1.19192	20.6945	<0.0001
8	3.52778	4.21212	0.68434	29.2224	<0.0001
10	78.5278	87.6061	9.0783	67.1004	<0.0001
11	26.5278	27.6364	1.1086	5.8921	0.0179
12	0.69444	1.06061	0.36617	9.9669	0.0024
34	25.4286	21.1818	4.2468	178.1598	<0.0001
35	26.8857	22.4848	4.4009	178.2783	<0.0001
36	26.2857	22.0606	4.2251	127.4480	<0.0001

Table 3-11. Different combinations of characters tested for use in logistic regression models as predictors of *Anolis carolinensis* and *A. porcatus* from outside of the believed range overlap. Starred model numbers were not tested due to higher misclassifications of specimens of known origin.

Character Combinations	Number of Misclassified Individuals	Model Number
1, 10	3	1
1, 35, 36	3	3
10, 35,36	5	2
1, 34	5	4
1, 35	7	*
34, 35, 36	8	*
10, 35	8	*
34, 35	8	*
34, 36	9	*
35, 36	9	*
10, 34	9	*
1, 36	10	*
10, 36	14	*

Table 3-12. Statistical results of the female whole-model test of each combination of characters used in the logistical regression formula. These prediction characters tested the accuracy of determining individuals as either *A. carolinensis* or *A. porcatus* from outside of the known range overlap.

Character Combinations	-Log Likelihood	Chi Square	Degrees of Freedom	Probability > Chi Square
1,10	28.3077159	56.6154	2	<0.0001
10,35,36	28.307874	56.6157	3	<0.0001
1,35,36	29.0636356	58.1273	3	<0.0001
1,34	29.0642612	58.1285	2	<0.0001

Table 3-13. Statistical results of the male whole-model test of each combination of characters used in the logistical regression formula. These prediction characters tested the accuracy of determining individuals as either *A. carolinensis* or *A. porcatus* from outside of the known range overlap.

Character Combinations	-Log Likelihood	Chi Square	Degrees of Freedom	Probability > Chi Square
1,10	47.0315725	94.0631	2	<0.0001
10,35,36	45.8342481	91.6685	3	<0.0001
1,35,36	45.1620403	90.3241	3	<0.0001
1,34	45.239926	90.4799	2	<0.0001

Table 3-14. Logistic regression predictor coefficients used in each model for female *A. carolinensis and A. porcatus*.

Model	Intercept (α)	β_1	β_2	β_3
1	78.498188	-8.489441	0.9287767	-
2	150.05191	-3.92875	-5.364675	0.893451
3	238.58774	-4.900912	-5.797392	-0.574746
4	258.33708	-6.433651	-6.584	-

Table 3-15. Logistic regression predictor coefficients used in each model for male *A. carolinensis and A. porcatus*.

Model	Intercept (α)	β_1	β_2	β_3
1	5.1194898	-6.338315	1.3522889	-
2	71.481711	-6.033094	-1.757668	1.370863
3	250.51778	-2.361721	-3.812316	-5.032913
4	193.8599	-3.611365	-5.608631	-

Table 3-16. Prediction vales for unknown species by each of the four available models. A response scored as 1 predicted *A. carolinensis*, while a response scored as 0 predicted *A. porcatus*. Each specimen was treated as an unknown, though every specimen was arbitrarily labeled based on the believed identity of the specimen from Miami-Dade County.

Anolis Species	Species ID	SEX	Model 1	Model 2	Model 3	Model 4
Unknown	*A. carolinensis*	m	1.0000	0.9999	1.0000	1.0000
Unknown	*A. carolinensis*	m	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	m	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	m	0.9991	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	m	1.0000	0.9973	1.0000	1.0000
Unknown	*A. carolinensis*	m	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	m	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	m	1.0000	0.9998	1.0000	1.0000
Unknown	*A. carolinensis*	m	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	m	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	m	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	m	0.6490	0.9995	1.0000	1.0000
Unknown	*A. carolinensis*	m	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	m	1.0000	0.9998	1.0000	1.0000
Unknown	*A. carolinensis*	m	0.9955	0.9996	1.0000	1.0000
Unknown	*A. carolinensis*	m	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	m	0.9786	0.9500	0.4964	1.0000
Unknown	*A. carolinensis*	m	0.0273	0.5548	0.9993	0.9770
Unknown	*A. carolinensis*	m	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	m	0.9979	1.0000	1.0000	1.0000
Unknown	*A. porcatus*	m	0.0000	0.0000	0.0000	0.0000
Unknown	*A. porcatus*	m	0.0000	0.0000	0.0141	0.0001
Unknown	*A. porcatus*	m	0.9979	0.0001	0.0032	0.8944
Unknown	*A. porcatus*	m	0.8391	0.0002	0.1057	0.9990
Unknown	*A. porcatus*	m	0.0000	0.0034	0.0000	0.0000
Unknown	*A. porcatus*	m	0.0000	0.0000	0.9824	0.3419
Unknown	*A. porcatus*	m	0.1683	0.0000	0.0000	0.0000
Unknown	*A. porcatus*	m	0.0001	0.0000	0.0000	0.0000
Unknown	*A. porcatus*	m	0.0000	0.0000	0.0000	0.0000
Unknown	*A. porcatus*	m	0.0002	0.0000	0.0000	0.0214
Unknown	*A. porcatus*	m	0.9996	0.0010	0.0000	0.3419
Unknown	*A. porcatus*	m	0.0000	0.0000	0.0000	0.0000
Unknown	*A. porcatus*	m	0.0000	0.0000	0.0000	0.0000
Unknown	*A. porcatus*	m	0.0000	0.0000	0.0000	0.0000
Unknown	*A. porcatus*	m	0.0885	0.4805	0.9532	0.9770
Unknown	*A. porcatus*	m	0.0000	0.0000	0.0000	0.0000
Unknown	*A. porcatus*	m	0.0000	0.0000	0.0131	0.3419
Unknown	*A. porcatus*	m	0.0273	0.0000	0.0034	0.3419

Table 3-16. Continued.

Anolis Species	Species ID	SEX	Model 1	Model 2	Model 3	Model 4
Unknown	*A. porcatus*	m	0.0273	0.0000	0.0003	0.9770
Unknown	*A. porcatus*	m	0.0000	0.0000	0.0000	0.0000
Unknown	*A. carolinensis*	f	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	f	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	f	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	f	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	f	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	f	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	f	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	f	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	f	1.0000	1.0000	1.0000	1.0000
Unknown	*A. carolinensis*	f	1.0000	1.0000	1.0000	1.0000
Unknown	*A. porcatus*	f	1.0000	0.9692	1.0000	1.0000
Unknown	*A. porcatus*	f	0.3661	0.7889	0.8761	0.0765
Unknown	*A. porcatus*	f	0.0570	0.0000	0.7794	0.9341
Unknown	*A. porcatus*	f	0.5682	0.0000	0.0282	0.9341
Unknown	*A. porcatus*	f	1.0000	1.0000	1.0000	1.0000
Unknown	*A. porcatus*	f	0.9912	0.9528	1.0000	0.0675

Table 3-17. Significant characters in stepwise DFA analysis for females in order of model importance. F ratio was recorded at the time each character was added to the model. -2 Log Likelihood is minus two times the natural log of the likelihood function evaluated at the best-fit parameter estimates.

Character	Prob>*F*	*F* Ratio	Number Misclassified	Percent Misclassified	-2 Log Likelihood
34	0.0000000	141.896	1	2.381	6.043
1	0.0000413	21.477	0	0	0.448
10	0.0069366	8.176	0	0	0.019
35	0.0078177	7.936	0	0	0.021
7	0.0088250	7.694	0	0	0.001

Table 3-18. Significant characters in stepwise DFA analysis for males in order of model importance. F ratio was recorded at the time each character was added to the model. -2 Log Likelihood is minus two times the natural log of the likelihood function evaluated at the best-fit parameter estimates.

Character	Prob>*F*	*F* Ratio	Number Misclassified	Percent Misclassified	-2 Log Likelihood
35	0.0000000	178.278	4	5.882	19.21
10	0.0000181	21.429	1	1.471	7.117
1	0.0000836	17.657	0	0	0.957
8	0.0001564	16.184	0	0	0.042
36	0.0251235	5.268	0	0	0.019
3	0.0050421	8.467	0	0	0.002

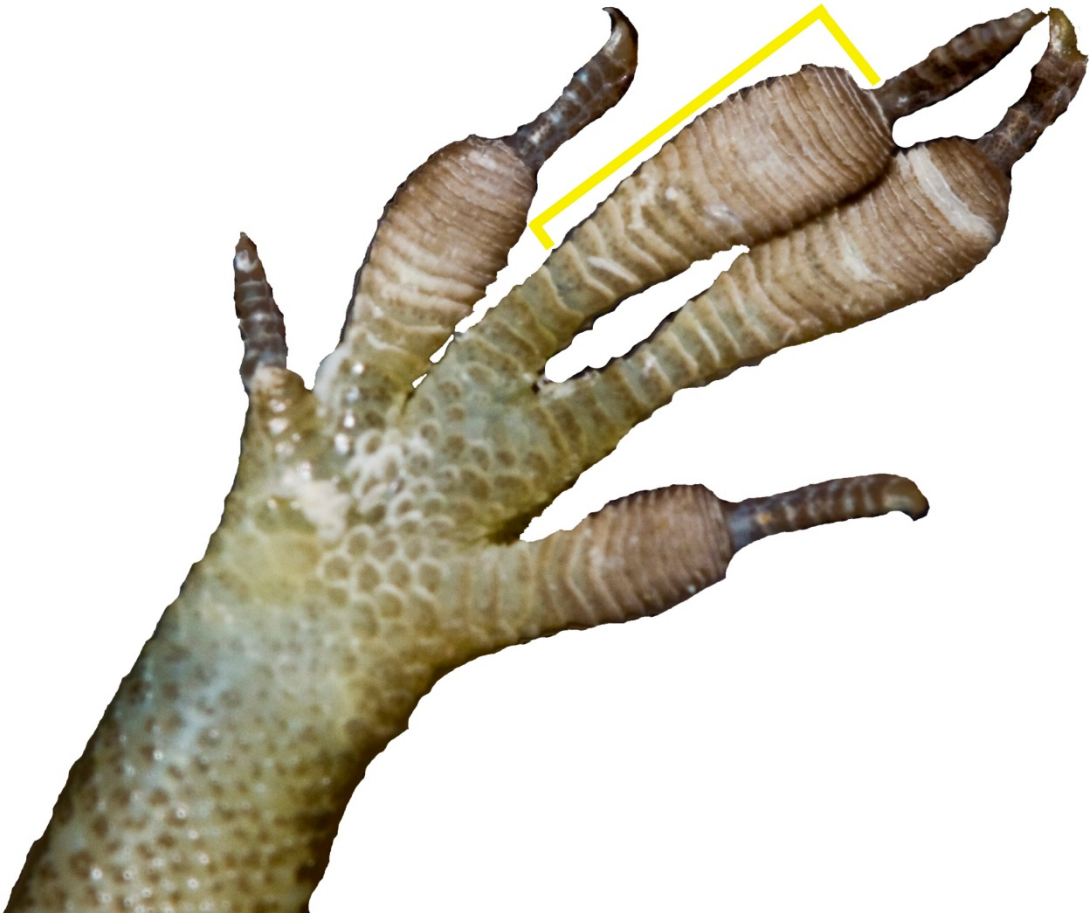

Figure 3-1. Illustration of a representative *A. chlorocyanus* (UF 157424) demonstrating expanded sub-digital lamellae on the third anterior digit numbering 15-24. This feature is highlighted in yellow and is counted from the tip of the digit to the point where lamellae scales become uniform in width.

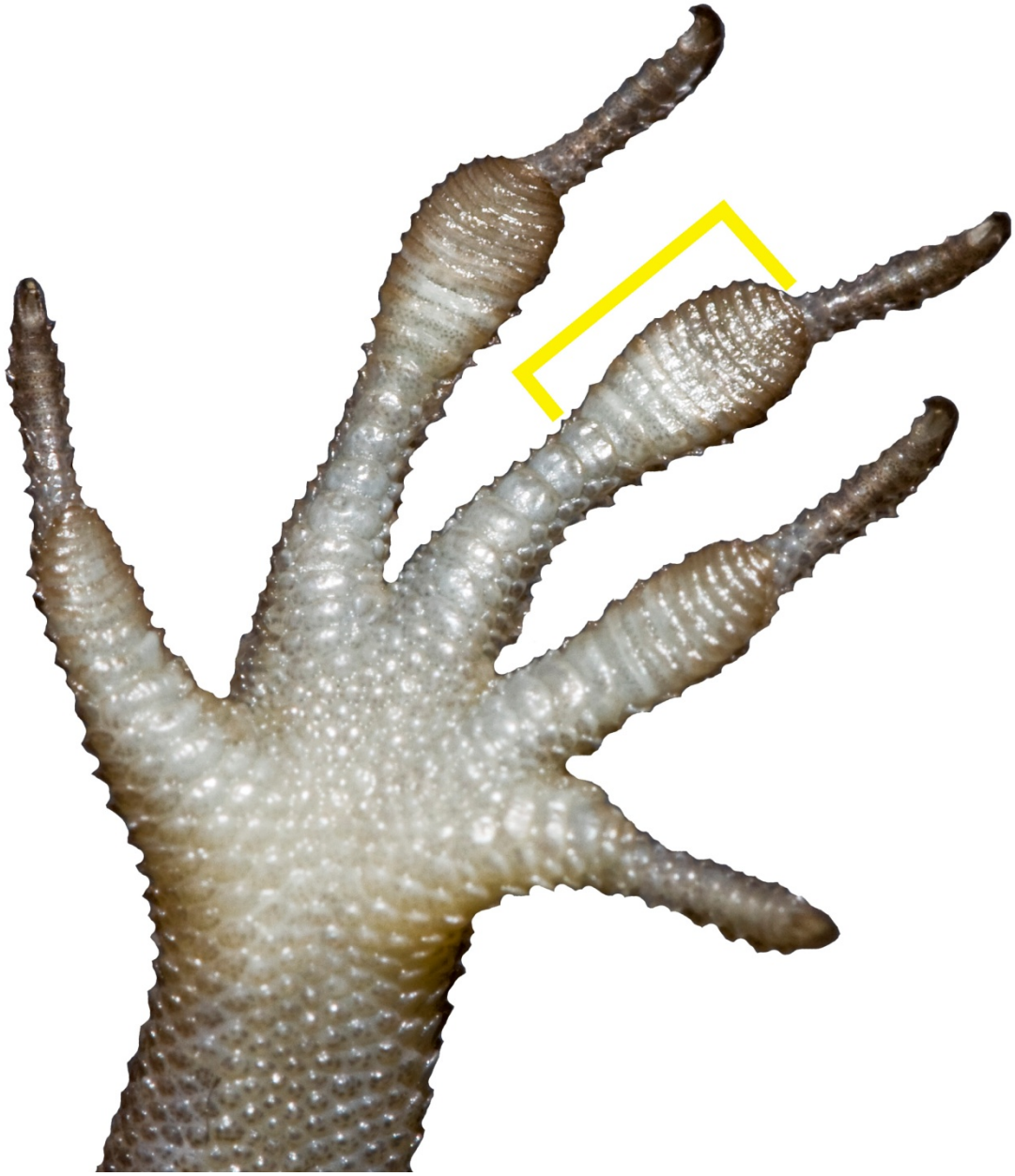

Figure 3-2. Illustration of a representative *A. cristatellus* (UF 155409) demonstrating expanded sub-digital lamellae on the third anterior digit numbering 14 or fewer. This feature is highlighted in yellow and is counted from the tip of the digit to the point where lamellae scales become uniform in width.

Figure 3-3. Illustration of a representative *A. chlorocyanus* (UF 157424) demonstrating the interparietal scale (circled in yellow) separated from the supra-orbital semicircles by at least one scale. The arrows indicate where the supra-orbital semicircles are located. These enlarged scales form a half moon shape around the supra-ocular scales and eye.

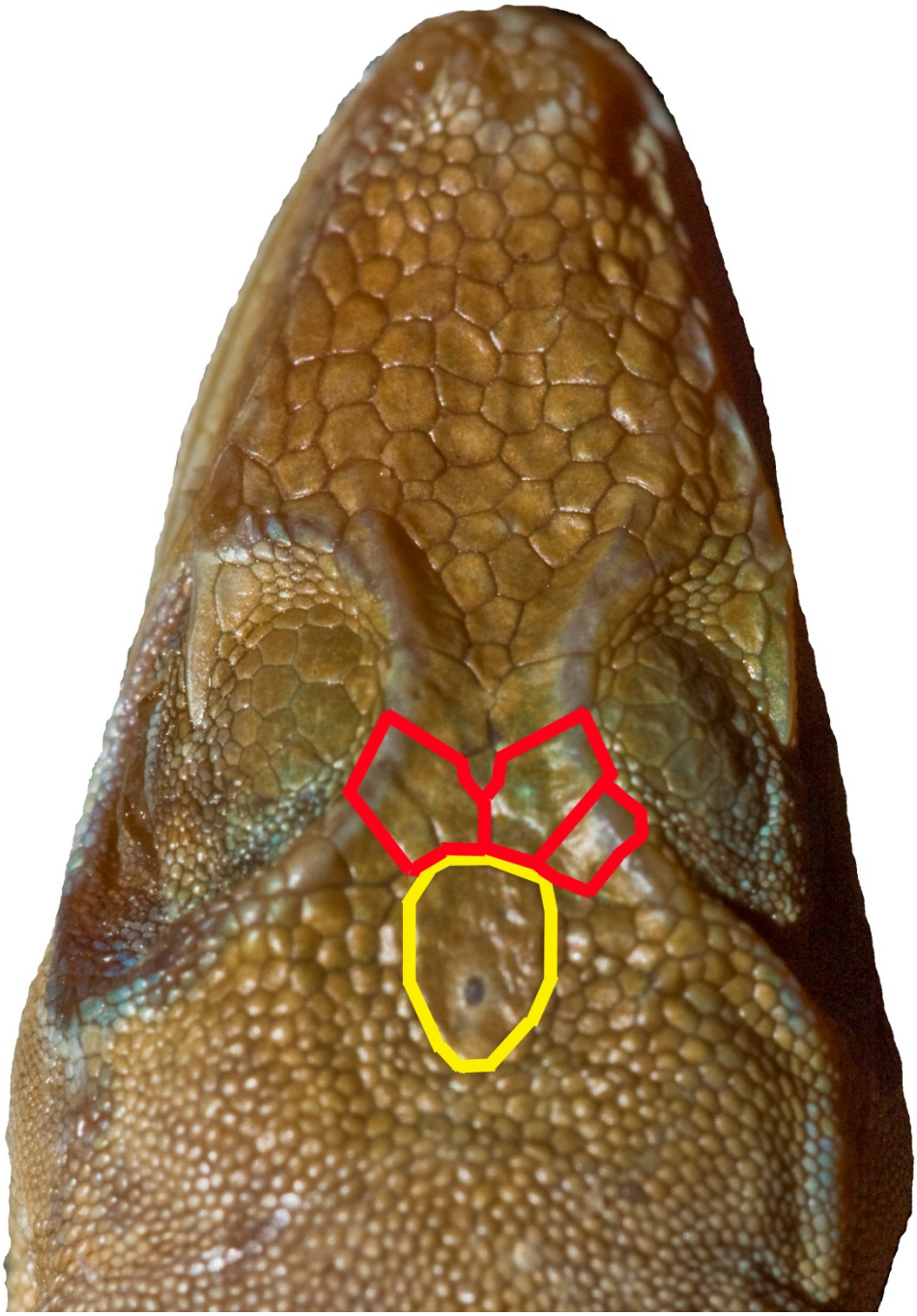

Figure 3-4. Illustration of a representative *A. trinitatis* (UF 91254) demonstrating the interparietal scale (highlighted in yellow) is always in contact with the supra-orbital semicircles (highlighted in red), which are enlarged scales forming a half moon shape around the supra-ocular scales and eye.

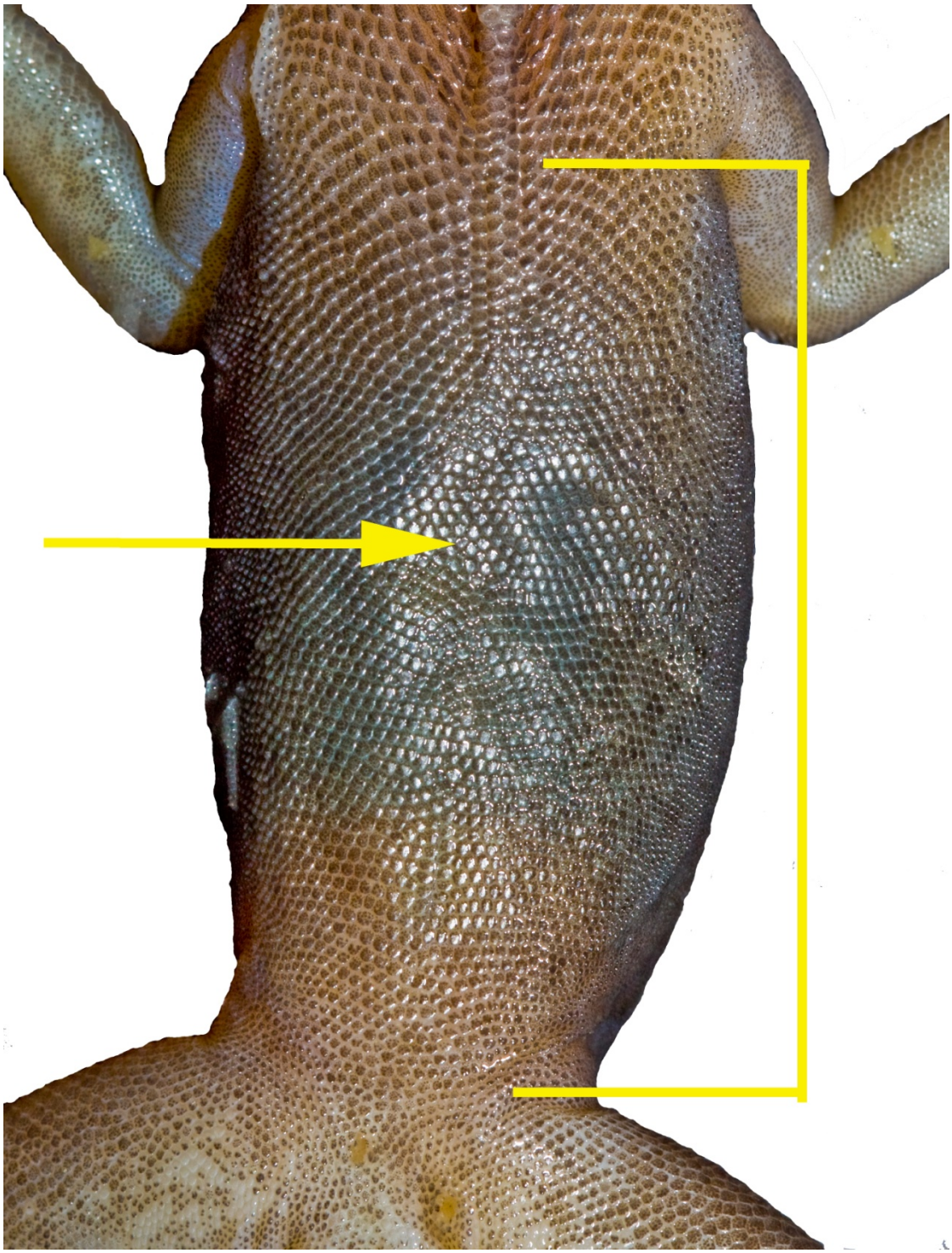

Figure 3-5. Illustration of a representative *A. cristatellus* (UF 155409) demonstrating 52-70 ventral scales counted at mid-body, from the posterior insertion of the arm to the anterior insertion of the leg. The yellow bracket illustrates where the count begins and ends while the arrow indicates the location of the mid-body scales.

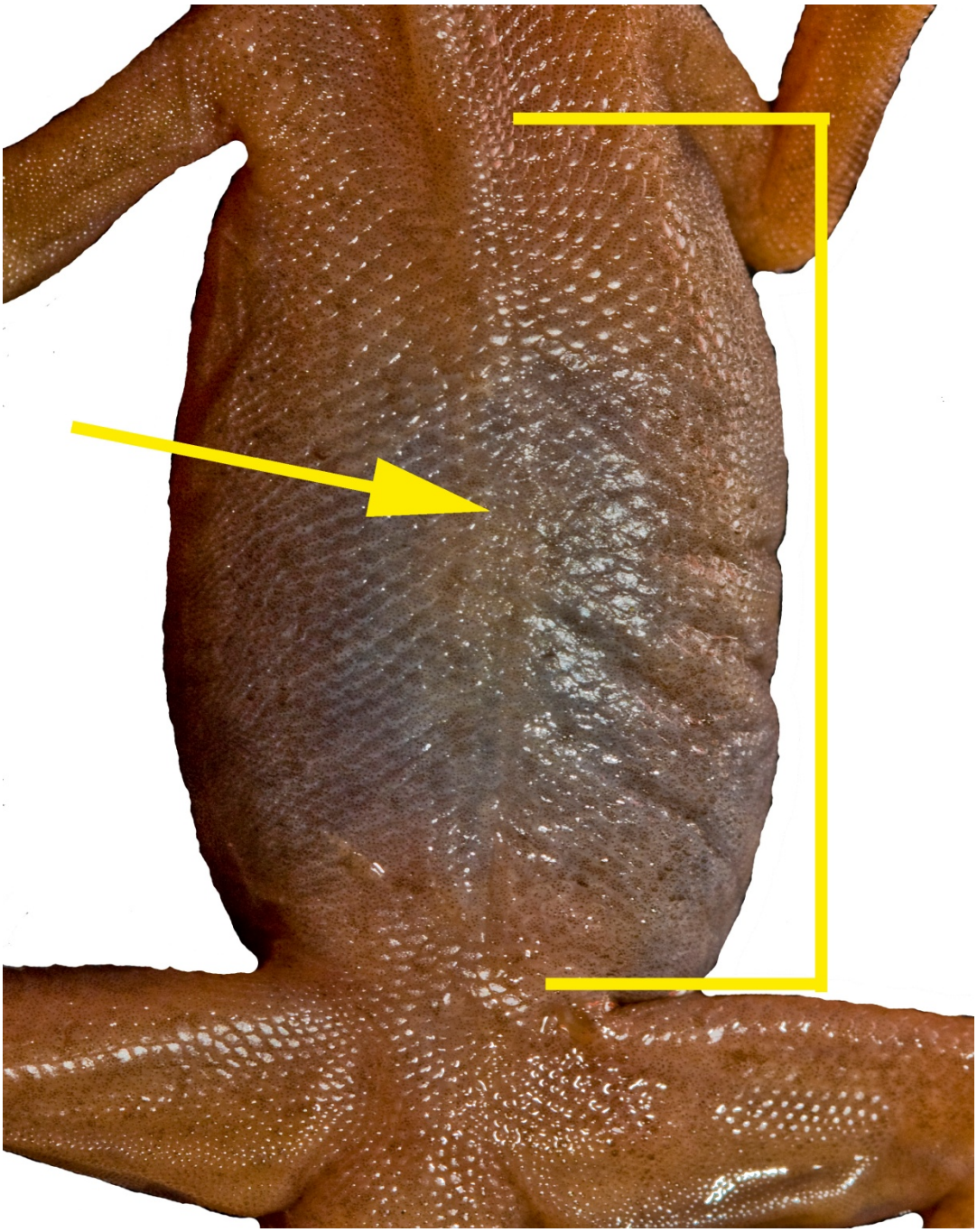

Figure 3-6. Illustration of a representative *A. cybotes* (UF 84766) demonstrating 30-49 ventral scales counted at mid-body, from the posterior insertion of the arm to the anterior insertion of the leg. The yellow bracket illustrates where the count begins and ends while the arrow indicates the location of the mid-body scales.

Figure 3-7. Illustration of a representative *A. garmani* (UF 121443) demonstrating at least two or more scales (highlighted in yellow) separating the supra-orbital semicircles which are the enlarged scales forming a half moon shape around the supra-ocular scales and eye.

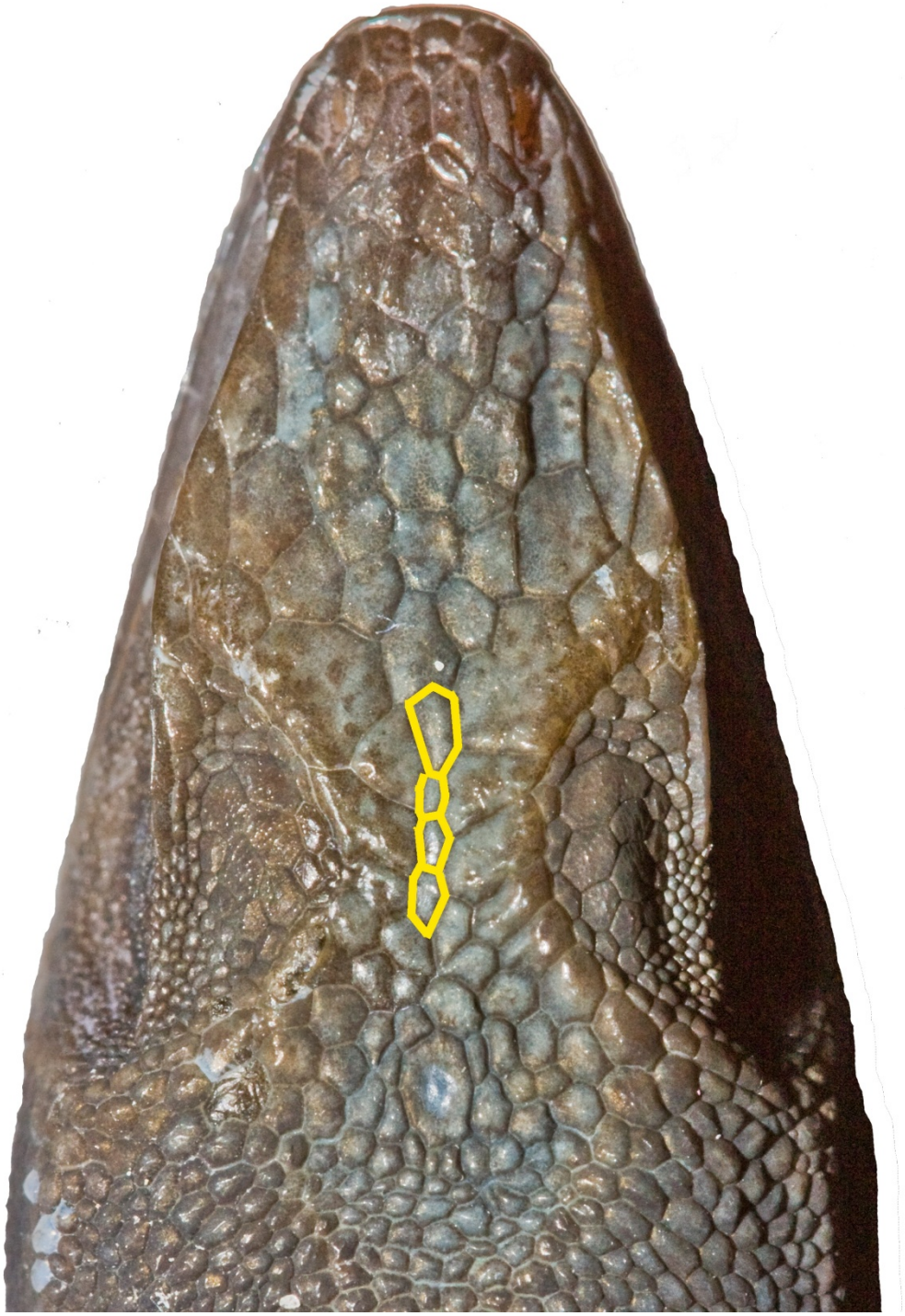

Figure 3-8. Illustration of a representative *A. chlorocyanus* (UF 157424) demonstrating 0-1 scales (highlighted in yellow) separating the supra-orbital semicircles, which are the enlarged scales forming a half moon shape around the supra-ocular scales and eye.

Figure 3-9. Close up illustration of a representative *A. distichus* (UF 152791) demonstrating small, round and keeled dorsal scales.

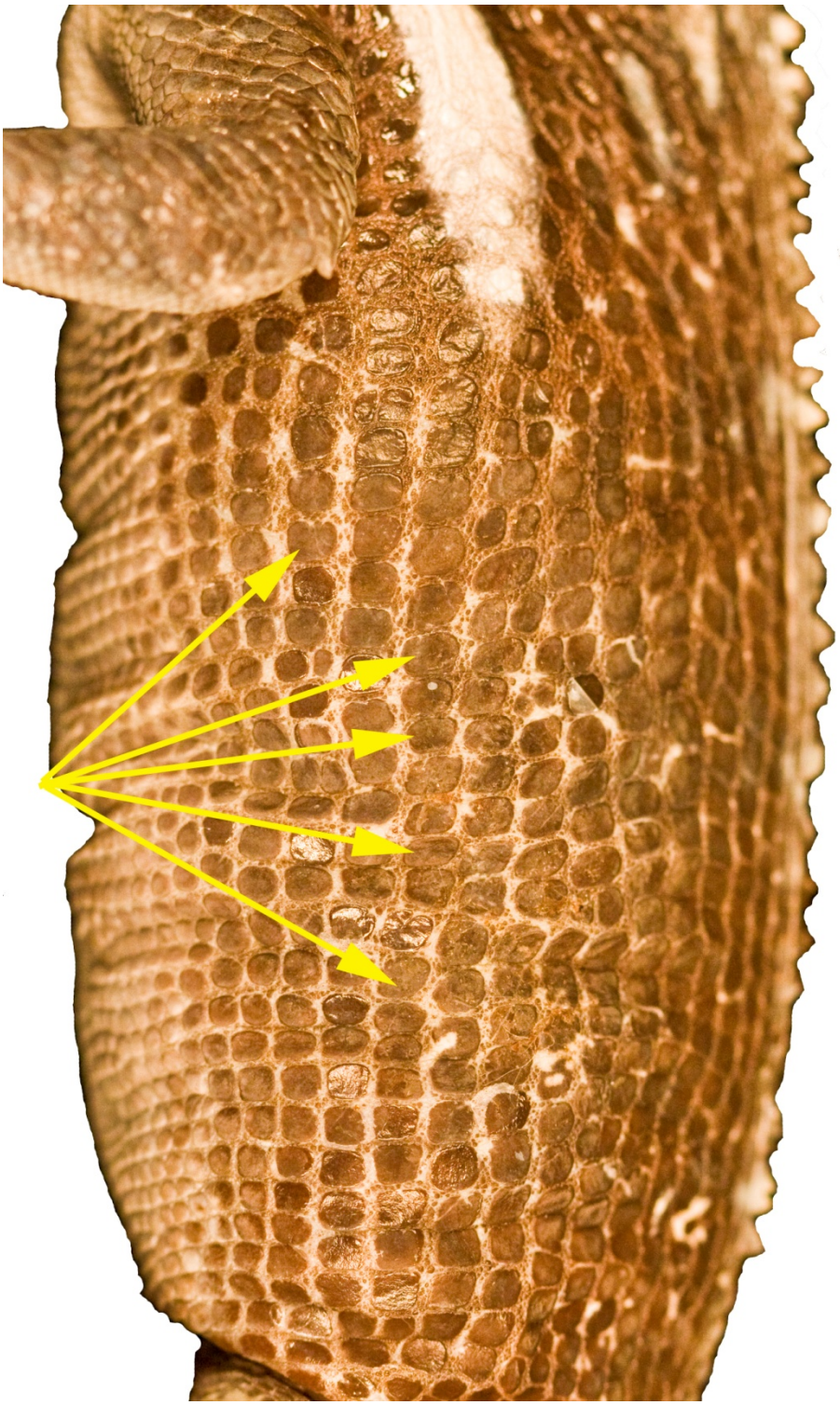

Figure 3-10. Close up illustration of a representative *A. equestris* (UF 155428) demonstrating large, flat, and smooth dorsal scales as indicated by the arrows.

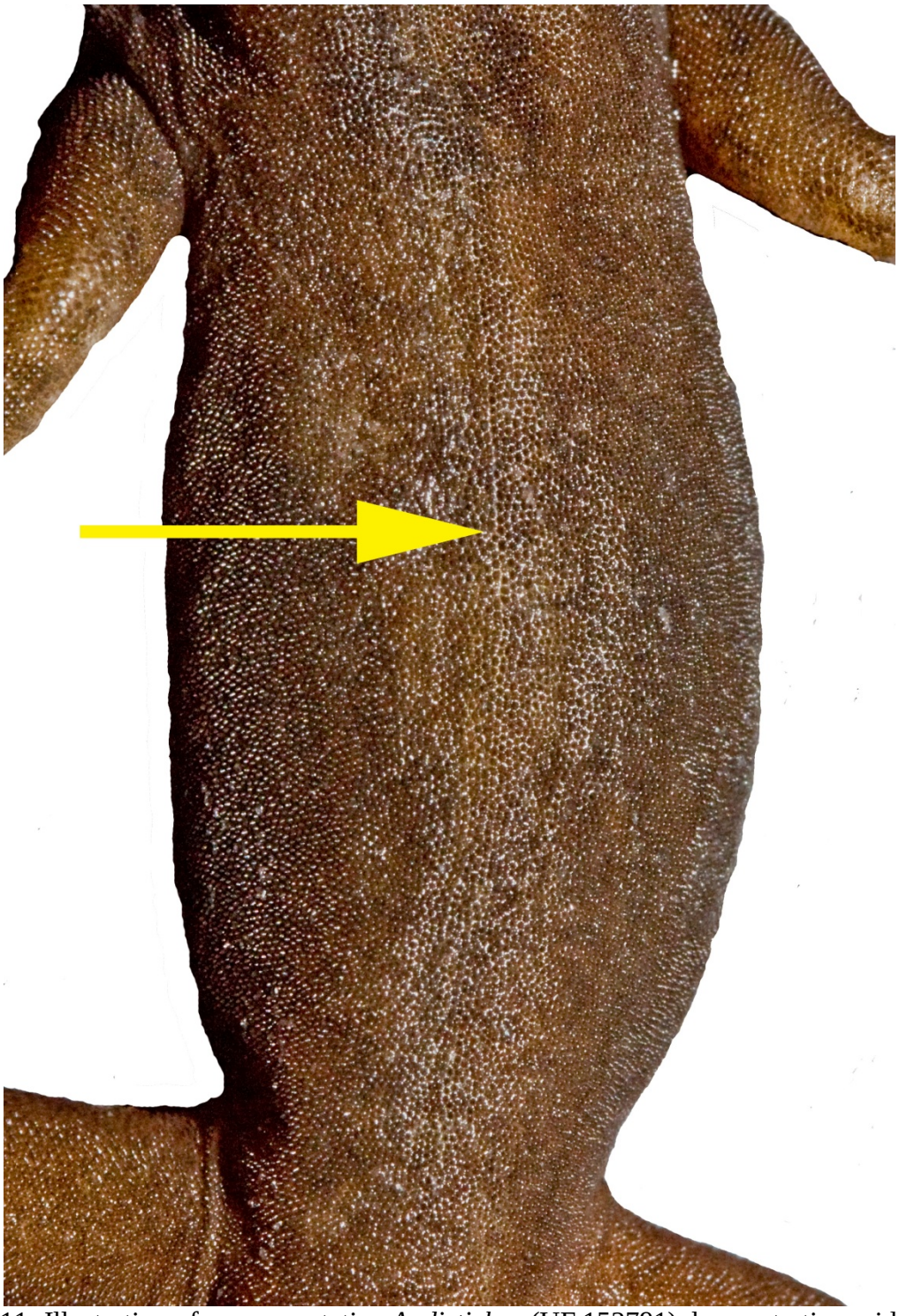

Figure 3-11. Illustration of a representative *A. distichus* (UF 152791) demonstrating mid-dorsal scales that are uniform in size in relation to the surrounding scales. The arrow indicates the position of the mid-dorsal scales.

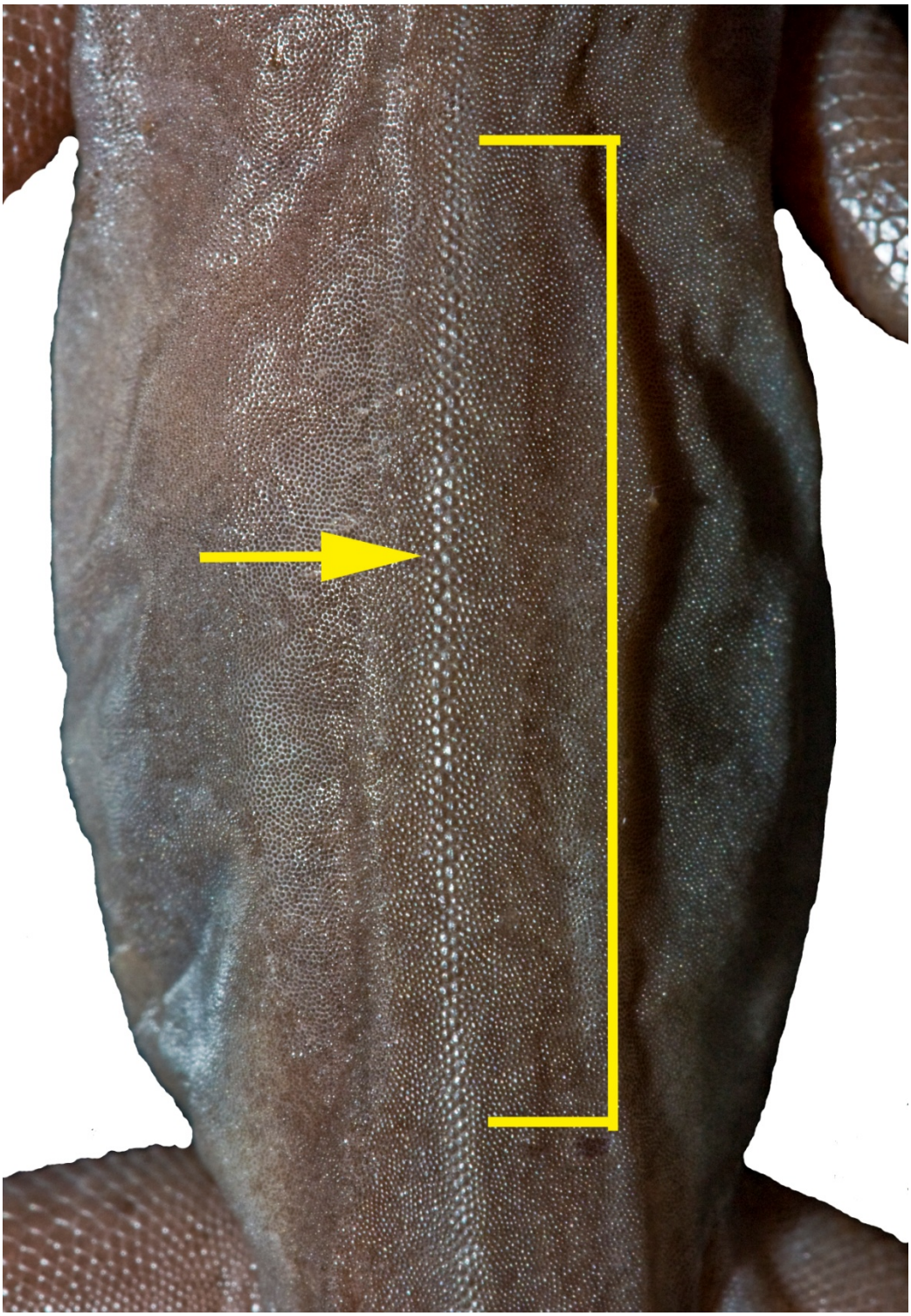

Figure 3-12. Illustration of a representative *A. cybotes* (UF 84766) demonstrating mid-dorsal scales that are expanded in size in relation to the surrounding scales. The arrow indicates the position of the mid-dorsal scales while the bracket denotes the region of the scales.

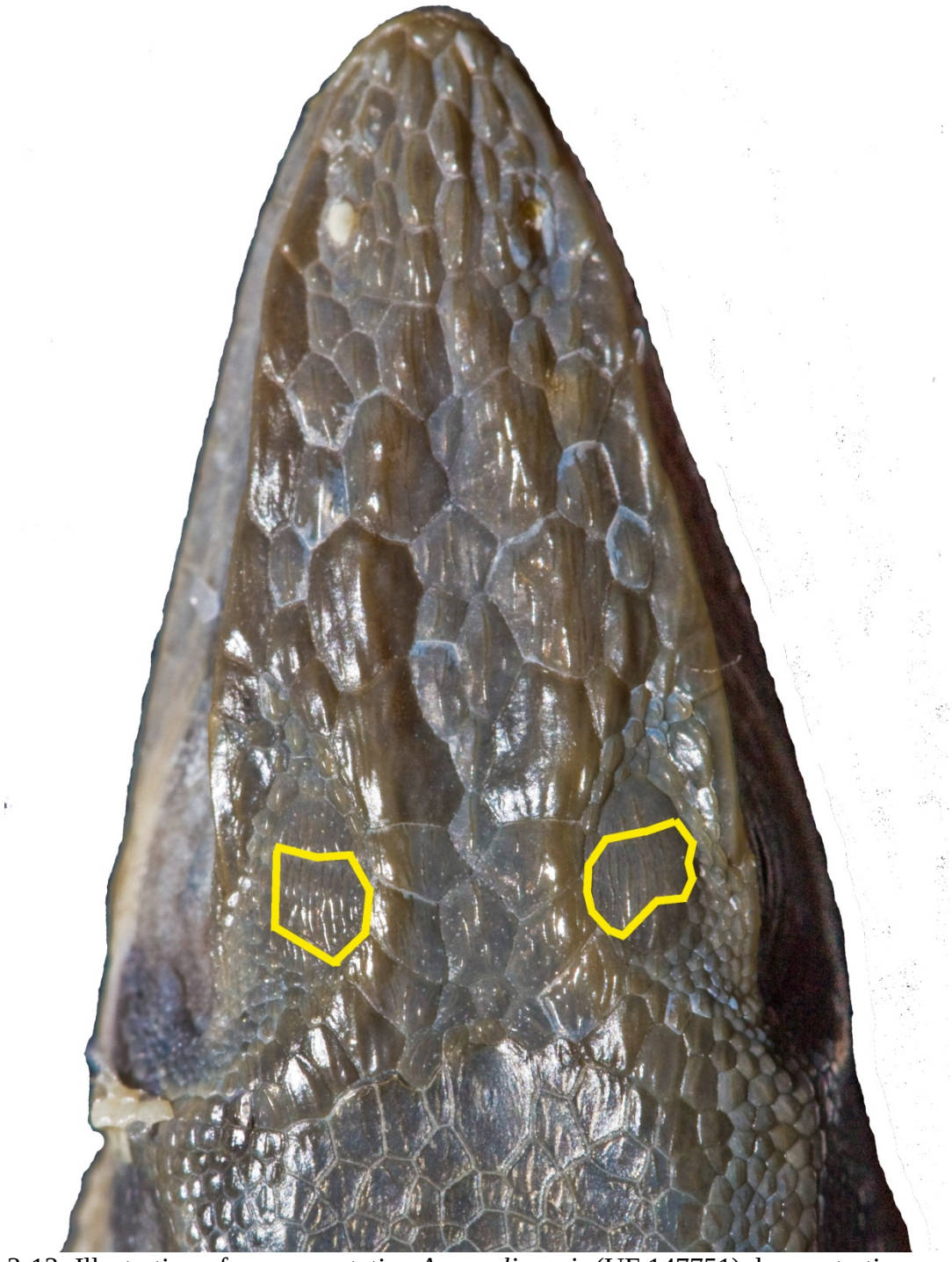

Figure 3-13. Illustration of a representative *A. carolinensis* (UF 147751) demonstrating multicarinate supra-ocular scales (highlighted in yellow). These scales are located over the orbit and have at least 2 or more keels.

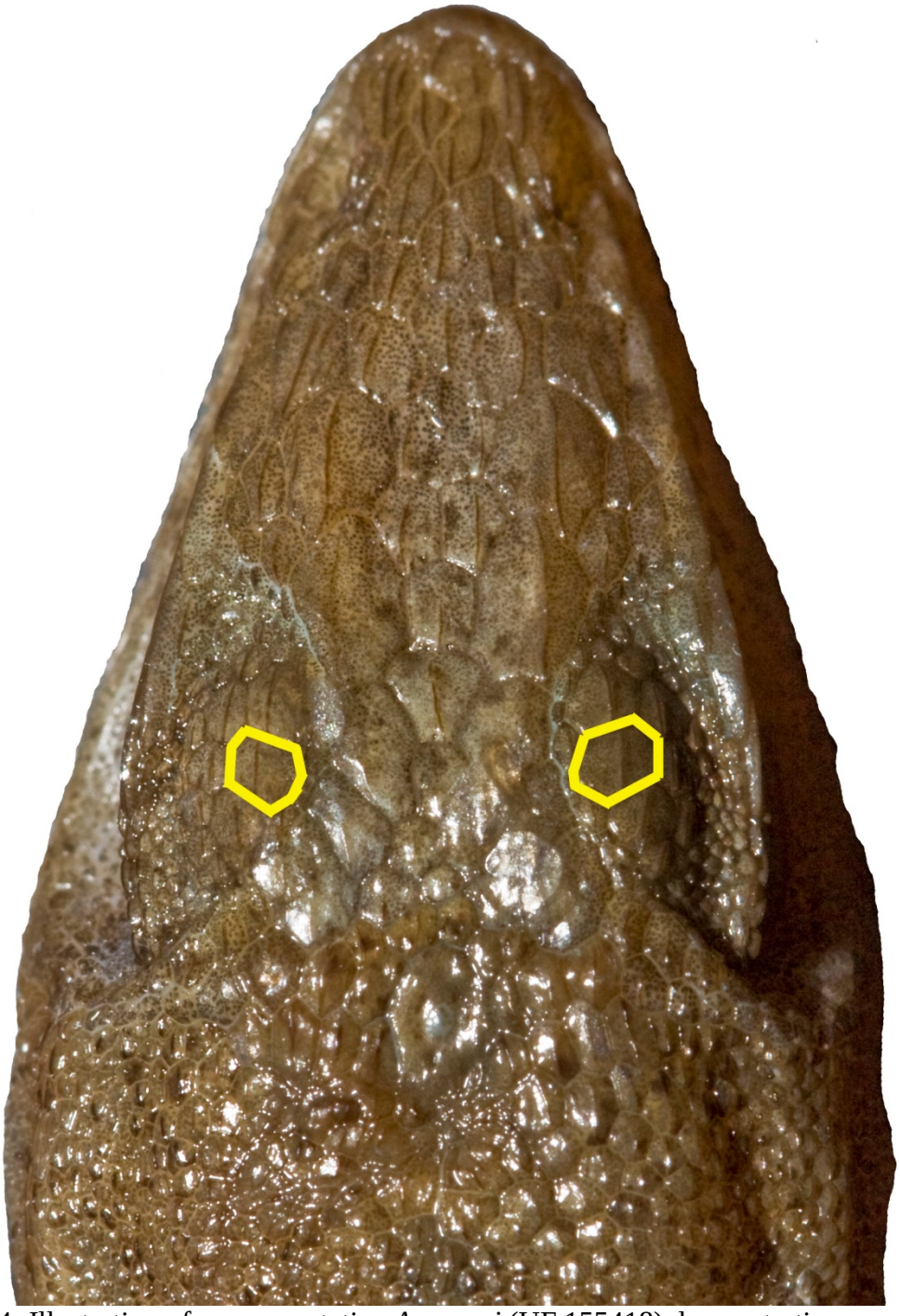

Figure 3-14. Illustration of a representative *A. sagrei* (UF 155418) demonstrating supra-ocular scales with a single keel (highlighted in yellow). These scales are located over the orbit and have no more than 1 keel.

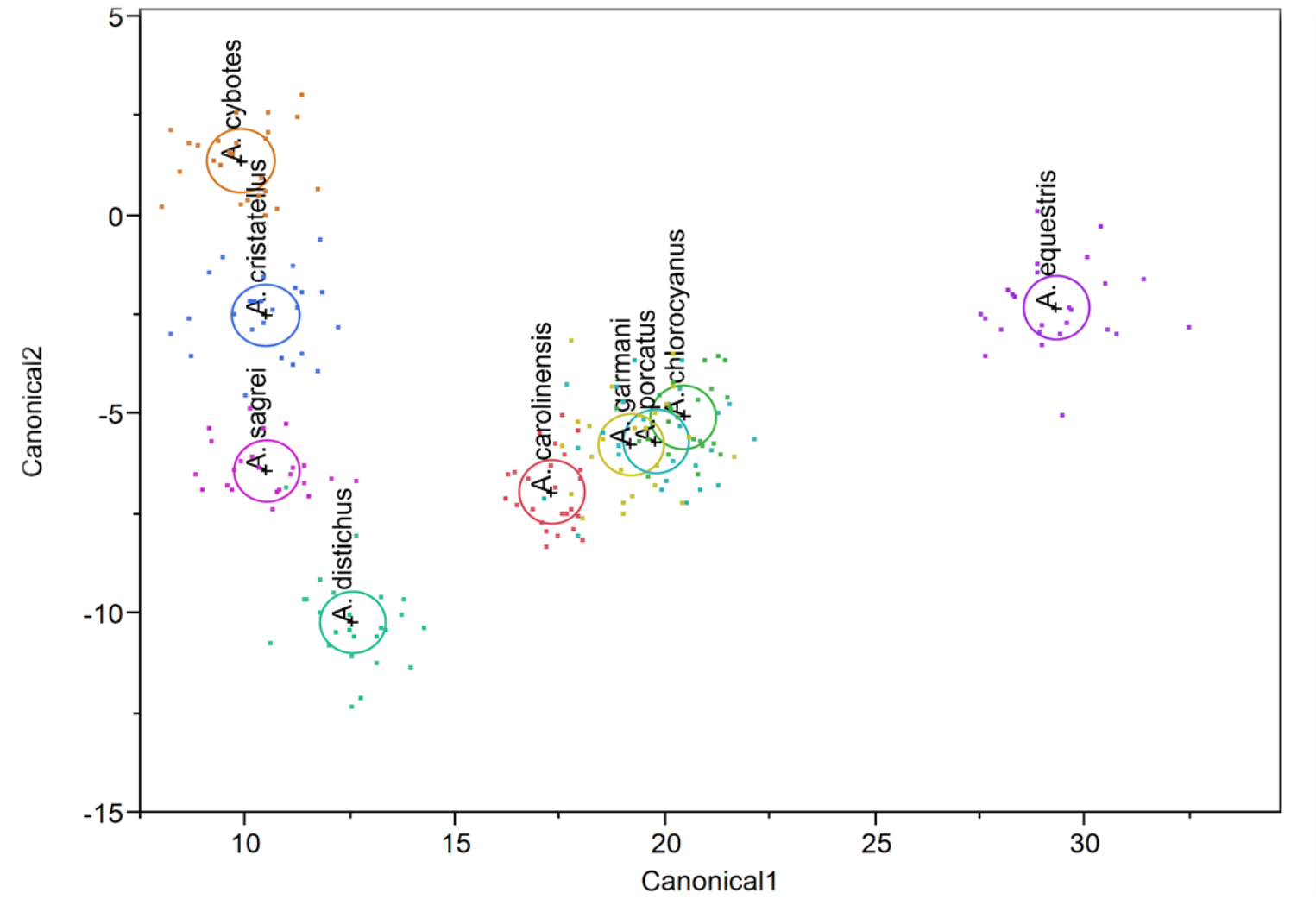

Figure 3-15. Projections of each *Anolis* specimen onto the discriminant axes. Circles represent the mean canonical ellipses for each species group. Colored points represent individuals of a particular species.

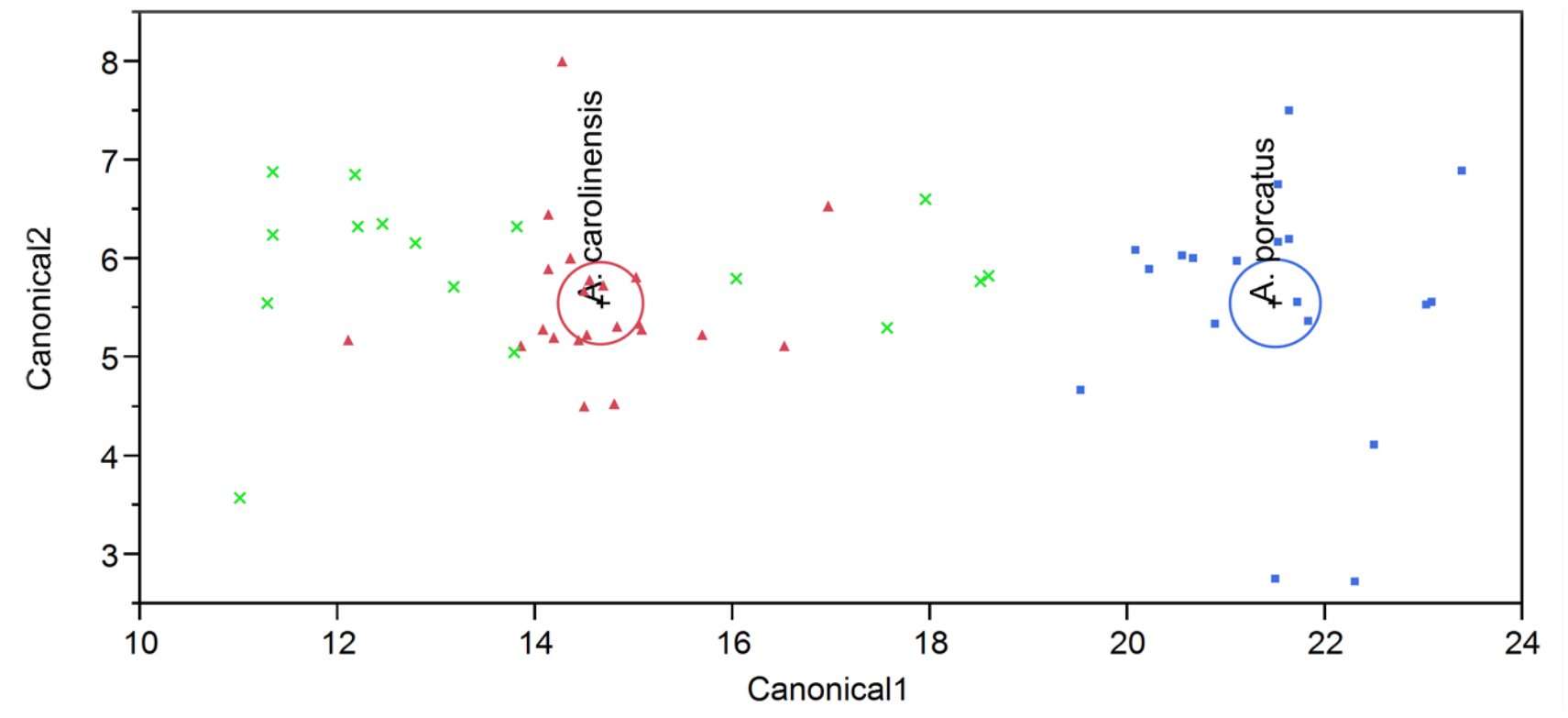

Figure 3-16. Projections of each female specimen onto the discriminant axes. Circles represent the mean canonical ellipses for each species group. Triangles represent *A. carolinensis*, squares represent *A. porcatus*, and X represents the unknown group.

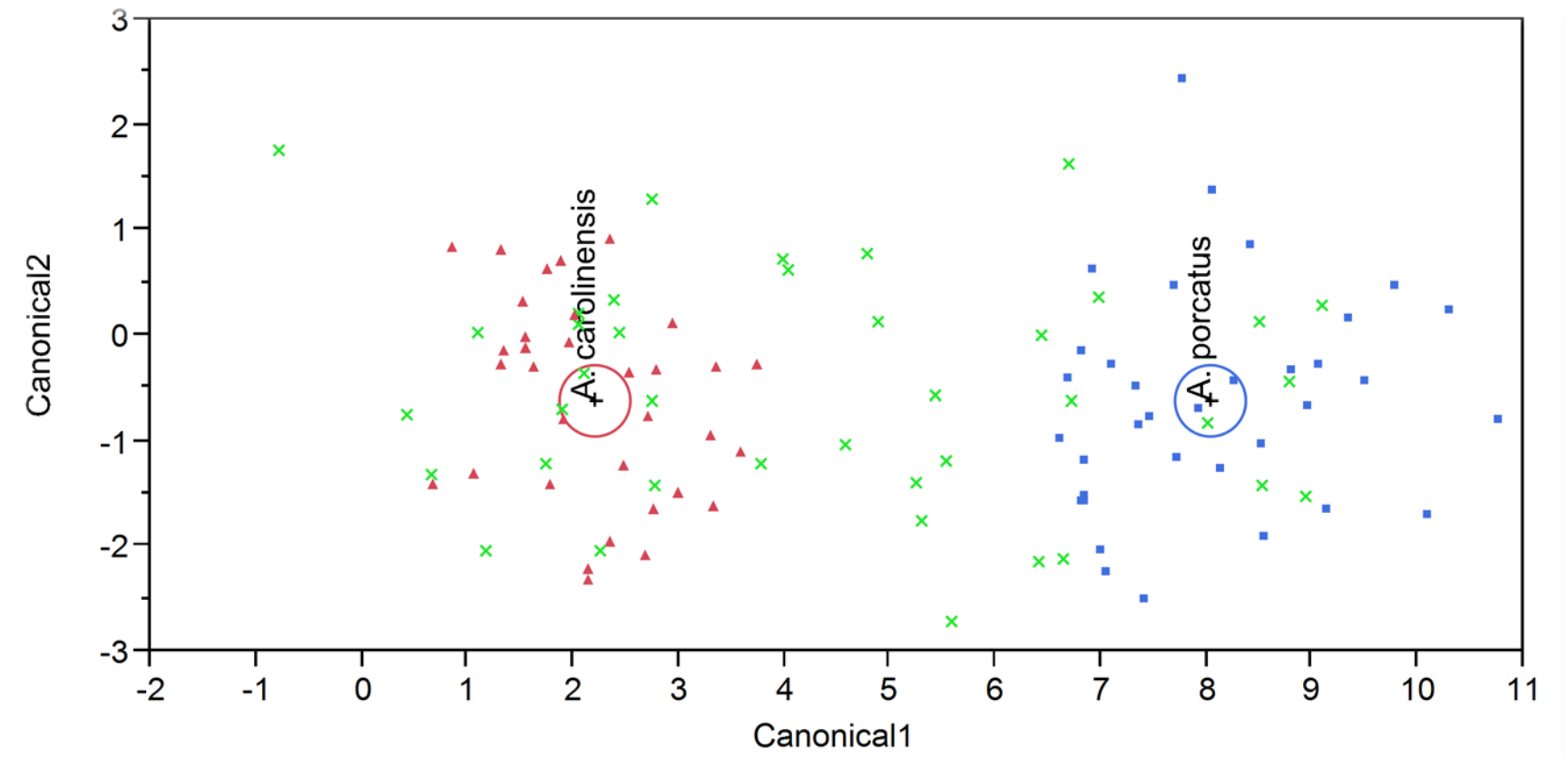

Figure 3-17. Projections of each male specimen onto the discriminant axes. Circles represent the mean canonical ellipses for each species group. Triangles represent *A. carolinensis*, squares represent *A. porcatus*, and X represents the unknown group.

1a Ventral scales keeled……..…….....2
b Ventral scales smooth……..…..……..…….....3

2a Tail laterally compressed; supra-ocular scales with one keel (Figure 3-14)…....*Anolis sagrei*
b Tail round; supra-ocular scales multicarinate (Figure 3-13)...*Anolis carolinensis/A. porcatus*

3a Dorsal scales large, flat, and smooth (Figure 3-10)…..…….……..……..*Anolis equestris*
b Dorsal scales small, round, and keeled (Figure 3-9)……..……..……..……..4

4a 2-3 scales between supra-orbital semicircles (Figure 3-7)…..…….....*Anolis garmani*
b 0-1 scales between supra-orbital semicircles (Figure 3-8)...…….…...…5

5a Expanded sub-digital lamellae on anterior, middle digit number 15-24 (Figure 3-1)..….....6
b Expanded sub-digital lamellae on anterior, middle digit number 14 or fewer (Figure 3-2)....7

6a 0 scales between interparietal scale and supra-orbital semicircles (Figure 3-4)
……..……..*Anolis trinitatis*
b 1 or more scales between interparietal scale and supra-orbital semicircles (Figure 3-3)
……..…..*Anolis chlorocyanus*

7a Mid-dorsal scales uniform in size relative to adjacent dorsal scales (Figure 3-11)
……...…….…..*Anolis distichus*
b Mid-dorsal scales not uniform in size relative to adjacent dorsal scales (Figure 3-12)…...….8

8a Longitudinal ventral scales, counted from posterior insertion of upper limb to anterior insertion of lower limb, number 30-49 (Figure 3-6)…….....…...*Anolis cybotes*
b Longitudinal ventral scales, counted from posterior insertion of upper limb to anterior insertion of lower limb, number 52-70 (Figure 3-5)…...……..……...….*Anolis cristatellus*

Figure 3-18. A key to the anoles of Florida.

CHAPTER 4
DISCUSSION

Many researchers have provided descriptions and character comparisons for anoline lizards throughout their native ranges (Oliver 1948; Collette 1961; Ruibal and Williams 1961; Ruibal 1964; Schwartz and Henderson 1991; Schettino 1999; Meshaka et al. 2004), and occasionally within their introduced ranges (Powell et al. 1998). Powell et al. (1998) provided a key, based largely on body color and pattern, qualitative character descriptions and presumed anoline species ranges in the United States which stops short of providing defining scale characters for a particular species. However, no dichotomous key exists that solely relies on scale characteristics in order to differentiate the anole species established in Florida. Schettino (1999) considers developing a key for iguanids to be difficult due to the change of body patterns and colors at death and through the use of preserving liquids, perhaps leading to keys only useful for identification of "in life" characteristics, although living anoles exhibit color changes as well. My study clearly demonstrated that scale characteristics are useful for species identification of Florida's introduced anoles. Moreover, I provided a statistically valid and defensible key.

While I found statistical support for differentiating *A. carolinensis* from *A. porcatus* using multiple characters, I was unable to find a single character to discern a difference between the two. Several authors purport that *A. carolinensis* and *A. porcatus* can be visually distinguished from each other (Powell et al. 1998; Meshaka et al. 2004), most notably by relative differences in body form. However, my study failed to identify a single difference using absolute scale counts or characteristics, although I was able to show evidence for identification using multiple scale characters One caveat, however, is that like all dichotomous keys, certain variations or irregularities among individuals may occur that even the best key cannot resolve. As a result, no key can correctly identify every single specimen.

Informative Meristic Characters

Character 1 (Figures 3-1 and 3-2), the number of expanded sub-digital lamellae on the third anterior digit, was the most significant character analyzed, based on its importance in the DFA, correctly classifying over 66% of individuals, and its ability to differentiate *Anolis chlorocyanus* and *A. trinitatis* from *A. cristatellus*, *A. cybotes* and *A. distichus*. Although not necessary for this key, it was also able to discern differences between *A. sagrei* and *A. carolinensis* (and *A. porcatus*), as well *A. equestris* from all other *Anolis* species considered. This characteristic is likely important due to difference in number of sub-digital lamellae and relative arborality, as well as the relation to organism size, between different ecomorphological classes (Collette 1961). Williams (1983) defined six different ecomorphological classes for anoles, of which, four different classes are represented in Florida. These include crown-giant (*A. garmani* and *A. equestris*), trunk (*A. distichus*), trunk-crown (*A. carolinensis, A. chlorocyanus, A. porcatus, A. trinitatis*) and trunk-ground (*A. cristatellus*, *A. cybotes*, *A. sagrei*). This classification is supported by my results (Table 3-2), though I only counted expanded lamellae as opposed to the total number of lamellae. For example, *A. garmani* ($\bar{x}$ = 19.24) had a mean number less than *A. chlorocyanus* and *A. porcatus* ($\bar{x}$ = 20.88, $\bar{x}$ = 20.32, respectively), though *A. garmani* is classified as a crown-giant. A count of total lamellae would demonstrate *A. garmani* has a greater number of total lamellae; more consistent with crown-giants. Other researchers have found that there is a positive correlation between the size of the toepads and the size of the organism (Irschick et al. 1997; Elstrott and Irschick 2004). Additionally, Beuttell and Losos (1999) state that even though *A. trinitatis* does not occur on an island with a full suite of ecomorphs, it most closely resembles a trunk-crown anole, which is supported by my results.

The remaining informative continuous characters were all significant in describing differences between species. Character 10, the number of longitudinal ventral scales, was the second most informative character in the DFA, classifying over 85% of specimens correctly upon addition to the model. This character was significantly different among several species; however it was only important in discerning *A. cristatellus* from *A. cybotes* (Figures 3-5 and 3-6) due to overlapping counts in other species. Generally speaking, with the exception of *A. distichus*, scale counts are higher for those taxa living higher in the canopy. However, since scale size (area) can vary from species to species, the number of longitudinal ventral scales is not necessarily a function of a lizard's size, though this trend is somewhat suggested by my data. Characters 6 and 12 had relatively small impacts on the DFA, explaining less than 2% of the overall model (Table 3-3). However, Character 6 (Figures 3-3 and 3-4) was especially important at discerning *A. trinitatis* from *A. chlorocyanus*, with the interparietal scale always in contact with the supra-orbital semicircles in *A. trinitatis*, which is in agreement with the original description of this species (Schwartz and Henderson 1991). *A. chlorocyanus* always had at least one scale between the two features. Character 12, the number of scales separating the supra-orbital semicircles, defines the difference between *A. garmani* and *A. chlorocyanus*, *A. cristatellus*, *A. cybotes*, *A. distichus*, and *A. trinitatis*; with *A. garmani* always having two or more (Figures 3-7 and 3-8). All remaining species have zero to one scale separating the supra-orbital semicircles.

There are five qualitative characters which were useful to the key but were not able to be statistically tested in a parametric fashion. Among these, Character 17 was the most important, as it is the first couplet in the key, differentiating species with keeled or flat ventral scales. *A. carolinensis*, *A. porcatus* and *A. sagrei* always had keeled ventral scales, whereas the remaining

species always had unkeeled ventral scales. Although the exact function of keeled ventral scales is unknown, several authors (Glor et al. 2005; Nicholson et al. 2005) have suggested this is an evolutionary trait to assist with dispersal and colonization of the mainland from islands; perhaps allowing species exhibiting this trait a better ability to swim. Other studies (Horton 1972; Malhotra and Thorpe 1991) have suggested that scale size may play an important role in such dispersal, potentially reducing desiccation and water loss, as a keel adds more surface area to a scale, resulting in less water loss. Characters 20 and 22 were useful for discerning *A. sagrei* from *A. carolinensis* and *A. porcatus*. *A. sagrei* has a tail base that is laterally compressed and only a single keel over the supra-ocular scales (Figure 3-14), whereas the other two species have round tail bases and multiple keels over the supra-ocular scales (Figure 3-13). Character 13 discriminates between *A. equestris* and all remaining species, as it is the only taxa to have smooth, flat dorsal scales with no keel (Figure 3-10). Finally, Character 14 separates *A. distichus* from *A. cristatellus* and *A. cybotes*, as it has mid-dorsal scales uniform to the surrounding scales (Figure 3-11). The others all show some degree of expansion of these scales in relation to the surrounding scales (Figure 3-12).

Morphometric Characters

Data collected for morphometric characteristics were not used in the differentiation of taxa due to the log-transformed and size-corrected nature of the data. These data serve only as a descriptive feature of each species in regards to all species established in Florida, though all log-transformed measurements are back-transformed in Table 3-4. The MANCOVA conducted on this set of data showed that each character was significantly different from one another, and univariate ANCOVAs that were subsequently conducted showed significant differences among species for each of the characters examined.

Axilla-groin distance, the distance from the posterior insertion of the forelimb to the anterior insertion of the hind limb, had the fewest significant differences between taxa. *Anolis equestris*, the largest of Florida's anoles, had the largest relative distance, and *A. cristatellus* had the shortest relative distance. This represents the largest mean size-corrected difference between taxa, which illustrates the lack of significant differences between all other species. The lack of distinction between the remaining species suggests that this feature is not useful in determining differences between most species, nor is it an indicator of relative arborality of a species, as all species generally conform to the same body shape.

The results from measurements of head length and head width appeared to be unrelated by species (i.e., the species with the longest head did not necessarily have the widest), though relative head length and width may have an impact on invasibility, as species with larger heads are able to consumer a wider range of prey (Schoener and Gorman 1968). *Anolis porcatus* had the longest relative head length, but relative head width in this species was significantly narrower than *A. cybotes*, which possessed the widest head. The smallest of Florida's anoles, *A. distichus* has the shortest relative head length, but again, has a significantly wider head than *A. chlorocyanus*, which possesses the narrowest relative head. However, these two characters were much more significant than axilla-groin distance, with larger size-corrected mean differences between the largest and smallest species for head length and head width.

Ear-eye distance, another indicator of relative head size, partially supports the data for relative head length and width. *A. cybotes* possesses the longest ear-eye distance in addition to having the widest relative head. *A. distichus*, with the shortest relative head size, also had the shortest ear-eye distance; head width being more closely aligned to ear-eye distance than head length. Another measure of head size, snout length, measured from the opening of the ear to the

tip of the naris, generally supports the finding of overall head length, though some differences occur, as with ear-eye distance, likely as a result of differences in head morphology. *A. porcatus* has the longest relative head as well as the longest relative snout of Florida's anoles, whereas *A. distichus* possesses the shortest head length and also has the shortest relative snout length. Although *A. porcatus* has a significantly longer head and snout than *A. carolinensis*, this information is not enough to definitively discern one species from the other.

Internarial distance measures the distance between the nares at the tip of the snout. *A. equestris*, although not having the longest or widest head relative to its size, had a significantly large distance between nares. The taxa with the widest head, *A. cybotes*, had the second largest internarial distance. *A. chlorocyanus*, with the narrowest relative head, also had the shortest internarial distance, likely indicating the positive relationship between head width and internarial distance. Naris-rostrum distance measures the distance from the opening of the nares to the tip of the rostral scale. *A. porcatus*, the taxa with the longest head, also had the longest relative naris-rostrum distance, while the taxa with the shortest head, *A. distichus*, had the shortest naris-rostrum distance, giving further support to positive association with head length.

Tibia length measures the length of the tibia, from the insertion at the knee joint to the insertion at the ankle joint. *A. cristatellus*, a trunk-ground species, had the longest relative tibia, whereas *A. equestris*, a crown-giant, had the shortest, indicating a decrease in relative tibia length as taxa align vertically from the ground to the canopy. These data are supported by size corrected tibias measured by Beuttell and Losos (1999) as a factor contributing to ecomorph type. Although size corrected morphometric data could not be used in differentiation between each particular species in Florida, it is important to note that several characters examined above

provide insight into the differences in outward morphological appearance between taxa, as well as potential indicators of ecomorph class.

Anolis carolinensis and *A. porcatus*

Although the dichotomous key resulting from my study should consistently and correctly identify the majority of *Anolis* species established in Florida, it does not differentiate *Anolis carolinensis* from *A. porcatus*, since no single verifiable character exists to separate the two, thus forcing researchers to employ multiple characters in a study such as this in order to distinguish them in the field. Since the original documentation of *A. porcatus* in Florida (Barbour 1904), subsequent researchers (Allen and Slatten 1945; Meshaka et al 2004) have reported the species from Miami-Dade and Monroe counties. Characters previously described as informative to differentiate these two similar species include arbitrary qualitative characters, such as larger and more rugose frontal and canthal ridges, and a larger overall head. Since Collette's (1961) study, it has been assumed that there are consistent differences between *A. carolinensis* and *A. porcatus* in the number of sub-digital lamellae, which has been further perpetuated in the literature (Meshaka et al. 2004), though no study has verified this assumption. More recently, however, Glor et al. (2005) illustrated that these two species maintain distinct genetic lineages in their native ranges, and Kolbe et al. (2007) demonstrated that the *A. porcatus* genome is present in Florida, further highlighting the need to diagnose these two species using morphology.

Because the overall analysis among all species was unsuccessful at diagnosing a non-overlapping character to differentiate between *A. carolinensis*, from outside of the presumed range overlap, with *A. porcatus* that were collected in Cuba, this warranted a need for further testing of additional characters focusing on digit morphology, specifically sub-digital lamellae. Several characters from the first analysis were statistically different from one another (e.g.

characters 1 and 10), however, counts always overlapped with one another, even when examining sexes separately, precluding the utility of those characters in a dichotomous key. All but two morphometric characters were different from one another, excluding internarial distance and tibia length, lending evidence to claims that these species could be diagnosed by head morphology. However, this fails to account for species occurring in the assumed range overlap or hybrid individuals.

Results from the binomial logistic regression analysis to examine differences between *A. carolinensis* and *A. porcatus* yielded hopeful, yet unverifiable results. Characters chosen to build regression models represented the largest mean differences between each taxa and were also statistically significant. Only one character chosen for the models, longitudinal ventral scalation, was not associated with digit morphology. When individuals of each species from outside of the known range overlap were tested using 13 different character combinations, no model accurately identified every specimen. Four models were selected to test unknown specimens from within the purported range overlap, arbitrarily labeled in the FLMNH-UF collection. These models represented the best predictors of a species true origin, only misclassifying between three and five individuals out of the 110 individuals examined by sex (Tables 3-11, 3-12 and 3-13). Coefficients obtained through the logistic regression model were then used as potential predictors for unknown specimens (Tables 3-14 and 3-15).

Each of the four models responded to unknown specimens by giving a response between zero (*Anolis porcatus*) and one (*Anolis carolinensis*). Even though a response was considered valid if it was within 0.05 of a whole number response, there were multiple instances where models provided intermediate responses, illustrating the uncertainty of predicting the proper species. Although no models were able to correctly predict both species one way or the other,

model 3 had the most similarities to other models, suggesting that it may contain the best set of predicting characters; number of expanded sub-digital lamellae on the 3rd anterior digit, total number of lamellae on the 4th anterior digit, and the total number of lamellae on the 3rd posterior digit. In all cases, *A. porcatus* had more lamellae per digit than *A. carolinensis*, though dimorphism between sexes necessitates taxa to be analyzed by sex, as gender affects lamellae counts (Collette 1961; Chun 2001). However, this model, although appearing to be the best at discerning these species from one another, cannot be considered valid until tested with individuals from within the range overlap with known genetic identities.

Further analysis of the continuous characters found to be statistically significant between *A. carolinensis* and *A. porcatus* were conducted with DFA testing of known specimens and projecting unknown species onto the pre-determined discriminant axes by sex. Females were tested first, and resulted in Character 34 (the total number of lamellae present on the 3rd anterior digit) as being the major determining factor in discerning between species, which was not included as a character in model 3 (considered to be the best predictive model). Furthermore, this character was only considered for use in one of the four models. However, with subsequent additions of characters into the DFA, 100% of known specimens were identified correctly, which was not accomplished by the regression analysis. Although all known specimens were classified properly, one unknown individual was unable to be definitively assigned to a species, either showing the weaknesses of the DFA or supporting Kolbe et al. (2007) in suggesting hybridization between the species. Therefore, the combination of characters used to produce this DFA (Table 3-17) were supported as predictors between females of these species.

Males were analyzed by DFA as well, and with the input from six significant characters, all known individuals were classified correctly relative to their origin. However, it is important

to note that different characters were more important for determining males than for females. For example, one of the three characters used in model 3, Character 35, was the primary distinguishing feature for males. Both male and female DFA's included Character 10, which was considered in two of the logistic models, but not used in the model arbitrarily determined to be the best predictor of species. However, Characters 1 and 36 were significant in the male DFA, providing support for the third logistic regression model, though character 36 did not explain any additional information. As above, there were five unknown individuals assigned to an origin having probabilities of belonging to the other species. These results lend support that males of both species can be discerned using the characters incorporated in this DFA model (Table 3-18). Though highly promising, these results cannot be truly verified until specimens with known genetic origins can be tested, thereby eliminating speculation of the models examined by my study.

Although I was not able to discern absolute differences between *A. carolinensis* and *A. porcatus*, I found evidence confirming assumptions made by Collette (1961) regarding relative differences in sub-digital lamellae. My study also refutes the claim that these two species can be consistently and accurately distinguished from each other, or otherwise identified as either species, as all tested characters in my study overlapped in scale counts. Canthal and frontal ridge height are often used to diagnose these species (Powell et al. 1998; Meshaka et al. 2004), but I did not measure these characters, largely because the differences in canthal and frontal ridge heights are extremely difficult to accurately measure, and these ridges are often greatly reduced in females of both species. Additionally, I have observed male *A. carolinensis* specimens from well outside the purported overlapping range (northern Florida and Georgia) to have comparable

head characteristics to Cuban stock *A. porcatus*. Only further analysis using both molecular and morphological methods is likely to reconcile this issue with certainty.

Phenotypic Plasticity and Gene Flow

One final consideration for all currently established anoles in Florida, as well as those that may become established in the future, is the potential for phenotypic plasticity and genetic flow. The key that I have presented in my study used features which are presently observed in Florida's *Anolis* species to differentiate them from each other. However, as environmental conditions change for Florida's anoles and potential new anoles seek open niches, characters expressed by presently established anoles could change in response to these environmental pressures. Losos et al. (2001) and Kolbe and Losos (2005) were able to demonstrate that both *A. sagrei* and *A. carolinensis* exhibited hind-limb plasticity when introduced to areas differing in vegetational structure from their native home range. While this is not one of the characters used for differentiating these two species, it is reasonable to assume that similar changes could occur to any species that is potentially driven to a new niche. At the time of my study, however, a literature search yielded no evidence that traits used to differentiate among species are phenotypically plastic, and characters chosen held up to the scrutiny of random verification to ensure accuracy of these features. This supports the notion that the characters represented in the key will hold through changes in environmental pressures.

Gene flow could change the ability of the key to accurately predict a species correctly, through introduction of a new sub-species into a population or introduction of individuals from a different donor region. Kolbe et al. (2007) demonstrated in *A. sagrei* that multiple native donor regions and admixture attributed to the morphological difference in Florida. Additionally, sub-specific variation was once able to be detected in *A. distichus* in Florida, as there were at least

two subspecies present in the state (Wilson and Porras 1983). However, *A. distichus* presently found in Miami-Dade County show characteristics of both *A. d. dominicensis* and *A. d. floridanus* subspecies, rendering it impossible to distinguish the two apart (Miyamoto et al 1986), resulting in a new phenotype found in Florida (Butterfield 1996). Over time, and especially in the presence of new *Anolis* species, changes could occur to the features included within my key, causing them to become invalid.

CHAPTER 5
SPECIES ACCOUNTS

The Green Anole, *Anolis carolinensis* (Voigt 1832), is the only native anole in to the United States, occurring in the Coastal Plain from North Carolina south through Florida to the Marquesas Keys and westward to southeastern Oklahoma and east-central Texas to the lower Rio Grande Valley (Conant and Collins 1998; Chun 2001). In Florida, it is found throughout the state (Figure 5-1). This species is distinguished as having keeled ventral scales; multicarinate supra-ocular scales (Figure 3-13); and a rounded tail base. Other characters include a maximum SVL of 76 mm; dorsum ranging from green to mottled green and brown to brown in metachrosis. Males have a pinkish-red dewlap (Figure 5-2a), as well as smaller, less prominent frontal and canthal scales as compared to the non-native *A. porcatus* (Ruibal and Williams 1961; Conant and Collins 1998). This species is very difficult to diagnose from the introduced *A. porcatus*, though most often having fewer sub-digital lamellae on third and fourth front digits and third rear digit (Collette 1961; Brian J. Camposano, pers. obs.).

The Hispaniolan Green Anole, *Anolis chlorocyanus* Duméril and Bibron 1837, is native to the island of Hispaniola. This species is distinguished as having smooth ventral scales; small, round and keeled dorsal scales (Figure 3-9); 0-1 scales between supra-orbital semicircles (Figure 3-8); 19-24 expanded sub-digital lamellae on the anterior third digit (Figure 3-1); and one or more scales between the interparietal scale and supra-orbital semicircles (Figure 3-3). Other characters include a maximum SVL of 76 mm; long, round-based tail; dorsum bright green to brown in metachrosis. Males exhibit a blue to bluish-white to white dewlap (Figure 5-2b) (Schwartz and Henderson 1991). *Anolis chlorocyanus* Duméril and Bibron 1837, was initially introduced to Florida in 1987 in Parkland, Broward County via the pet trade as a result of

released or escaped pets (Butterfield et al. 1994) and is still present (Brian J. Camposano, pers. obs.). Kolbe et al. (2007) demonstrated that this population originated from a single locality in Hispaniola. Bartlett (1988) claimed that a population of this species was present in Miami, Miami-Dade County, in 1987 but died out following the construction of a train station (*also see*: Meshaka et al. 2004), though no definitive proof of this population exists (Figure 5-3). In October 2008, this species was documented in Palm Beach County at the Palm Beach Zoo, where over 70 voucher specimens were collected from 2008-2010. The origin of this introduction is unknown. The FWC (2011) reports that a population was established in Port Mayaca, Martin County in 1986 on a reptile dealer's property along the eastern shore of Lake Okeechobee, but was later extirpated in 1991 due to cold weather. No voucher exists for this population.

The Puerto Rican Crested Anole, *Anolis cristatellus* Duméril and Bibron 1837, is native to Puerto Rico, Isla Vieques, Isla Culebra, Isla Culebrita and the U.S. and British Virgin Islands (Schwartz and Henderson 1991). This species is distinguished as having smooth ventral scales; small, round and keeled dorsal scales (Figure 3-9); 0-1 scales between the supra-orbital semicircles (Figure 3-8); 14 or fewer expanded sub-digital lamellae on the third anterior digit (Figure 3-2); mid-dorsal scales expanded in relation to adjacent dorsal scales (Figure 3-12); and longitudinal ventral scales from the posterior insertion of the forelimb to the anterior insertion of the rear limb numbering 52-70 (Figure 3-5). They reach a maximum SVL of 75 mm. Males have a laterally compressed tail base with a high fin and dorsal crest; dorsum bronzy, greenish gray to dark brown in metachrosis; and males with a large yellow-tan to orange dewlap (Figure 5-2c) (Schwartz and Henderson 1991; Meshaka et al. 2004). *Anolis cristatellus* Duméril and Bibron 1837 was first reported in Florida from Key Biscayne, Miami-Dade County in 1975 as an

intentional introduction (Schwartz and Thomas 1975). Brach (1977) later reported that the population was occupying a four block area in the vicinity of West Enid Drive at the southern end of the island. Wilson and Porras (1983) reported a secondary population from Key Biscayne at the old Crandon Park Zoo, as well as a new locality in the vicinity of SW 97th Street and 57th Avenue (Red Road) and several blocks to the west in 1976. They believed that this population may have resulted from a new introduction, as adult males had brighter, more orange dewlaps, which was supported by Kolbe et al. (2007), showing that this species in Florida is derived from has at least two locations in Puerto Rico. Meshaka et al. (2004) reported two other populations from North Miami, Miami-Dade County, resulting from deliberate introductions, for which taxonomic vouchers exist (Figure 5-4). Seigel et al. (1999) reported a population from Brevard County, which was discovered to be erroneous (Brian J. Camposano and Kenneth L. Krysko, pers. obs.) and is a misidentified *A. sagrei*. From 2005- 2009, specimens were vouchered (FLMNH collection) from additional localities, including The Barnacle Historic State Park and Fairchild Tropical Gardens in Miami-Dade County, and from Hollywood in Broward County.

The Large-Headed Anole, *Anolis cybotes* Cope 1862, is native to Hispaniola, as well as Île-à-Vache, Île de la Tortue, Île à Cabrit, Île de la Gonâve, Isla Saona, Isla Catalinita and Isla Catalina (Schwartz and Henderson 1991). This species is distinguished as having smooth ventral scales; small, round and keeled dorsal scales (Figure 3-9); 0-1 scales between the supra-orbital semicircles (Figure 3-8); fewer than 14 expanded sub-digital lamellae on the third anterior digit (Figure 3-2); mid-dorsal scales expanded in relation to adjacent dorsal scales (Figure 3-12); and longitudinal ventral scales from the posterior insertion of the forelimb to the anterior insertion of the rear limb numbering 30-49 (Figure 3-6). Other characters include maximum SVL of 77 mm; short, laterally compressed tail; variable colored dorsum, from tan to medium brown to reddish

brown or gray. Males have a large cream to creamy yellow dewlap (Figure 5-2d) (Schwartz and Henderson 1991; Meshaka et al. 2004). *Anolis cybotes* Cope 1862 was first introduced and reported by Ober (1973) as an intentional self-introduction at his home in northeastern Miami-Dade County. Ober (1973) reported there was a high probability of spread from the initial site of introduction via trash removal, but Wilson and Porras (1983) were unable to detect any secondary populations, though they noted that the population was still abundant at the initial site of introduction. Subsequent visits to this site in 2008 yielded no lizards (Brian J. Camposano, pers. obs.). Butterfield et al. (1994) reported a second colony from Parkland in Broward County, the site of a former pet dealer. Specimens from both sites show mitochondrial evidence of two origin sites in Hispaniola (Kolbe et al. 2007). The FWC (2011) also reports that this species was established in 1986 in Port Mayaca, Martin County. The FLMNH holds taxonomic vouchers from all three introduction sites, with the Broward and Martin County sites still in persistence, and one voucher from Pompano Beach in Broward County (Figure 5-5).

The Bark Anole, *Anolis distichus* Cope 1861, is native to the Bahama Islands (Schwartz and Henderson 1991). This species is described as having smooth ventral scales; small, round and keeled dorsal scales (Figure 3-9); 0-1 scales between the supra-orbital semicircles (Figure 3-8); fewer than 14 expanded sub-digital lamellae on the third anterior digit (Figure 3-2); and mid-dorsal scales that are uniform in relation to adjacent dorsal scales (Figure 3-11). Other characters include a maximum SVL of 58 mm; a small, laterally compressed tail; variable colored dorsum, ranging from yellowish green to dark brown in metachrosis; a dark occipital ‘U’ or ‘V’ shaped mark. Males have a small pale yellow to pale green dewlap (Figure 5-2e) (Schwartz and Henderson 1991; Meshaka et al. 2004). *Anolis distichus* Cope 1861 was first recorded in Florida as the nominate race (*A. d. floridanus*) by Smith and McCauley (1948) and from Brickell Park in

Miami-Dade County. At least two, possibly three, subspecies have been identified in Florida, though Wilson and Porras (1983) contest that *A. d. floridanus* is a native member of the Florida herpetofauna, having established in Florida on its own. However, Schwartz (1971) argues that this race either differentiated locally or represents a western Andros Island population that had become established in Florida, likely as an intentional release. King and Krakauer (1966) found this race to be abundant around Miami, from the Miami River south to Kendall and from the Atlantic coast to West Miami. They also reported two additional subspecies present in Florida. The first, *A. d. dominicensis,* was reported from the Tamiami Canal near 32nd Avenue and NW 24th Street and was believed to have been introduced accidentally as cargo stowaways (Kraus 2009). The second, *A. d. ignigularis,* was reported to have been released in the vicinity of 84th Street and SW 100th Avenue in Sunset Park, Miami-Dade County prior to 1965. However, Wilson and Porras (1983) reported that this colony has since been extirpated. Although mitochondrial evidence suggested four different origins for this species in Florida (Kolbe et al. 2007), *A. d. dominicensis* and *A. d. floridanus* have been suggested to compromise the others integrity as a race, resulting in one phenotype present in Florida (Butterfield 1996). This species has expanded its range significantly, as the FLMNH holding have taxonomic vouchers from Broward, Collier, Miami-Dade, and Monroe Counties (Figure 5-6), with Bartlett (1994) reporting it from Lee County and Meshaka et al. (2004) reporting it from Palm Beach and Martin Counties.

The Knight Anole, *Anolis equestris* Merrem 1820, is native to Cuba, Archipiélago de Sabana-Camagüey and the cays north of Matanzas. This species is described as having smooth ventral scales and large; flat and smooth dorsal scales (Figure 3-10). Other characters include a maximum SVL of 188 mm; dorsum bright green to black in metachrosis; greenish yellow labials;

yellow postlabial stripe to the ear opening; large pale pink dewlap present in both sexes (Figure 5-2f); tail and body laterally compressed; and a rugose cephalic casque (Schwartz and Henderson 1991, Schettino 1999). *Anolis equestris* Merrem 1820 was first reported from an unspecified locality in "southern Florida" by Neill (1957). However, King and Krakauer (1966) stated that the original introduction occurred intentionally in 1952 at the University of Miami's old North Campus in Coral Gables, Miami-Dade County, by a student in the Department of Biology. The original distribution was centered in a 20-city-block area of Coral Gables, from Canal Way south to Bird and LeJuene roads, and west to Segovia Avenue (King and Krakauer 1966). The spread of this species beyond its original introduction site has been both natural and human-assisted (Lever 2003), with two distinct origin populations from Cuba (Kolbe et al 2007). In 1972, it was reported from Elliott Key (Brown 1972) and the Miami Seaquarium on Virginia Key, Miami-Dade County (Dalrymple 1980). Other reports by Brach (1976) and Wilson and Porras (1983) suggested this species was expanding its range and becoming widespread in Miami-Dade County. Northern range expansion into other counties was first documented in 1974 in Fort Lauderdale, Broward County. This species has spread further to the north and west, and is presently known from 11 counties including Brevard, Broward, Collier, Highlands, Lee, Martin, Miami-Dade, Monroe, Palm Beach, Polk and St. Lucie (Figure 5-7), with unverified reports from Volusia and Orange Counties (Camposano et al. 2008).

The Jamaican Giant Anole, *Anolis garmani* Stejneger 1899, is native to Jamaica. This species is described as having smooth ventral scales; small, round and keeled dorsal scales (Figure 3-9); and 2-3 scales between the supra-orbital semicircles (Figure 3-7). Other characters include a maximum SVL of 131 mm; males with a distinct dorsal crest; verticillate tail; dorsum bright emerald green to black in metachrosis; oblique straw-colored bars visible in dark phase.

Males have a pale orange dewlap with a yellowish green border (Figure 5-2g) (Schwartz and Henderson 1991). *Anolis garmani* Stejneger 1899 was first reported in Florida by Roberts (1977) in a popularized pamphlet describing their presence the state, though Wilson and Porras (1983) were first made aware of this population in 1975. This population was restricted to the vicinity of SW 63rd Court and 69th Street in South Miami, where local residents had reported knowing about the population "for some time" (Wilson and Porras 1983). The origin of the introduction is unknown, as it had clearly been present for some time upon collection of an adult and four juveniles in 1976 (Wilson and Porras 1983), though Kolbe et al. (2007) demonstrated that it has two source populations from Jamaica. Bartlett and Bartlett (1999) purport to have found a second population in 1988 in Fort Myers, Lee County, along the coast of the Gulf of Mexico, though no known voucher exists for this population. The FWC (2011) additionally reports a population from Port Mayaca, Martin County, introduced in 1986 on a reptile dealer's property, but has since died out, as well as a population from Lake Worth, Palm Beach County in 2003 which had been established by a reptile collector. No known vouchers exist for these specimens, as the FLMNH only has records from the Miami-Dade population (Figure 5-8), which is still present (Brian J. Camposano, pers. obs.).

The Cuban Green Anole, *Anolis porcatus* Gray 1840, is native to Cuba, Isla de la Juventud, Archipiélago de los Canarreos, Cayos de San Felipe, Archipiélago de Sabana-Camagüey and Archipiélago do los Colorados. This species is described as having keeled ventral scales; multicarinate supra-ocular scales (Figure 3-13); and a rounded tail base. Other characters include a maximum SVL of 73 mm; dorsum ranging from green to mottled green and brown to brown in metachrosis. Males have a pinkish-red dewlap (identical to *A. carolinensis*; Figure 5-2a); as well as larger, more prominent frontal and canthal scale ridges as compared to

the native *A. carolinensis* (Ruibal and Williams 1961; Schwartz and Henderson 1991). This species is indistinguishable from the native *A. carolinensis*, though it generally has more sub-digital lamellae on the third and fourth front digits and the third rear digit (Collette 1961; Brian J. Camposano, pers. obs.). *Anolis porcatus* Gray 1840 was first reported from the Florida Keys, Monroe County in 1904 (Barbour 1904) and later from Key West, Monroe County in 1937 (Allen and Slatten 1945). Vance believed that *A. porcatus* from Key West was likely erroneous, but Meshaka et al. (1997) reported this species in Florida from northern Miami, Miami-Dade County in 1991 and from sites in South Miami adjacent to that of *A. garmani* since 1987. Bartlett and Bartlett (1999) stated that *A. porcatus* is firmly established in a small number of colonies in Miami, which were increasing in numbers. This species is documented from Lee, Miami-Dade and Monroe counties (Figure 5-9), though individual accounts are likely erroneous due to the inability to distinguish this species from the native *A. carolinensis*. However, this species has been confirmed to be an established member of the Florida herpetofauna through mitochondrial DNA analysis, having three population origins in western Cuba and sharing mitochondrial DNA with the native *A. carolinensis*, further supporting claims that these species are hybridizing (Kolbe et al. 2007).

The Brown Anole, *Anolis sagrei* Duméril and Bibron 1837, is native to the Bahama Islands, including Crooked-Acklins Bank, Rum Cay, and San Salvador Island, Cuba, Isla de la Juventud, Jamaica, Cayman Islands, Swan Island, Atlantic coast of Mexico to Belize and Islas de la Bahía. This species is described as having keeled ventral scales; a single keel over the supra-ocular scales (Figure 3-14); and a laterally compressed tail base. Other characters include a maximum SVL of 70 mm; dorsum variable from ground tan to very dark brown to black in metachrosis; males with an orange-red dewlap (Figure 5-2h); and a nuchal, dorsal and caudal

crest (Schwartz and Henderson 1991; Schettino 1999). *Anolis sagrei* Duméril and Bibron 1837 was first documented from the Florida Keys, Monroe County, by Garman (1887), the first non-native reptile documented in Florida, likely arriving as a cargo stowaway. Subsequently, Goin (1947) reported it from Hillsborough County, Oliver (1950) reported it from Palm Beach and Pinellas counties, Bell (1953) noted its presence in Miami-Dade County, King (1960) reported it from Broward County and Ruibal (1964) documented the species in Lee County. Spread of this species throughout Florida has been prolific. It is thought to have been aided by multiple introductions in different localities in Florida, all associated with seaports (King 1960), minimizing the founder effect and allowing for rapid colonization, and predominantly facilitated by human actions (Lee 1985; Lee 1987; Godley et al. 1981; Campbell 1996). In 2003, Campbell documented this species occurring in every county in peninsular Florida. This species has been documented in 53 of Florida's 67 counties (Figure 5-10), though it is likely present in a greater number of counties.

The Saint Vincent's Bush Anole, *Anolis trinitatis* Reinhardt and Lütken 1862, is native to St. Vincent and many coastal cays, as well as Chateaubelair Island. This species is described as having smooth ventral scales; small, round and keeled dorsal scales (Figure 3-9); 0-1 scales between the supra-orbital semicircles (Figure 3-8); expanded sub-digital lamellae on the third anterior digit numbering 15-19 (Figure 3-1); and 0 scales between the interparietal scale and the supra-orbital semicircles (Figure 3-4). Other characters include a maximum SVL of 74 mm; males with bright green or blue-green shading to blue or blue-gray dorsum; a butter-yellow dewlap with pale bluish scales or greenish wash; females with a duller dorsum and a small, non-distinct dewlap (Schwartz and Henderson 1991). *Anolis trinitatis* Reinhardt and Lütken 1862 was first found in Florida in 2005 at the Fontainebleu Hotel in Miami Beach, Miami-Dade

County (Figure 5-11). This population originated from a hobbyist release of multiple individuals onsite at the hotel in several large banyan trees (Joseph P. Burgess, pers. comm.). In subsequent years, gravid females and juvenile lizards were observed on site, indicating that the population was established. However, the population began to decline over the next several years from the time of introduction, and might have been severely impacted by the removal of the banyan trees and development of a paved pool area (Joseph P. Burgess, pers. comm.). On a trip to this site in 2010, an extensive post-construction search yielded no *A. trinitatis*, though other *Anolis* species were present on site (Brian J. Camposano, pers. obs.), suggesting that this population might have been extirpated. It is possible, however, that this species was relocated to nearby vegetation in response to construction or was transferred to different sites in Miami-Dade County with the removal of the large banyan trees.

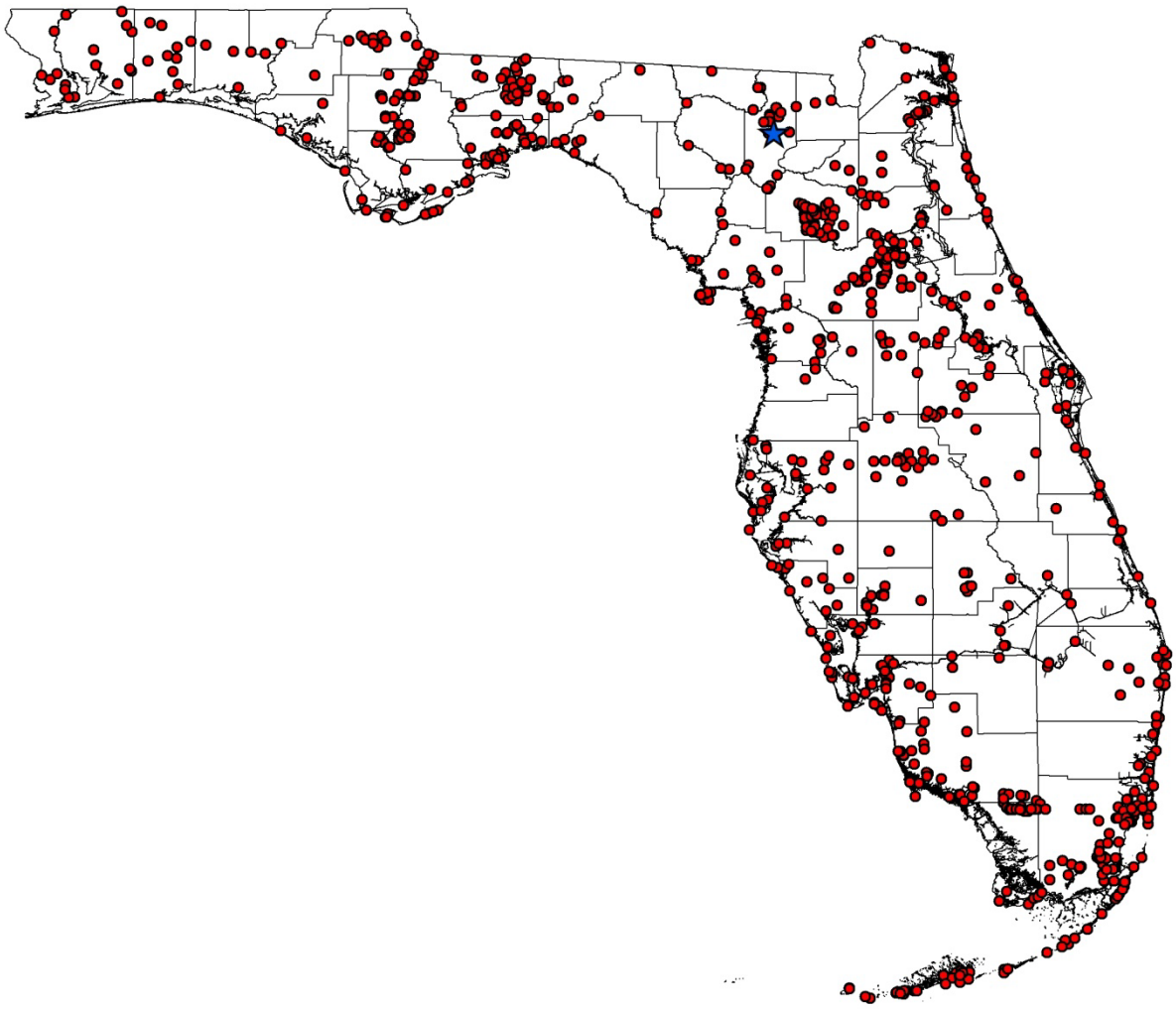

Figure 5-1. Geographic distribution of Green Anoles (*Anolis carolinensis*). See Appendix B for voucher specimens from systematic collections used to create map. Note that the star represents the earliest known specimen from systematic collections examined (YPM 01309) collected in 1868.

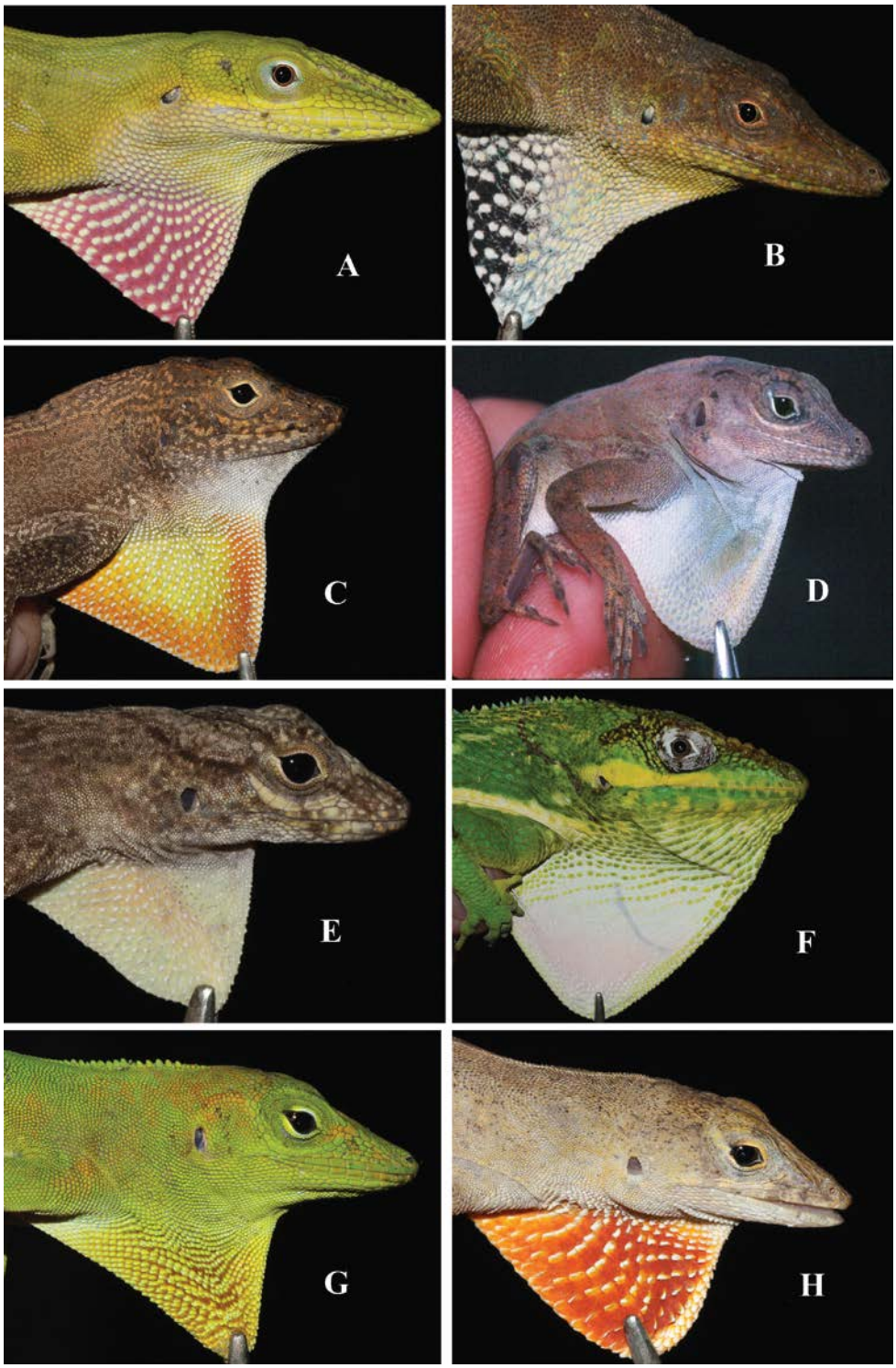

Figure 5-2. Illustration of dewlaps for A) *A. carolinensis*, B) *A. chlorocyanus*, C) *A. cristatellus*, D) *A. cybotes*, E) *A. distichus*, F) *A. equestris*, G) *A. garmani* and H) *A. sagrei*. Not pictured are *A. porcatus* and *A. trinitatis*, due to a lack of a living specimen.

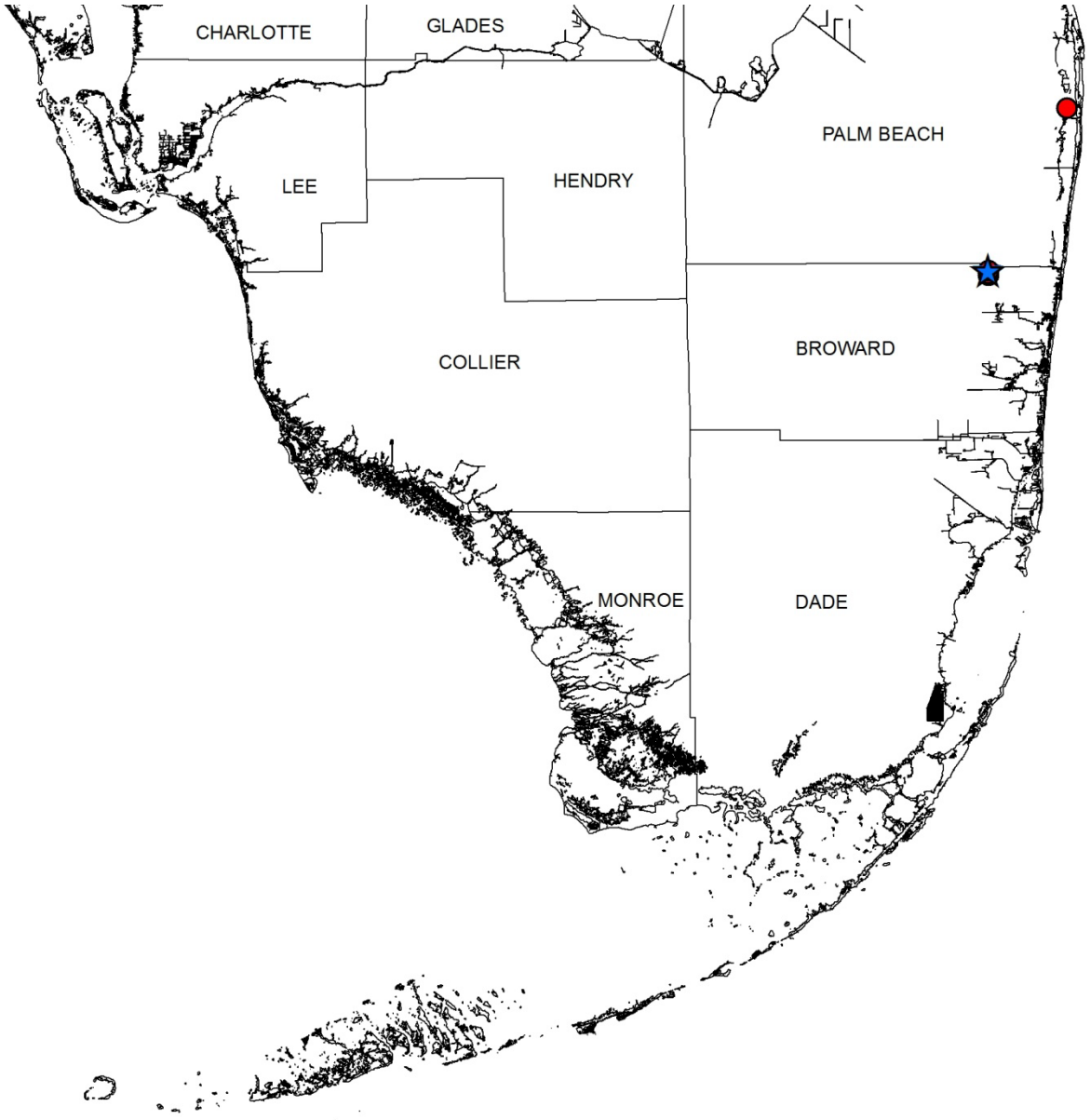

Figure 5-3. Geographic distribution of Hispaniolan Green Anoles (*Anolis chlorocyanus*). See Appendix B for voucher specimens from systematic collections used to create map. Note that the star represents the earliest known specimen from systematic collections examined (KU 210033) collected March 1988.

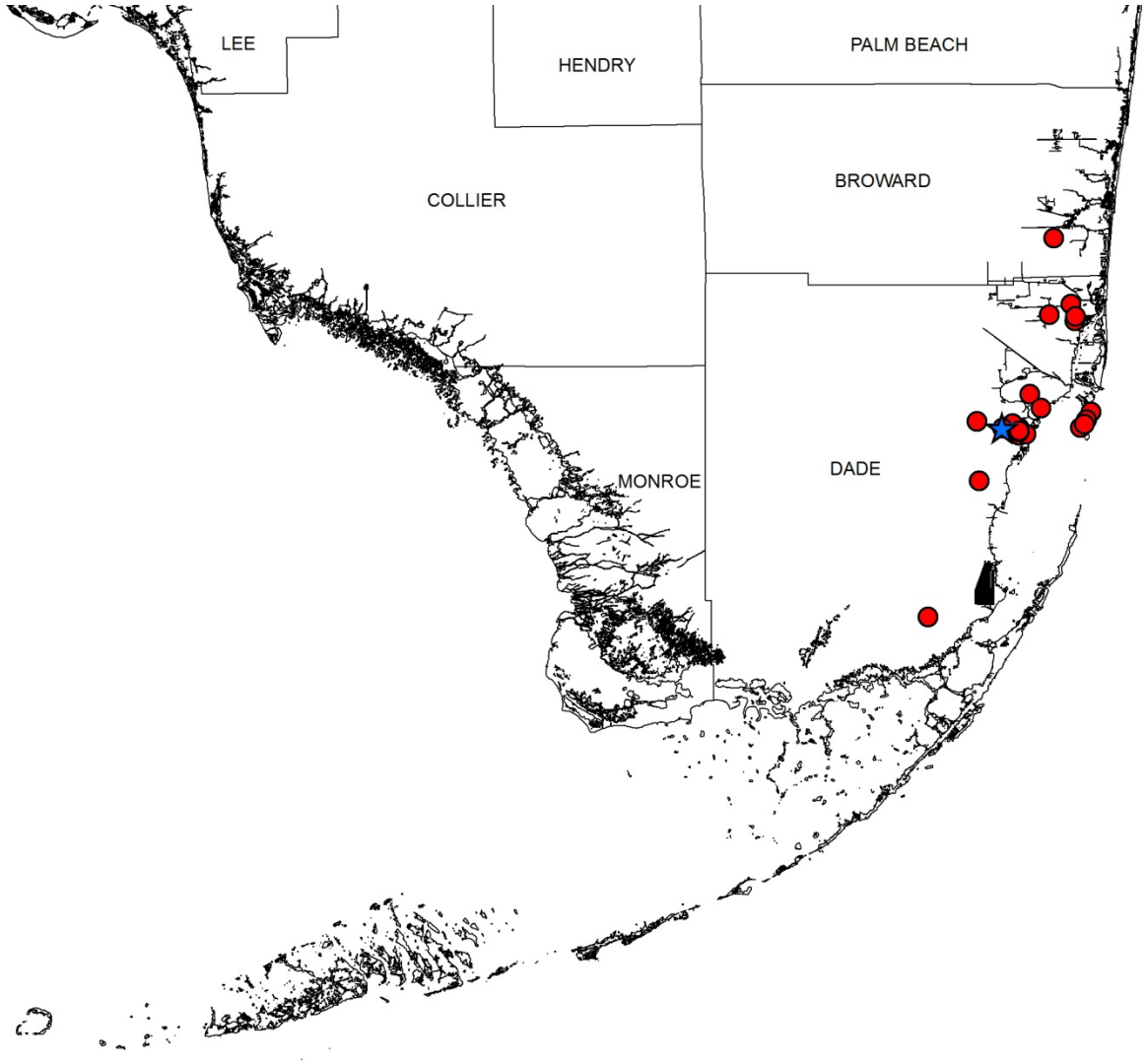

Figure 5-4. Geographic distribution of Puerto Rican Crested Anoles (*Anolis cristatellus*). See Appendix B for voucher specimens from systematic collections used to create map. Note that the star represents the earliest known specimen from systematic collections examined (MCZ 146223) collected on 23 April 1975.

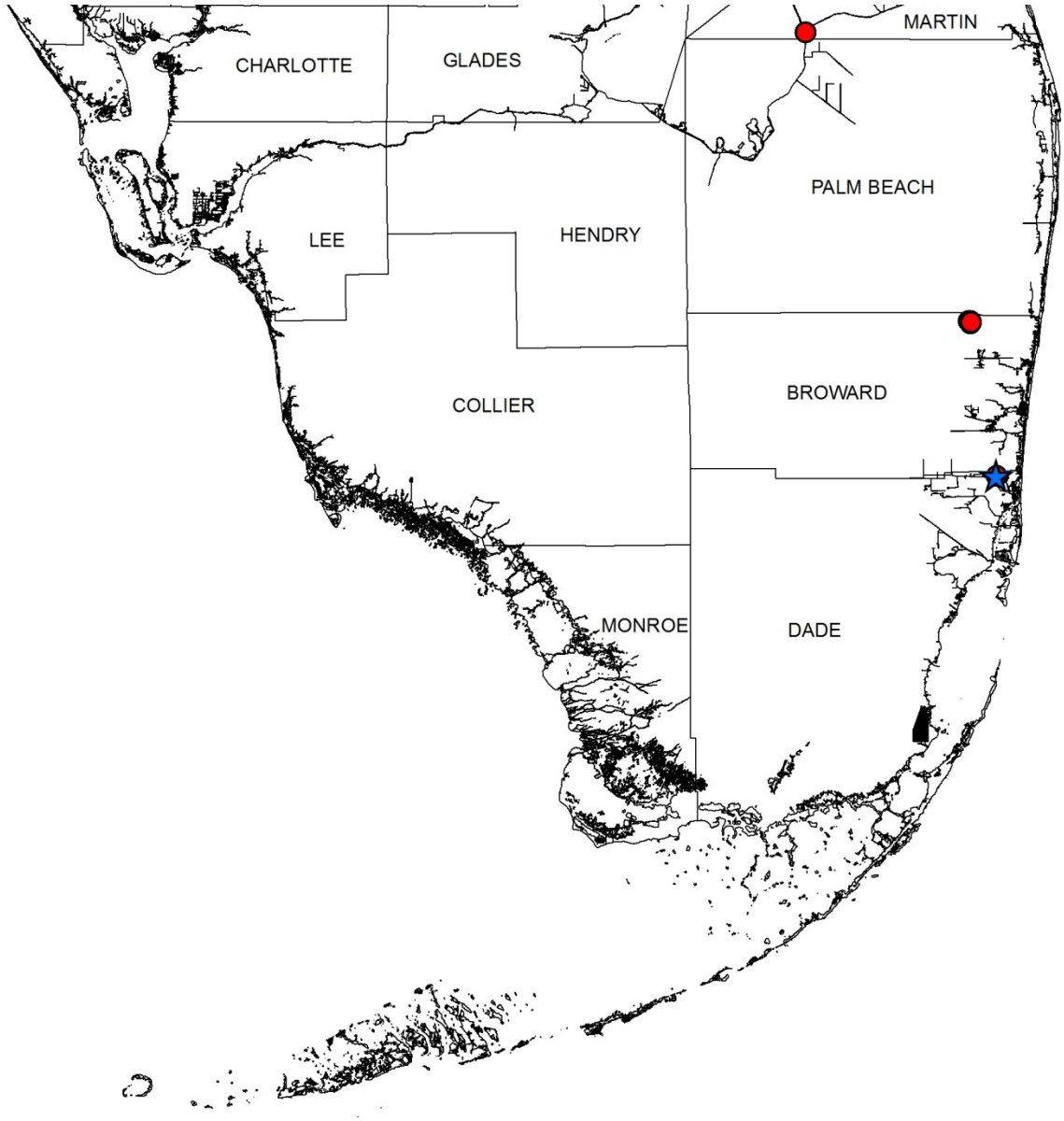

Figure 5-5. Geographic distribution of Large Headed Anoles (*Anolis cybotes*). See Appendix B for voucher specimens from systematic collections used to create map. Note that the star represents the earliest known specimen from systematic collections examined (UF 91063) collected on 25 November 1969.

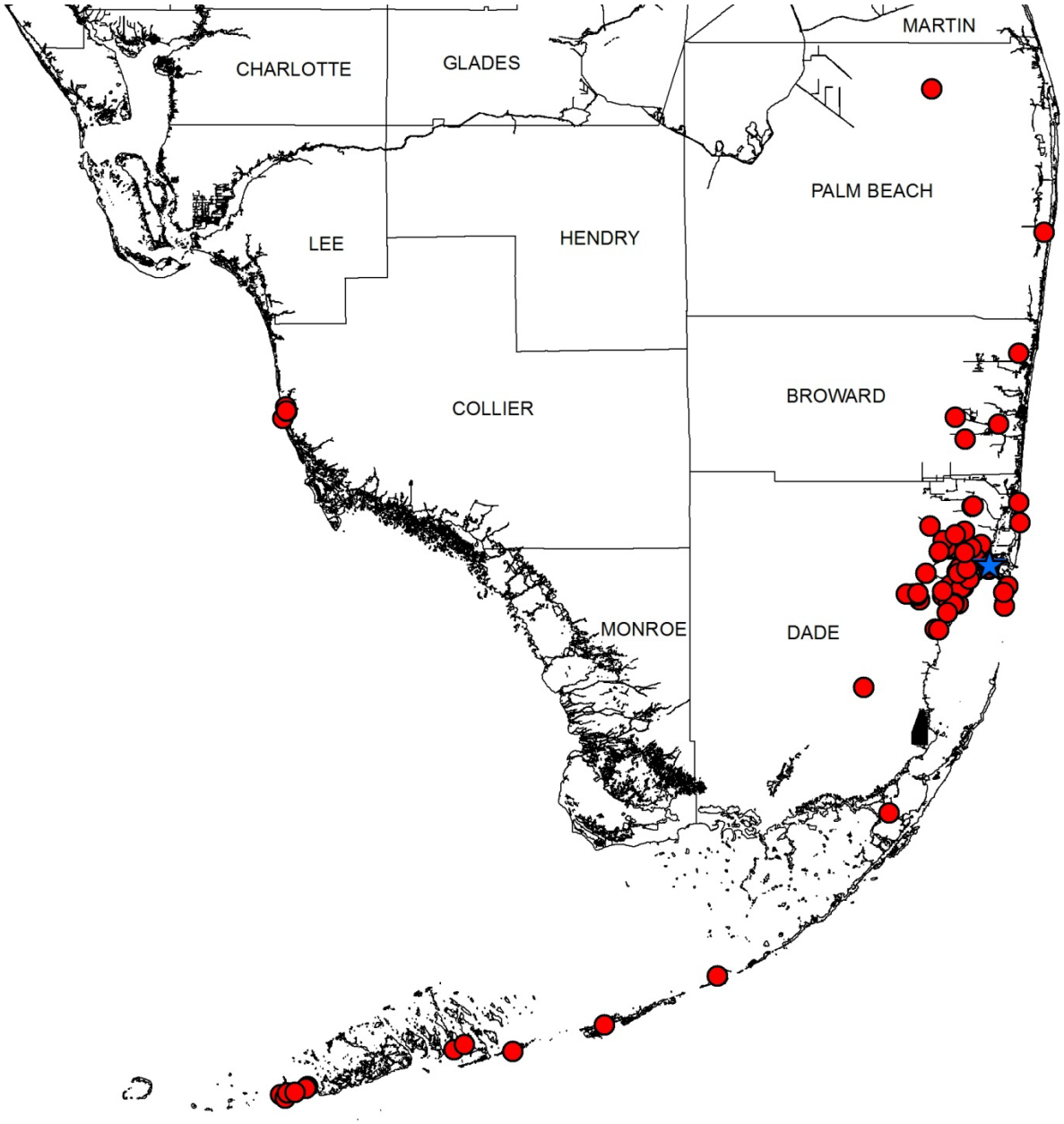

Figure 5-6. Geographic distribution of Bark Anoles (*Anolis distichus*). See Appendix B for voucher specimens from systematic collections used to create map. Note that the star represents the earliest known specimen from systematic collections examined (FMNH 55502) collected on 6 November 1946.

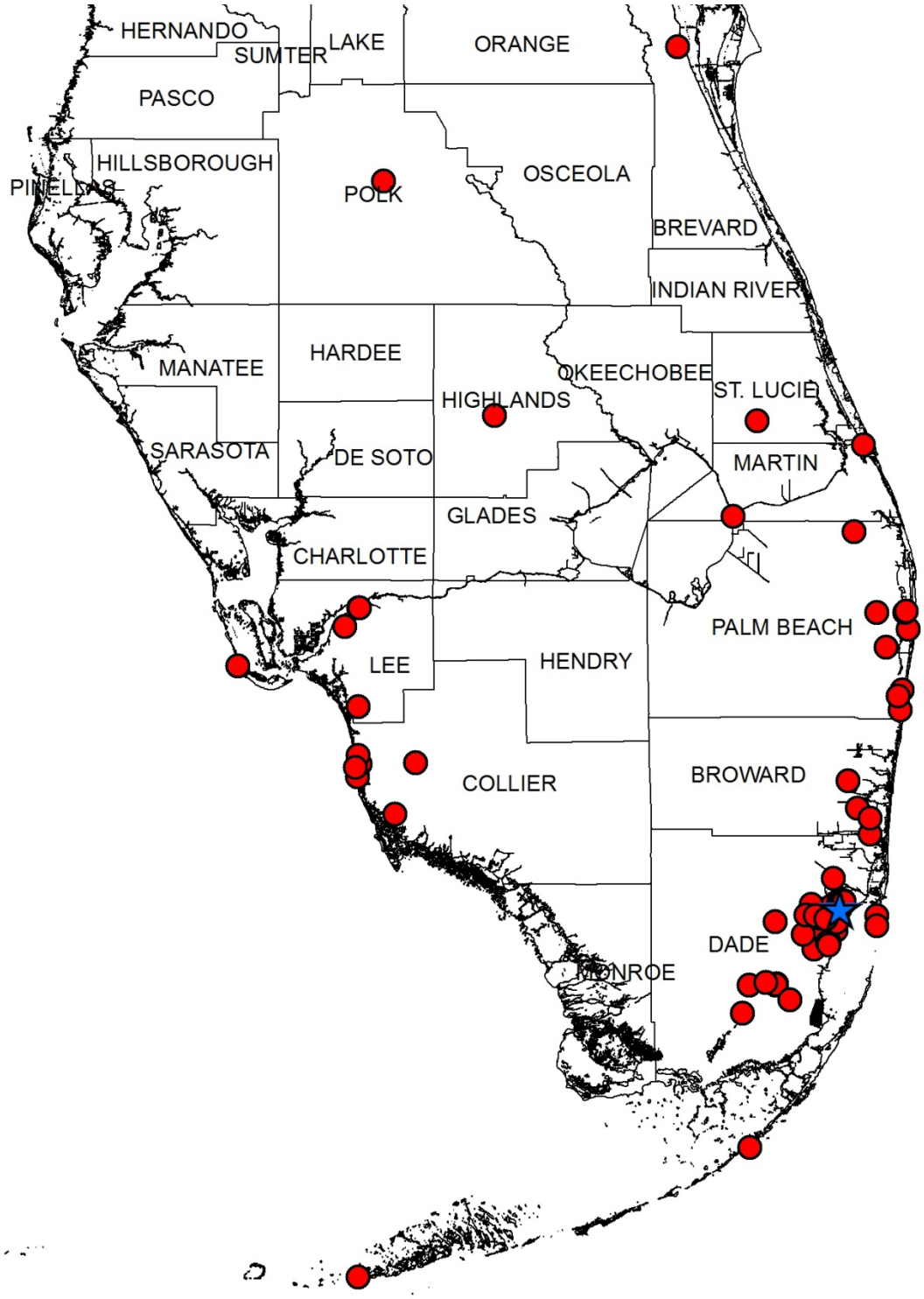

Figure 5-7. Geographic distribution of Knight Anoles (*Anolis equestris*). See Appendix B for voucher specimens from systematic collections used to create map. Note that the star represents the earliest known specimen from systematic collections examined (LACM 61680) collected on 5 Apr 1957.

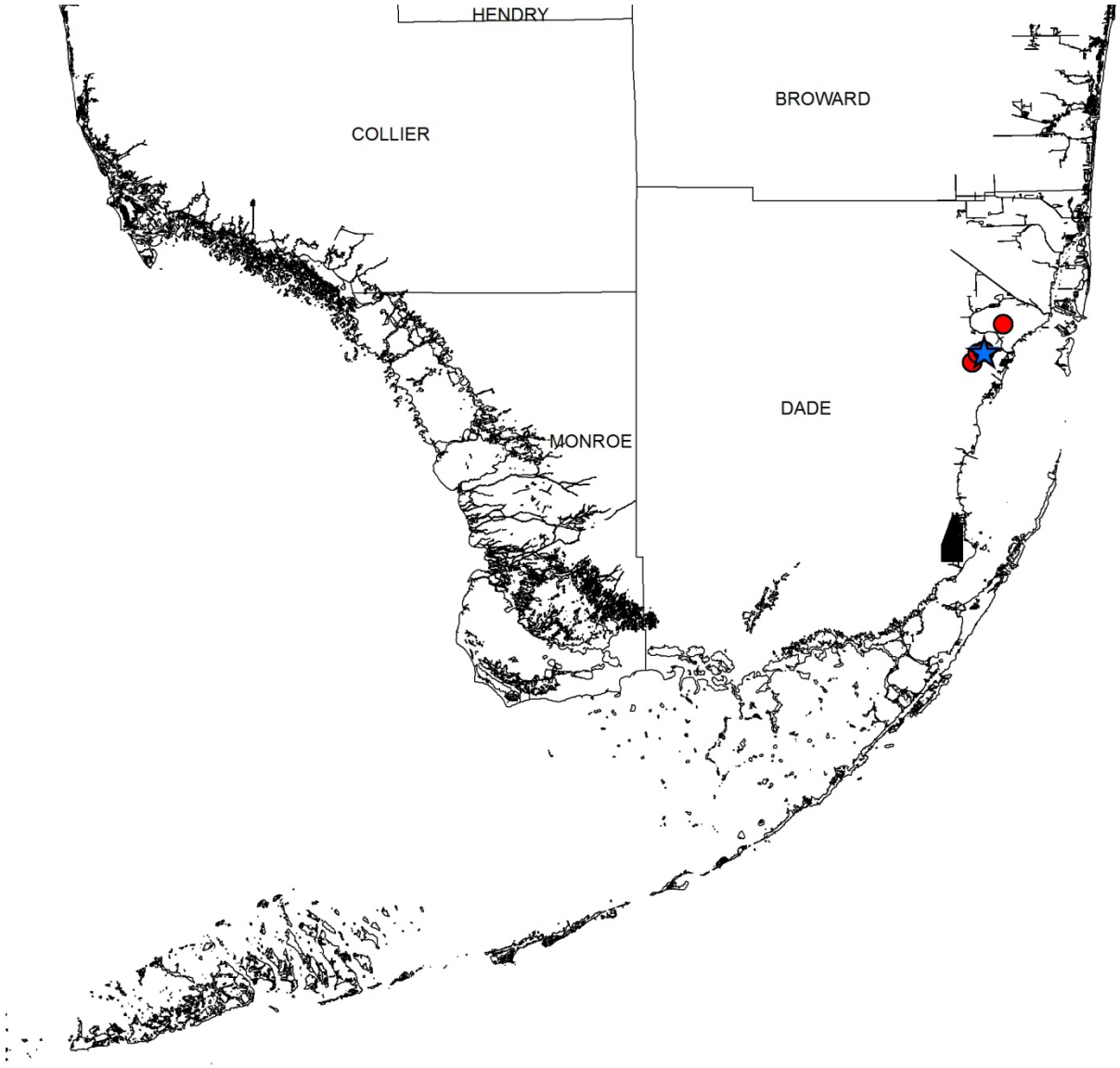

Figure 5-8. Geographic distribution of Jamaican Giant Anoles (*Anolis garmani*). See Appendix B for voucher specimens from systematic collections used to create map. Note that the star represents the earliest known specimen from systematic collections examined (LSUMZ 35367) collected on 15 February 1978.

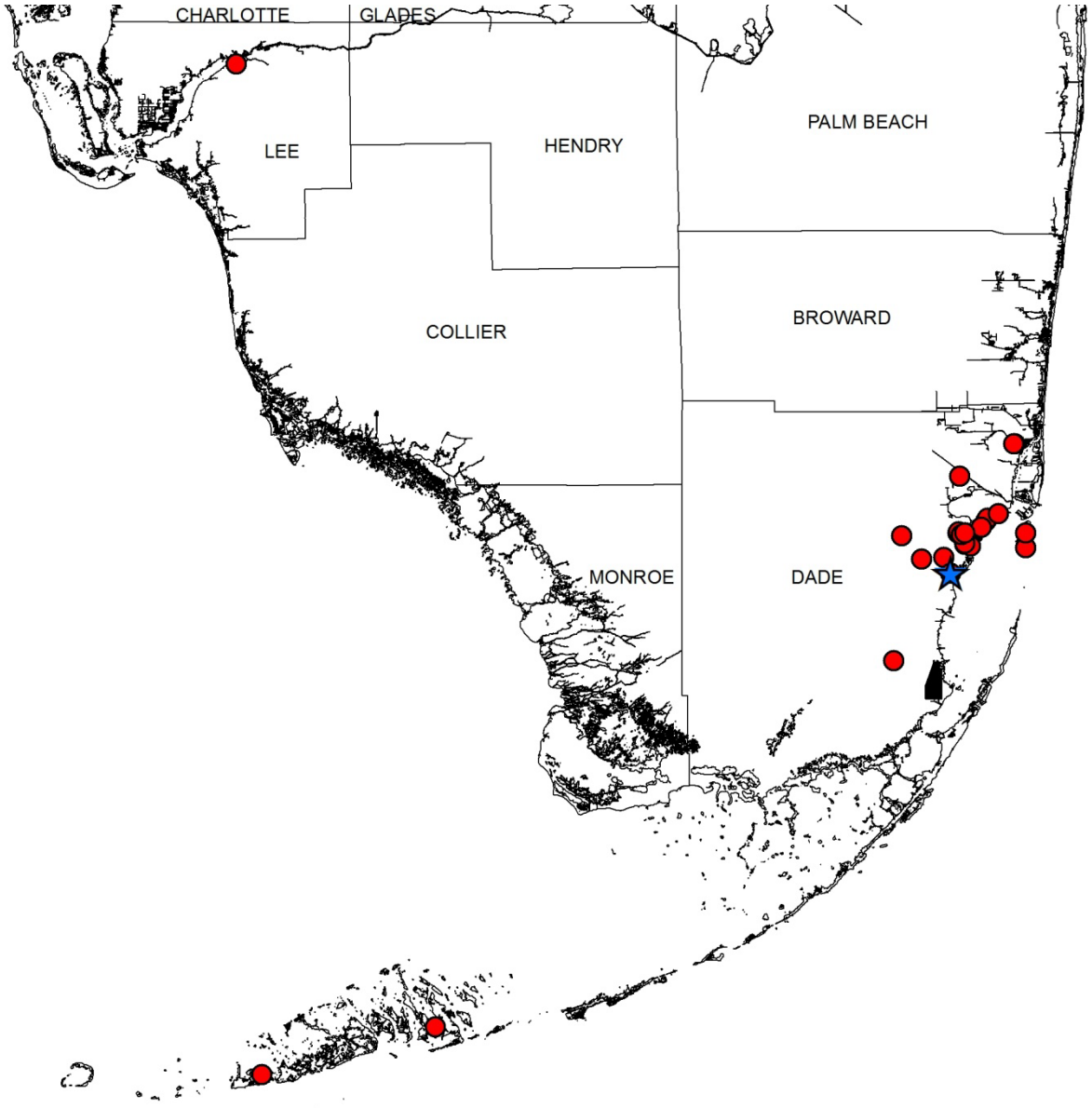

Figure 5-9. Arbitrary geographic distribution of Cuban Green Anoles (*Anolis porcatus*), based on collectors assumptions. See Appendix B for voucher specimens from systematic collections used to create map. Note that the star represents the earliest known specimen from systematic collections examined (UF 91293) collected on 6 August 1975. It is important to note that although this species genome has been shown to exist in Miami-Dade County, the accuracy of which these specimens were identified is questionable at best.

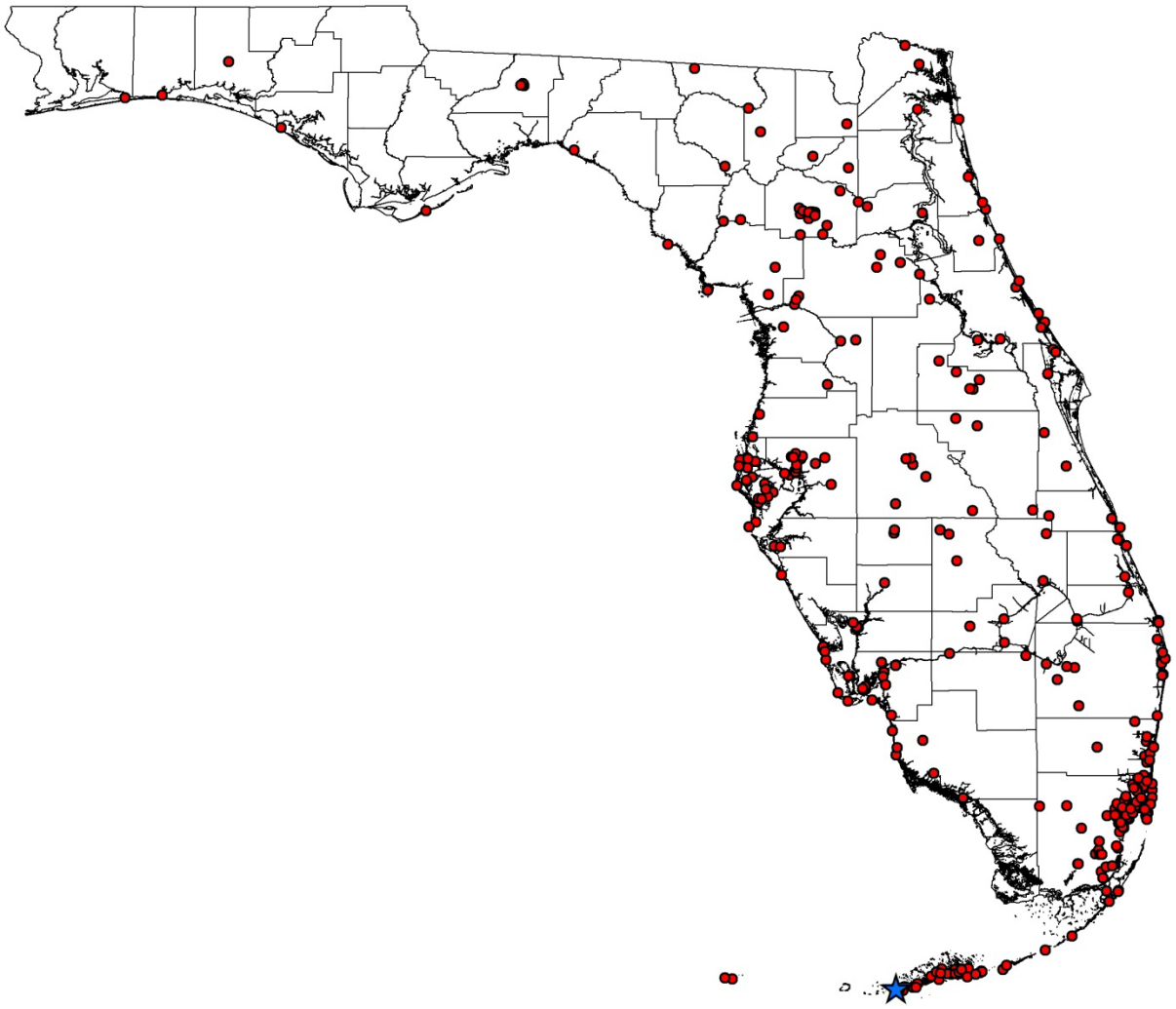

Figure 5-10. Geographic distribution of Brown Anoles (*Anolis sagrei*). See Appendix B for voucher specimens from systematic collections used to create map. Note that the star represents the earliest known specimen from systematic collections examined (MCZ 29907) collected on 20 April 1931.

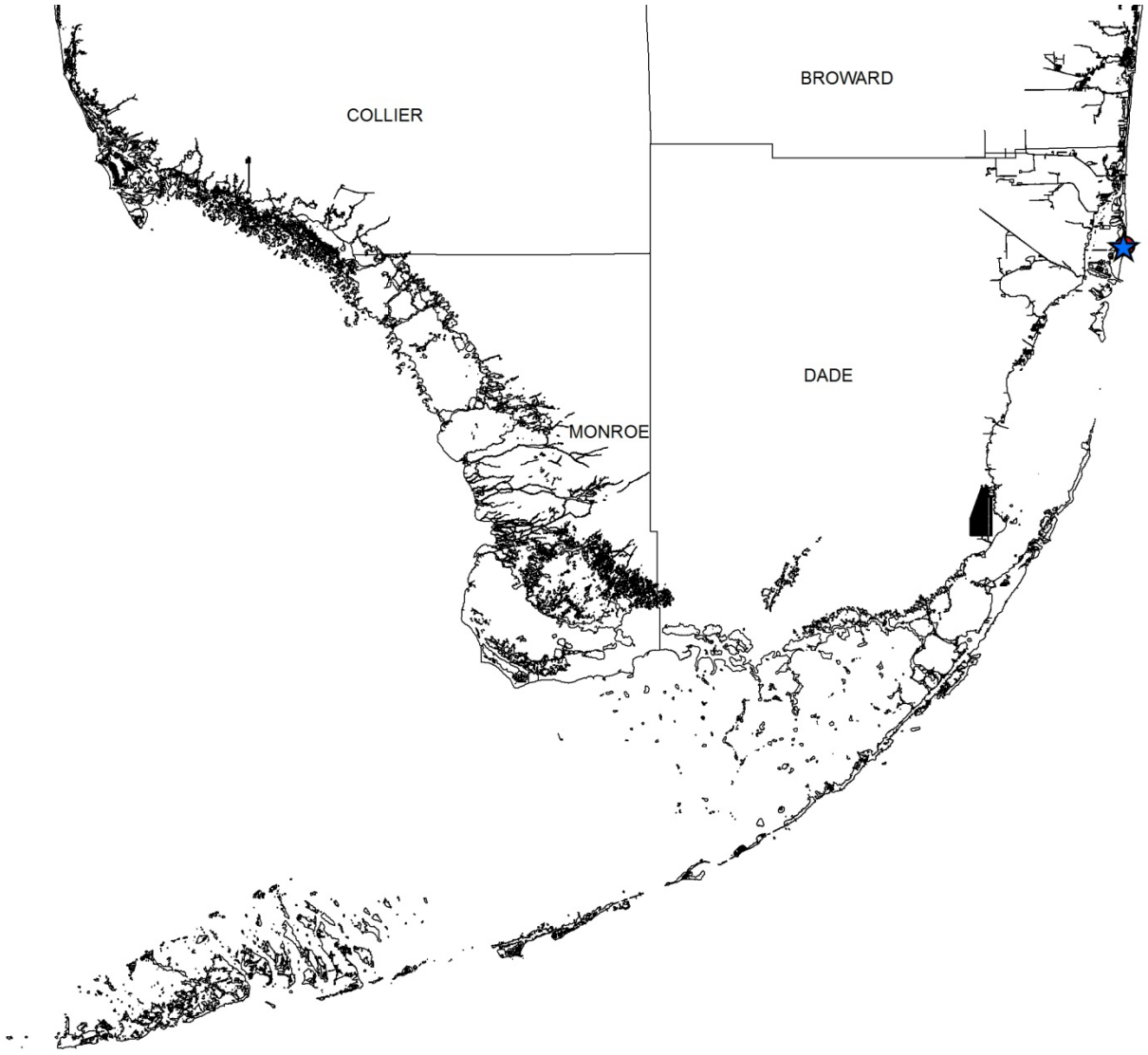

Figure 5-11. Geographic distribution of St. Vincent's Bush Anoles (*Anolis trinitatis*). See Appendix B for voucher specimens from systematic collections used to create map. Note that the star represents the earliest known specimen from systematic collections examined (UF 144299) collected in April 2005.

CHAPTER 6
CONCLUSIONS

Documentation of Florida's non-indigenous herpetofauna began more than 145 years ago, and Florida presently has more documented non-indigenous herpetofaunal species than any other place in the world (Kraus 2009; Krysko et al. 2011). As more people arrive in Florida and as the pet trade continues to flourish, it is likely that Florida will become home to many more non-indigenous species. Though only 10 species of anoles have been confirmed as established in Florida by my definition, there are many other species that have the potential to be added to Florida's herpetofauna (Latella et al. 2010). Because anoles not only spread horizontally in space, but also vertically in vegetation, consistently occupy the microhabitats defined by their Caribbean ecomorphs (Williams 1983) where they are found together in Florida (Todd. S. Campbell, pers. comm.), and because of Florida's subtropical climate, there is a high likelihood that an introduced anole could find an available niche and become established in Florida's herpetofauna.

Although my study provides a detailed account of each species established in Florida, as well as a dichotomous key to identify each species (except for *A. carolinensis* and *A. porcatus*), there are some limitations of the key. First, this key only pertains to those species presently in Florida. Should another species arrive that is similar to a species already present in Florida, the usefulness of this key could diminish over time. With over 370 extant species in the genus *Anolis* (The Reptile Database 2010), many species will share some of the same characteristics used to discern taxa in this study. At a time when more established anoles are discovered, there may arise a considerable need to revise this key. The alternative, however, is that a new taxon discovered would be discernible through use of this key, providing evidence to support a new

species in Florida. Second, the sample size from which *A. trinitatis* was analyzed was small (N = 18), perhaps not providing enough of a sample to adequately verify the features identified by the key. Therefore, discretion must be used when attempting to verify an individual as this species. Third, I was unable to find a definitive way, using a single character useful to researchers in the field, to discern *A. carolinensis from A. porcatus*. Multiple character analysis was useful, but was not 100% accurate for all specimens, and was not verified via analysis with individuals in which species designation was certain. The results of my study provide good groundwork for their identification, but can only be verified with further examination using morphological features with known genetic identities. Without molecular data, the results in this study are at best an educated guess based on specimens from non-overlapping ranges. This should be a future goal of researchers interested in *Anolis* morphology and genetics.

APPENDIX A
Anolis SPECIMENS MORPHOLOGICALLY EXAMINED FOR KEY VERIFICATION

Anolis carolinensis.—United States: Florida: Collier County: UF 102105–06, 102110, 102114, 102116, 102119, 102124, 102126, 102128, 102133–36, 102138–40, 102142–44; Columbia County: UF 3222 (1–2), 102150–55; De Soto County: UF 102255, 102260, 102262, 102264–67, 102275–76, 102278, 102281–84; Duval County: UF 3226 (1, 3, 10 & 12), 3590 (1, 2, 3, 4, 5, 6, 8, 9, 12, & 13), 102223–24; Escambia County: UF 3214 (1–2), 56040–41; Gilchrist County: UF 102228–35; Indian River County: UF 2518, 3221, 96714–17, 102288–89, 103022, 103035–39; Marion County: UF 35889, 35892, 35901–02, 35916, 35920, 35925, 35933–35, 35938, 35940, 35943, 35946, 35952, 39911, 39923, 39928, 39937, 39939, 39948, 39955, 39962, 102629, 102679, 117587, 117591; Miami–Dade County: UF 23690, 23692, 23694, 23699, 23708, 23717, 23739, 23741, 23744, 23749, 23753, 23759, 86558, 86560, 91305–07, 102173, 102178, 102184, 102190, 102196; Okaloosa County: UF 34430, 34445, 56035–39, 65025–26, 65473, 75115–22, 138397; United States: Georgia: 1409 (2–3), 2555 (5–7), 2556 (3 & 5), 3232 (2, 4 & 5), 4121–2, 4199–1, 9295 (4, 6, 7 & 10), 73731, 102460, 102466–67, 102473–74, 102477, 102479–81. (185)

Anolis chlorocyanus.—Dominican Republic: UF 6672, 15283, 86579, 86581–82, 121640; Haiti: UF 12267 (1, 4, & 9), 12270–6, 12271–2, 62730–31, 62741, 87603, 91719, 91726, 91731, 121646; United States: Florida: Broward County: UF 134216, 134583, 134694–96, 141574, 141586, 155413–16; Palm Beach County: UF 154681–84, 154857, 155326–29, 157366–427. (100)

Anolis cristatellus.—United States: Florida: Broward County: UF 157199; Miami–Dade County: UF 86988, 121416, 121450, 121721–29, 122479–80, 122483–92, 122494–98, 130661, 130665–66, 130670–74, 130777, 131493–94, 131498–503, 133833–34, 134816, 134818–20, 134992–99, 135004–06, 135011–17, 135030–32, 135035–36, 135038, 135042–43, 135982, 135984, 135990, 135998–6004, 136078, 141843, 144144–48, 144151–54, 144156, 144338–39, 144560–62, 147671–73, 151361, 155402–04, 155406–11, 157069, 157071. (121)

Anolis cybotes.—Haiti: UF 12252–3, 12253–2, 12256–1, 12257–3, 12260, 12262–9, 12263–3, 12264 (1 & 4), 12266–1, 12295, 15491, 89701–03, 89705, 89707, 89709–11, 89714, 89716, 89718–19, 89722, 89724, 89726, 89730–31, 89733–34, 89736, 89739–41, 89745, 89747, 89751, 89753–54, 90472, 90479–80, 90486, 90488–89, 90491–92, 90494, 90496, 90541–42, 90544–49, 90551, 90554, 91073, 91078, 91082–84, 121870, 121872–73, 121881, 121884–85, 121887–88, 121891–93, 121901, 121908, 121920, 121926–30, 121934; United States: Florida: Broward County: UF 131522–26, 157131; Martin County: UF 131446–48, 131527–29, 131540; Miami–Dade County: UF 84765–66, 86689, 91063, 91065, 91290, 121796. (106)

Anolis distichus.—United States: Florida: Broward County: UF 144327–29, 120907–08; Collier County: UF 152789–91; Miami–Dade County: UF 2515–2, 2908–3, 3261–2, 3262 (3, 6, 11, 12, 13 & 17), 12046, 12047 (1, 3 & 5), 12048 (1, 3, 4 & 6), 22017–20, 23764, 23780, 23785–86, 23793–98, 23801, 23805–06, 23809–12, 23817–24, 23828–29, 23831–35, 23837, 23839, 23841, 23844, 23847–50, 23852–53, 23855–57, 23859–61, 23863–66, 23869–70, 23873–74, 23877, 23880–83, 23886, 23888, 23890–91, 23893, 23898, 44317, 74949–54, 74956–57, 78688, 85399–400, 121422–24, 121436, 121452, 121458, 121935–37, 131495, 131512, 132687, 134706–07,

134947, 135995–96, 144141, 144149, 155412, 155429–32, 157073–75; Monroe County: UF 121939, 129704–05, 132449–50, 132457, 135975, 137229, 137417, 142683–86. (149)

Anolis equestris.—United States: Florida: Brevard County: UF 150871; Broward County: UF 86714, 137715, 140586, 141120, 142894–96, 145031–34, 157134; Collier County: UF 100104, 137037–42, 157493–94; Highlands county: UF 153968; Lee County: UF 141841, 144191, 145694, 151376, 152335, 154471; Martin County: UF 131449, 131530; Miami–Dade County: UF 21908–09, 22022–37, 40618, 42432, 63077–82, 66920–21, 74958, 80343, 83799, 89569–74, 90925, 99187, 99674, 121125, 121425, 121445–48, 122474–75, 130653, 130685, 131477, 131489, 132727, 134839, 134916, 137714, 138394, 141229, 141576, 144135, 144220, 145027–29, 145216, 145359–61, 145471, 146882–901, 146907–22, 150534, 150732, 151359, 152322, 155428; Monroe County: UF 52748, 151192; Palm Beach County: UF 137015, 141949, 144334, 149862, 150533, 150535, 151601, 154585; Polk County: UF 153967; St. Lucie County: UF 137459. (153)

Anolis garmani.—Jamaica: UF 18608–10, 18612, 18744, 18821, 21653, 39441, 89293–94, 90931–33, 121998–2012; United States: Florida: Miami–Dade County: UF 121438–44, 122813, 130679–80, 130682–84, 130774, 130980, 131483–86, 141577, 141592, 144192–94, 144215–18, 144858, 146902–06, 155424–27, 157080–81. (68)

Anolis porcatus.—Cuba: CAS 7913, 8289, 8308, 9277–79, 14602–04, 39270–71; REGLOR 1625, 2346, 2357, 2537, 2641, 2650, 2683, 2699, 2711, 2888, 2900, 2926, 2978, 2990, 3008, 3020, 3032, 3045, 3059, 3080, 3084; UF 7708, 21865–66, 91291–92; USNM 194314, 194317, 194319, 194322, 194326, 194330, 194332–33, 194347–48, 194351, 194356, 315947–48, 315950–53, 315955–56, 335833–44, 498072, 498076–80, 498083, 498087–88, 498090. (79)

Anolis sagrei.—United States: Florida: Alachua County: UF 47681–83, 50231–33, 50719, 61160, 87815–17, 101663–66, 124246, 134178, 135286–90, 137219, 151169; Brevard County: UF 125949, 134162–77, 144327–29; Broward County: UF 74945, 91107–08, 99332, 99710, 131475–76, 135689–93, 155417–20; Collier County: UF 50722–23, 78770, 101667, 127708–09, 137131, 157484; Dixie County: UF 134185–86; Duval County: UF 95566–67, 133204; Flagler County: UF 101602–03, 117758, 127125–29; Hillsborough County: UF 3252, 3256–59, 3300, 12050, 48920, 49002, 50686–90, 76226, 81693, 84032–33, 86547–51, 101668–70, 123900; Indian River County: UF 103014–16, 103018–21, 103027, 103029–30; Miami–Dade County: UF 14027, 22041–42, 50705, 86529, 86534, 87113, 99138, 99447, 122600, 122616, 122618, 122637–56, 122658, 122660–69; Monroe County: UF 3268, 7097, 7783, 44336, 50693–94, 86566–67, 86570–76, 91109–14, 142682, 151374, 152815–19, 152821–25, 101607–08, 124689, 125028–33, 127118–22, 127124, 134158–61. (213)

Anolis trinitatis—St. Vincent: UF 91254, 124399–414; United States: Florida: Miami-Dade County: UF144299. (18)

APPENDIX B
Anolis SPECIMENS GEO-REFERENCED

Anolis carolinensis.—United States: Florida: Alachua County: AUM 3461; FMNH 94733-9; KU 18542, 18712-3; LACM 61513; LSUMZ 15244, 44150, 44153, 44162-3; MCZ 6586, 57382, 80114-5, 157717-22; MSB 45167, 45169, 45180-1; MVZ 53806; TNHC 4659-60; UF 66, 71, 1177, 1312, 1964, 2179, 2183, 2505, 2558, 2605-6, 2900, 3211, 3228-9, 3581, 7497, 7554, 8025, 8848, 8920, 9080, 9204, 9560-2, 10009, 11132-3, 11711, 11975, 14371, 14413-4, 14579-80, 14678, 19086, 49025-6, 49028, 60905, 79986, 91298-301, 101837-46, 123200, 137344, 144889, 145750, 152726; UMMZ 56534-6, 56604, 56606, 57744-6, 64171-2, 68856, 77204-6, 130994, 148854, 173783-818; USNM 004726, 009439; Baker County: UF 2187, 102150; Bay County: MCZ 86341; UF 3269, 78390-1, 88769, 101847-50; Bradford County: CU 4115; UF 3236, 3238-9, 101851; Brevard County: MCZ 5752, 6782, 6890, 174024-38; UF 8998-9, 46393, 47029-31, 101852-3; USNM 011996, 015603, 018029, 044829; Broward County: MCZ 182961-5; TCWC 24802-3, 24805; UF 101854-5, 157200; UMMZ 108378, 111407; USNM 232393; Calhoun County: AUM 27709; CAS 214346, 214408; UF 3231, 3235, 9112, 26131-8, 75128, 101856-60;UMMZ 106192; Charlotte County: UF 3210, 65186, 101862-74; Citrus County: CAS 165947, 103092, 210981-3, 214313-7, 228250-61; CU 2288, 3850, 3864; MCZ 4421; UF 35928-30, 80218, 101883-7; UMMZ 73991, 106199; Clay County: UF 3240, 91535-7; USNM 210055; Collier County: FMNH 192444; LSUMZ 71419; MCZ 51924-6, 69192, 80160-2, 182971-2; UF 3212, 3248-9, 3295, 29351-2, 65841-2, 75126, 78073, 102103-44, 102542; UMMZ 98477, 101615, 107197, 108376-7, 109229, 109294-7, 109394; USNM 014735, 301976; YPM 06965-6; Columbia County: CAS 228239-42; CU 11887, 12910; MVZ 241536; UF 1303, 2512, 3222, 102151-5; USNM 078474, 468057-8; UTEP 14193; De Soto County: FMNH 23225-6, 23230; UF 102254-84; USNM 022343; Dixie County: UF 19138, 102222; Duval County: CU 1574; FMNH 829, 142676, 208310; MCZ 13403; UF 3218, 3225-7, 3242-3, 3590, 9202-3, 25432-40, 102223-4; UMMZ 81152; USNM 014143, 521801; Escambia County: CAS 1100-3; LSUMZ 52949; MCZ 560-1; UF 3214, 56040-1; UMMZ 81151; USNM 004175, 005149, 534355-65; UTEP 18476; Flagler County: UF 4062; UMMZ 100824; Franklin County: CAS 218687-8; LSUMZ 32777-81; MCZ 96288; UF 8821, 17233-6, 18398, 19712, 56042-9, 73725-30, 75123, 102225, 143300-1; Gadsden County: UF 1429, 3241, 4563, 7778, 7781, 9114, 87096, 102226-7; UMMZ 116696; Gilchrist County: UF 102228-35; Glades County: CAS 165958, 204798; UF 3244; UMMZ 56161, 148829; Gulf County: CAS 214399, 218695-6, 218700-4; UF 3250, 8822, 9111, 9113, 9510, 102236; Hamilton County: UF 102237-41; Hardee County: UF 115626; Hendry County: LSUMZ 71418, 71561; UF 7142, 102245-50; UMMZ 56159-60; Hernando County: CAS 165953; MVZ 53790-1; Highlands County: CAS 238481; LACM 15593-4, 61514; UF 9007, 102251-3, 152665; Hillsborough County: FMNH 2988, 42662-8; MCZ 5753, 161393-403, 174023; MVZ 196142; UF 3032, 3206, 3253-5, 43686-93, 81694, 123130, 150248; UMMZ 61640; USNM 245321; UTEP 9496; YPM 01307, 01312; Holmes County: UF 9376-7, 102285-7; UTA 34884; Indian River County: MCZ 12982-3, 168511; UF 2518, 3221, 96714-7, 102288-9, 103022-6, 103035-9; UTA 16770; USNM 312891; Jackson County: CU 9059; LSUMZ 30565, 31222, 71294; TCWC 13757-8; UF 1433, 2641, 3942, 4150, 6946, 9424, 49020-4, 56034, 66728, 102290, 129215; UMMZ 106009; USNM 468116-22, 468134, 473621-3, 473625, 489964-8; Jefferson County: FMNH 8130, 8143; UF 7777, 8904, 10055, 15866, 16113, 102291-5; Lafayette County: UF 102296-8; Lake County: CU 4048; FMNH 94740-3; TNHC 9632-3; UF 3247, 102299, 105845-50; UMMZ 56605; USNM 019992, 020031, 468074-7; YPM 09267; Lee

County: CU 1573, 1573, 1644-5, 1942, 1944, 2449, 2574, 3041, 3311, 3362-3, 3844, 4078, 5221, 5247; LACM 15606; MCZ 68952-5; MVZ 53796; UF 2509, 2511, 2557, 3217, 3251, 4085, 8624-5, 29328-9, 32530, 102413-44, 134106-7; USNM 312892-3, 537096; YPM 01291-2, 01295, 01297, 10299-300, 01302, 01809-10, 01814-20, 01825-8, 01836-8, 01842, 05897-900; Leon County: AUM 35224, 35303; FMNH 8128-9; LSUMZ 71448; MCZ 80116-9, 80837-41, 80926-9, 81538-40, 83219-26, 84053-65, 84996-8, 86338-40, 87291-310, 93398-402, 93406, 93437, 93681-3, 96060-1, 96289-95, 96692-6, 100150, 101231, 101887-8, 101930-4; TCWC 8905; UF 15900-4, 15906, 65940, 75146-66, 91310, 102376-90, 102459, 141423, 143302-4, 143355, 158560, 162758; UMMZ 56725, 101617, 106010-1; Levy County: CAS 214318, 228265, 228274; LSUMZ 15243; UF 2516, 3092, 3129, 3208-9, 3213, 9563, 14581-5, 14677, 87715-8, 87720, 91312-3, 102300-3, 137861; USNM 071023, 104254, 115394, 135470-1; Liberty County: UF 3220, 3245-6, 7779, 9110, 10095, 10098, 10100, 10133, 10161, 17031-5, 50818, 75134-45, 75167-70, 91297, 102391-412, 158700-1; UMMZ 86466, 106193; Madison County: UF 85025-6, 102304; Manatee County: UF 3216, 75133, 101875-82, 102305-6; USNM 245625; Marion County: AUM 17534; CAS 9075, 9099; CU 2498, 3302; 3377; LSUMZ 71456, 71466; MSB 20079; MVZ 53802-5; TCWC 10754; UF 1513, 3072, 7498, 9051, 35887-910, 35912-27, 35931-52, 36108, 39910-23, 39925-66, 42522, 48478, 80217, 102622, 102624-791, 117587-91; UMMZ 44718-21, 44741-2, 46922, 52399-400, 53046-53, 57079, 102760; USNM 312895-6, 321325-6; Martin County: LSUMZ 28850; UF 102307-10; Miami-Dade County: CAS 12573, 172096, 174339-42, 185346; CU 1991, 2089, 2679, 3096, 3303, 5368, 5836, 6014; FMNH 251977-82; LACM 15595-600, 15607, 74311-2, 116113-4; LSUMZ 22775, 24003-4, 41352, 42466, 57367-8, 57371-3; MCZ 974, 12974-5, 31798-810, 38440-1, 51929-32, 80153-9, 84091-5, 92678-9, 93573, 110395-6, 116749, 130794-6, 143910-5; MSB 16229; MVZ 214941-6; UF 2510, 9078-9, 11787, 12400, 23686-778, 86552-62, 91302-9, 99299, 99586, 99641, 99671, 99704, 99750, 102172-4, 102176-97, 118919, 132680, 145030, 147736-53, 152792, 157079, 157132, 157558; UMMZ 105969, 106194-5, 107196, 108191-2, 108373-4, 108382-3, 109227-8, 110667; UTA 10316, 16273; USNM 032094, 062078 085214-21, 085224, 132113, 202944-5, 258167, 312889-90, 523788; YPM 01310, 01847, 06938; Monroe County: CAS 10446, 174227-8, 193189; CU 13050; FMNH 2700, 21667, 27031-2, 83219, 94746-9, 160044, 160046, 160050, 168588, 168615, 168617-8, 168624; LACM 15601-5, 61500-12, 74313, 116115; LSUMZ 71409; MCZ 622, 4396, 7440, 12873-5, 13401-2, 13406, 13723, 53170-2, 80163-9, 84096-102, 126709-11, 130797, 146400-3, 146425-7, 158970, 169213; MSB 41312; MVZ 53797-800; UF 67, 1028-9, 1092, 1097, 2904, 3237, 3267, 7098, 8626-34, 9583, 12399, 14376, 29323-7, 43830-2, 49027, 67399-400, 91314-7, 102175, 102521-39, 102543-621, 118918, 135072, 140829, 151120; UMMZ 71364, 102542, 106196, 106200, 107198, 108193-7, 108375, 108379-81, 109230, 112394, 115964, 118511, 148853, 173756-82, 182259; USNM 060583, 062079, 062086, 083481, 085200-13, 085222-3, 085225-31, 095728-32, 095813-6, 102604-5, 195475, 218749, 259125-6, 312894, 504887, 523363-5, 537097-104; YPM 01294, 01811-3, 06939-40; Nassau County: UF 3233-4, 102313-4, 106650; USNM 056923-4, 066606; Okaloosa County: AUM 13786, 20444-5, 30533, 30581; UF 34430, 34445, 56035-9, 65025-6, 65473, 75115-22, 138397; Okeechobee County: LACM 61515; UF 9590; Orange County: CU 4537; LSUMZ 42468; MCZ 164394, 178097-102; MVZ 36584-6; USNM 124131-2, 131877-8, 541441-3, 541630-4; YPM 09770-2; Osceola County: UF 2186, 8877; USNM 028843, 036197, 036240-2, 223994; Palm Beach County: AUM 14184-5,18079-80; CAS 165963-7, 165993; LACM 3802-4; MCZ 12984-7, 51927-8, 153516; TCWC 10408-10; UF 2506-8, 2513, 3219, 4065, 8753, 152793; UMMZ 106191; USNM 036409, 061652, 313414; YPM 01293, 01296,

01298, 01303, 01821-4, 01829-35, 01843; Pasco County: CAS 165959-60, 165974; Pinellas County: CAS 198633; CU 971; FMNH 94744-5; UF 3207, 3265, 81695-6, 105844; UMMZ 61641; USNM 010594-6; Polk County: CAS 238497; CU 5285, 11888-90; FMNH 25756; MVZ 53801; UF 2698, 2704, 2801, 2895, 2973, 2985, 2988, 3031, 38910, 75124-5, 90261, 91296, 102342-9; UMMZ 106012; USNM 022345, 048722-3, 061964; Putnam County: UF 3224, 35911, 39924, 69880, 86486-92, 102350-2; USNM 139196-200; Santa Rosa County: AUM 30450-1; LSUMZ 56388-9, 83585; UF 102353, 114817-20, 117720, 141184, 146014; USNM 011391; Sarasota County: CU 12663; MVZ 53792-5; UF 4045, 29349-50, 102354-67; UMMZ 101616; USNM 009965, 061336; Seminole County: KU 16691; UF 3038; USNM 084475-7, 312897-904; St. Johns County: MCZ 566, 5750, 7863, 174052-70; UF 50349, 50636-8, 50783, 50790, 102368, 115063, 121362; USNM 004177, 008305; YPM 01309, 01844-6; St. Lucie County: MCZ 168518; UF 7139; USNM 118808-9; Sumter County: UF 80219; Suwannee County: MCZ 162818-27; UF 102145-9, 102369, 124802; Taylor County: CAS 214332-8, 214344; UF 3230, 102370; Volusia County: CU 1466; FMNH 854, 6163; MCZ 12872, 13399, 174039-51; MVZ 36583, 36587; UF 75127, 124107, 124193; UMMZ 43973-4; USNM 008903, 082477, 468067; Wakulla County: MCZ 80113; UF 9255, 9836, 55903-6003, 56018-33, 75129-32, 91311, 102371-5, 144948; Walton County: UF 8903, 102311-2; Washington County: UF 64705. (2561)

Anolis chlorocyanus.—United States: Florida: Broward County: AUM 33672-3; KU 210033; UF 134216, 134583, 134694-8, 141574, 141586, 155413-6; Palm Beach County: UF 154681-4, 154857-8, 155326-9, 157366-427. (88)

Anolis cristatellus.—United States: Florida: Broward County: UF 157199; Miami-Dade County: AUM 34061-98; KU 204314-7, 222393-4; LSUMZ 36654-6, 57375-80, 57618, 57847-8; MCZ 146223-6; MVZ 214984-92; UF 43622, 86988, 99384, 121416, 121450, 121721-9, 121767, 122479-99, 130657-68, 130670-4, 130690-2, 130720-2, 130776-7, 131493-4, 131498-503, 133833-4, 134816-20, 134991-9, 135004-18, 135022-4, 135030-43, 135982-7, 135989-90, 135998-6004, 136078, 141596, 141842-3, 144144-56, 144337-9, 144560-2, 145368, 147671-3, 151360-1, 155402-11, 157069-72, 157543, 164750; UMMZ 225107-13.(255)

Anolis cybotes.—United States: Florida: Broward County: AUM 33674-7; KU 220255-6; UF 88647, 131522-6, 134714, 141575, 157131; Martin County: UF 131446-8, 131527-9, 131540; Miami-Dade County: UF 84765-6, 86542, 86689, 91063-5, 91290, 99290, 99409, 99692, 121796-7. (35)

Anolis distichus.—United States: Florida: Broward County: LACM 139821-9; MSB 54671; UF 114327-9, 120907-8; Collier County: UF 152789-91, 157457, 157461, 157473-6; Miami-Dade County: CAS 185347-8; FMNH 55502; KU 68977, 92682-6, 204318, 220257; LACM 61654-74, 74890-8; LSUMZ 28848-9, 28880; MCZ 50001, 53797, 57268-71, 77586-7, 79194-6, 93774-5, 96542-9, 143916-42, 143944-57, 164407, 164410-11; MSB 41278-80; MVZ 53813-8, 214994-5; UF 2515, 2908, 3261-2, 12046-8, 19219, 22016-21, 23779-900, 34010, 48913, 74946-57, 78688-9, 85397-03, 99348, 99783, 100105-6, 120759, 121422-4, 121436, 121451-2, 121458, 121503, 121935-8, 122476, 123889, 130669, 130675-6, 130686-8, 130693-6, 130703, 130717-9, 130778, 131495, 131504, 131511-2, 132687-8, 134704-8, 134845, 134942-7, 135002-3, 135019-21, 135026-9, 135974, 135993- 7, 137108, 141598, 143311-2, 143404, 144123, 144141-3,

144164-5, 147675-8, 155412, 155429-32, 157073-5; UMMZ 106189, 108188-90, 108371-2, 109231-2, 128169-70, 148869, 173820-60, 225098; UTA 2498-9;USNM 127114, 245580-7; YPM 06982-3; Monroe County: AUM 33823-62; KU 221730; MCZ 152734-5; UF 44316-7, 121939, 129704-5, 132449-50, 132457, 137390, 137417, 142683-6; Palm Beach County: AUM 33863-88, 33901-11; USNM 504888. (554)

Anolis equestris.—United States: Florida: Brevard County: UF 150871; Broward County: UF 86714, 137715, 140586, 141120, 142894-6, 145031-4, 157134; Collier County: UF 100104, 137037-42, 157493-4, 164551; USNM 547963; Highlands County: UF 153968; Lee County: UF 141841, 144191, 145694, 151376, 152335, 154471; Martin County: UF 131449, 131530, 163966; Miami-Dade County: AUM 35823; KU 220258; LACM 61680-6, 74878-80; LSUMZ 24010, 30725, 42087, 56737; MCZ 85093, 85564, 93445, 131609, 140112, 142470, 143901-9, 171444-7, 174816, 175020-1, 182994; MVZ 214996-9; UF 21908-9, 22022-37, 40618, 42432, 63078-82, 66920-1, 74958, 80343, 83799, 89569-74, 90925, 99187, 99674, 121125, 121425, 121445-8, 122474-5, 130653, 130685, 131477, 131489, 132727, 134839, 134916, 137714, 138394, 141229, 141576; 144135,144220, 145027-29, 145216, 145359-61, 145471, 146882-901, 146907-22, 150534, 150732, 151359, 152322, 155428, 162757; UMMZ 225093-7; UTA 35597; USNM 194847, 245588-9, 252596-9,523789; UTEP 15976; YPM 07023, 07028; Monroe County: UF 52748, 151192; Palm Beach County: TCWC 80508; UF 137015, 141949, 144334, 149862, 150533, 150535, 151601, 154585; Polk County: UF 153967; St. Lucie County: UF 137459. (221)

Anolis garmani.—United States: Florida: Miami-Dade County: LSUMZ 35367, 36644-6; MCZ 164406; MVZ 215000-5; UF 121437-44, 122813, 130680-4, 130774, 130980, 131483-6, 141577, 141592, 144192-4, 144215-8, 144858, 146902-6, 155424-7, 157080-1, 157559. (54)

Anolis porcatus.—United States: Florida: Lee County: UF 137029; Miami-Dade County: UF 91293, 120758, 121312, 122478, 130775, 130779-80, 1131487-8, 131492, 131513-4, 131535, 132464, 132470, 132710-1, 134217-9, 134715-28, 134841-2, 134917, 135483-4, 135952-3, 135965-7, 135969, 135981, 137098, 137100-1, 140588, 141593, 144136-8, 149681-714, 155421-3; Monroe County: UF 132451-2, 132458; UMMZ 225090-2. (96)

Anolis sagrei.—United States: Florida: Alachua County: CAS 228245-9; UF 47681-3, 50231-3, 50719, 61160, 87815-7, 101663-6, 124246, 134178, 135286-90, 137219, 151169; Baker County: UF 101609-10; Bay County: UF 78392-6; Bradford County: UF 134179-84; Brevard County: LSUMZ 80413; UF 125949, 134162-77, 144327-9; Broward County: LACM 139830-54; MSB 53358-73; UF 74945, 91107-8, 99332, 99710, 131475-6, 134689-93, 155417-20; USNM 202904-12; Charlotte County: UF 121462-3, 121505, 134121-4; USNM 0062002; Citrus County: UF 81850; Clay County: UF 124687; Collier County: UF 50722-3, 78770, 101667, 127708-9, 137131, 157484; USNM 301977-80, 301987, 547964-7; Columbia County: UF 101604; De Soto County: UF 134141-5; Dixie County: UF 134185-6; Duval County: UF 95566-7, 133204; Flagler County: UF 101602-3, 117758, 127125-9; Franklin County: UF 103501; Gilchrist County: UF 122516, 134187-8; Glades County: UF 134152-5; USNM 504889; Hamilton County: UF 101611, 155914; Hardee County: UF 115625, 134146-7; Hendry County: UF 134114-8; Hernando County: UF 134189; Highlands County: CAS 214419, 238485; UF 152721; Hillsborough County: LACM 131394-404; LSUMZ 71669-74; MVZ 53811-2; UF

3252, 3256-9, 3300, 12050, 48920, 49002, 50686-90, 76226, 81693, 84032-3, 86547-51, 101668-70, 123900; USNM 245322, 290580; UTEP 9495, 9506; Indian River County: MCZ 166909-11, 168509-10; UF 41504-5, 96718-33, 101014-21, 103027-30, 134112-3; UTA 16771-2; Lake County: UF 50726; Lee County: MCZ 68199-203; UF 101671-5, 103031-4, 121504, 122891-5, 133219, 133248-9, 133501, 134100-5, 134108-9, 134119-20, 137024-8, 152667, 157489; USNM 202955-6, 504890, 537105-11; Leon County: UF 151200-3, 152947-50; Levy County: CAS 228266, 228273; UF 122515, 134585, 152344; Manatee County: UF 99346, 146478-80; Marion County: UF 50724-5, 70559, 102623, 122593-4, 124228, 130981, 152834; Martin County: UF 122463, 131444-5, 131457-60, 134658, 145014-8; Miami-Dade County: AUM 19763; CAS 111007-8, 174343-6, 185340; CU 8926-32, 13014; KU 68979, 204319-20; LACM 61550-67, 66657, 74881-9, 131387-93; LSUMZ 23857, 23917-8, 28844-7, 28855, 28872-9, 41353, 50822-3, 57369-70, 71655; MCZ 511845-6, 51933-9, 93551-72, 122745-61, 149569, 150313, 164408-9, 165249, 182987-90; MSB 16227-8, 16230, 41276-7; MVZ 215193-213; UF 7745, 14027, 22041-4, 28102-4, 50702-11, 78690-1, 86527-37, 87113, 99138, 99374, 99423, 99440, 99447, 99473-4, 99538, 99552, 99635, 121415, 121449, 121461, 121768, 122600-700, 122704-5, 130677, 130700-2, 131507-10, 132465-6, 132683-4, 132686, 134215, 134709-13, 134840, 134843-4, 134846-9, 134901-2, 134918-28, 135000-1, 135025, 135075-7, 135472-3, 135476, 135479, 135482, 135630, 135948-51, 135954-5, 135959-64, 135968, 135975, 135977-8, 135988, 135991-2, 137099, 137102-7, 137109, 140758-60, 141597, 141844, 143293, 143313-4, 143362-4, 144130-4, 144219, 144260, 144563, 147788-93, 157076-8, 157082-3; UMMZ 106197, 107195, 108186-7, 108367-9, 109226, 181807, 182082, 188035-6, 188055-6, 225099-105; UTA 2500, 10317-21, 16274-9, 34597; USNM 128119, 138528-32, 202946-8, 220210, 245590-6, 258171-7; YPM 06944-6; Monroe County: AUM 2753, 21558; CAS8241, 8391, 144058, 184319, 210506; FMNH 21666, 27033-4, 83218, 160045, 160047-9, 160051-2, 168589-90, 168622-3; KU 68980-1, 92693-7; LACM 15608-20, 61568-74; LSUMZ 6511, 18994, 28854, 71661-7; MCZ 2447, 29907, 32498, 32577-85, 45212-4, 146404-24, 146428-60, 158971, 158973-9, 173212; MVZ 150161-6, 175934-5; TNHC 55300-9; UF 59, 1252, 2153, 2905, 3268, 7097, 7783, 44336, 50692-701, 57175, 67397-8, 86563-76, 91109-31, 98781-2, 98796-800, 102540-1, 122706, 130765, 132447-8, 137215, 137391-2, 142681-2, 142689, 143309, 151374, 152815-25; UMMZ 72442, 95568, 97484, 106190, 107194, 108185, 108366, 108370, 115965-6, 118512, 148933, 173861-947, 178280-1; UTA 8122-3; USNM 085175-99, 202917-27, 218750, 246845, 312911, 323194-8; Nassau County: UF 95568, 106651-2; Okaloosa County: UF 133632-3; Okeechobee County: UF 134125-30; Orange County: AUM 35787-9; MCZ 175829-30, 181402-3; UF 151250; USNM 245314; Osceola County: UF 134131-40; Palm Beach County: CAS 165962; MCZ 152592, 154934-53, 157206, 173193-6; UF 2859, 3071, 3263, 12049, 23936-41, 28105-40, 48921, 50691, 90535-9, 101676, 122465, 122504, 134699-703, 135629; USNM 258178-83; Pasco County: CAS165961; UF 142576; Pinellas County: CAS 165977-8, 166675-6, 169427-9, 200899; FMNH 204587; LACM 126181; LSUMZ 45781, 71656-8; MCZ 175778; TNHC 48857-63; UF 2860, 3260, 50712-8, 66726, 102340-1, 151001; USNM 245316-7, 245626-30, 257532, 258745; Polk County: CAS 238495; UF 43330-2, 50720-1, 123971-2, 134148-51; USNM 245315; Putnam County: UF 101605-6, 123401; Santa Rosa County: UF 152754-6; Sarasota County: USNM 549665-74; Seminole County: UF 134190-4; St. Johns County: UF 34404, 115692-3, 117451-8, 119126; St. Lucie County: MVZ 240606-7; UF 44103-6, 101601; Sumter County: UF 50685, 80801; Suwannee County: UF 134195-9; Taylor County: CAS 214327; Union County: UF 134200; Volusia County: UF 101607-8, 124689, 125028-35, 127117-24, 134156-61; Walton County: UF 153462-3. (1511)

Anolis trinitatis.—United States: Florida: Miami-Dade County: UF 144299, 151034. (2)

LIST OF REFERENCES

Achieng, A.P. 1990. The impact of the introduction of Nile Perch, *Lates niloticus* (L.) on the fisheries of Lake Victoria. Journal of Fish Biology 37: 17-23.

Allen, E.R., and R. Slatten. 1945. A herpetological collection from the vicinity of Key West, Florida. Herpetologica 3: 25-26.

Barbour, T. 1904. Batrachia and reptilian from the Bahamas. Bulletin of the Museum of Comparative Zoology 46: 54-61.

Bartlett, R.D. 1988. In search of reptiles and amphibians. E. J. Brill, New York, New York, USA. 363pp.

Bartlett, R.D. 1994. Florida's alien herps. Reptile & Amphibian Magazine (March-April):56-73, 103-109.

Bartlett, R.D., and P.P. Bartlett. 1999. A field guide to Florida reptiles and amphibians. Gulf, Houston, Texas, USA. 280pp.

Bell, L.N. 1953. Notes on three subspecies of the lizard *Anolis sagrei* in southern Florida. Copeia 1953:63.

Beuttell, K. and J.B. Losos. 1999. Ecological morphology of Caribbean anoles. Herpetological Monographs 13: 1-28.

Brach, V. 1976. Habits and food of *Anolis equestris* in Florida. Copeia 1976:187-189.

Brach, V. 1977. Notes on the introduced population of *Anolis cristatellus* in south Florida. Copeia 1977: 184-185.

Brown, L.N. 1972. Presence of the knight anole (*Anolis equestris*) on Elliott Key, Florida. Florida Naturalist 45:130.

Buden, D.W., and A. Schwartz. 1968. Reptiles and birds of the Cay Sal Bank, Bahama Islands. Quarterly Journal of the Florida Academy of Science 31: 290-320.

Burnell, K.L., and S.B. Hedges. 1990. Relationships of West Indian Anolis (Sauria: Iguanidae): An approach using slow-evolving loci. Caribbean Journal of Science 26: 7-30.

Buth, D.G., G.C. Gorman, and C.S. Lieb. 1980. Genetic divergence between *Anolis carolinensis* and its Cuban progenitor, *Anolis porcatus*. Journal of Herpetology 14: 279-284.

Butterfield, B.P. 1996. Patterns and processes of invasions by amphibians and reptiles into the West Indies and south Florida. Dissertation, Auburn University, Auburn, Alabama, USA.

Butterfield, B.P., W E. Meshaka, Jr., and R.L. Kilhefner. 1994. Two anoles new to Broward County, Florida. Herpetological Review 25: 77-78.

Campbell, T.S. 1996. Northern range expansion of the brown anole (*Anolis sagrei*) in Florida and Georgia. Herpetological Review 27:155-157.

Campbell, T.S. 2003. The introduced brown anole (*Anolis sagrei*) occurs in every county in peninsular Florida. Herpetological Review 34:173-174.

Camposano, B.J., K.L. Krysko, K.M. Enge, E.M. Donlan, and M. Granatosky. 2008. The knight anole (*Anolis equestris*) in Florida. Iguana 15:212-219.

Carr, A.F., Jr. 1939. A geckonid lizard new to the fauna of the United States. Copeia 1939: 232.

Chun, W.C.H. 2001. Population systematic of the Carolina anole, *Anolis carolinensis* Voigt (squamata: iguana: polychrotidae): geographical variation in morphology. Thesis, California State University, Long Beach, California, USA.

Collette, B. 1961. Correlations between ecology and morphology in anoline lizards from Havana, Cuba and southern Florida. Bulletin of the Museum of Comparative Zoology 125: 136-162.

Cope, E.D. 1863. On *Trachycephalus, Scaphiopus* and other American Batrachia. Proceedings of the Natural Sciences of Philadelphia 1: 43-54.

Conant, R., and J.T. Collins. 1998. A field guide to amphibians and reptiles of eastern and central North America. Third edition, expanded. Houghton Mifflin, Boston, Massachusetts, USA. 616pp.

Dalrymple, G.H. 1980. Comments on the density and diet of a giant anole *Anolis equestris*. Journal of Herpetology 14:412-415.

Elstrott, J., and D.J. Irschick. 2004. Evolutionary correlations among morphology, habitat use and clinging performance in Caribbean *Anolis* lizards. Biological Journal of the Linnaean Society 83: 389-398.

Elton, C. 1958. The Ecology of Invasions by Animals and Plants. Methuen, London, United Kingdom. 181pp.

Enge, K.M., K.L. Krysko, K.R. Hankins, T.S. Campbell, and F.W. King. 2004. Status of the Nile monitor (*Varanus niloticus*) in southwestern Florida. Southeastern Naturalist 3: 571-582.

Engeman, R.M., D. Hansen, and H.T. Smith. 2005. *Chamaeleo gracilis* (graceful chameleon). Reproduction in Florida. Herpetological Review 36: 445-446.

Florida Fish and Wildlife Conservation Commission [FWC]. 1999-2011. Florida's Nonnative Species page. http://www.myfwc.com/wildlifehabitats/nonnative_index.htm. Accessed 10 Aug 2011.

Foran, B.D. 1986. The impact of rabbits and cattle on an arid calcareous shrubby grassland in central Australia. Vegetatio 66: 49-59.

Fritts, T.H. and G.H. Rodda. 1998. The role of introduced species in the degradation of island ecosystems: a case history of Guam. Annual Review of Ecology and Systematics 29: 113-140.

Garcia-Berthou, G. 2001. On the misuse of residuals in ecology: testing regression residuals vs. the analysis of covariance. Journal of Animal Ecology 70: 708-711.

Garman, S. 1887. On West Indian Iguanidae and on West Indian Scincidae in the collection of the Museum of Comparative Zoology at Cambridge, Mass., U.S.A. Bulletin of the Essex Institute 19: 25-50.

Glor, R.E., M.E. Gifford, A. Larson, J.B. Losos, L.R. Schettino, A.R.C. Lara, and T.R. Jackman. 2004. Partial island submergence and speciation in an adaptive radiation: a multilocus analysis of the Cuban green anoles. Proceedings of the Royal Society B 271: 2257-2265.

Glor, R.E., J.B. Losos, and A. Larson. 2005. Out of Cuba: overwater dispersal and speciation among lizards in the *Anolis carolinensis* subgroup. Molecular Ecology 14: 2419-2432.

Godley, J.S., F.E. Lohrer, J.N. Layne, and J. Rossi. 1981. Distributional status of an introduced lizard in Florida: *Anolis sagrei*. Herpetological Review 12:84-86.

Goin, C.J. 1947. Studies on the life history of *Eleutherodactylus ricordii planirostris* (Cope) in Florida, with special reference to the local distribution of an allelomorphic color pattern. University of Florida Press, Gainesville, Florida, USA. 66pp.

Green, A.J. 2001. Mass/length residuals: measures of body condition or generators of spurious results? Ecology 82: 1473-1483.

Hadley, C.E. 1931. Color changes in excised and intact reptilian skin. Journal of Experimental Zoology 58: 321-331.

Horton, D.R. 1972. Lizard scale size and adaptation. Systematic Zoology 21: 441-443.

Hulbert, R.C., Jr., editor. 2001. The Fossil Vertebrates of Florida. University of Florida Press, Gainesville, Florida, USA.

Irschick, D.J., and J.B. Losos. 1996. Morphology, ecology and behavior of the twig anole, *Anolis angusticeps*. Pages 291-301 *in* R. Powell and R. W. Henderson, editors. Contributions to West Indian Herpetology: A Tribute to Albert Schwartz. Society for the Study of Amphibians and Reptiles, Ithica, New York. Contributions to Herpetology, volume 12.

Irschick, D.J., L.J. Vitt, P.A. Zani, and J.B. Losos. 1997. A comparison of evolutionary radiations in mainland and Caribbean *Anolis* lizards. Ecology 78: 2191-2203.

King, F.W. 1960. New populations of West Indian reptiles and amphibians in southeastern Florida. Quarterly Journal of the Florida Academy of Sciences 23: 71-73.

King, F.W., and T. Krakauer. 1966. The exotic herpetofauna of southeast Florida. Quarterly Journal of the Florida Academy of Sciences 29: 144-154.

Kolbe, J.J. and J.B. Losos. 2005. Hind-Limb Length Plasticity in *Anolis carolinensis*. Journal of Herpetology 39: 674-678.

Kolbe, J.J., A. Larson, and J.B. Losos. 2007. Differential admixture shapes morphological variation among invasive populations of the lizard *Anolis sagrei*. Molecular Ecology 16: 1579-1591.

Kolbe, J.J., R.E. Glor, L.R. Schettino, A C. Lara, A. Larson, and J.B. Losos. 2007. Multiple sources, admixture, and genetic variation in introduced *Anolis* lizard populations. Conservation Biology 21: 1612-1625.

Kraus, F. 2009. Alien reptiles and amphibians: a scientific compendium and analysis. Invading Nature: Springer Series in Invasion Ecology, Volume 4. Springer, New York, New York, USA. 563pp.

Krysko, K.L., and K.J. Daniels. 2005. A key to the geckos (Sauria: Gekkonidae) of Florida. Caribbean Journal of Science 41: 28-36.

Krysko, K.L., and K.M. Enge. 2005. A new non-native lizard in Florida, the butterfly lizard, *Leiolepis belliana* (Sauria: Agamidae). Florida Scientist 68: 247-249.

Krysko, K.L., J.P. Burgess, M.R. Rochford, C.R. Gillette, D. Cueva, K.M. Enge, L.A. Somma, J.L. Stabile, D.C. Smith, J.A. Wasilewski, G.N. Kieckhefer III, M.C. Granatosky, and S.V. Nielsen. 2011. Verified non-indigenous amphibians and reptiles in Florida from 1863 through 2010: Outlining the invasion process and identifying invasion pathways and stages. Zootaxa 3028: 1-64.

Latella, I.M., S. Poe, and J.T. Giermakowski. 2010. Traits associated with naturalization in *Anolis* lizards: comparison of morphological, distributional, anthropogenic, and phylogenetic models. Biological Invasions 13: 845-856.

Lee, J.C. 1980. Variation and systematics of the *Anolis sericeus* complex (Sauria: Iguanidae). Copeia 1980: 310-320.

Lee, J.C. 1985. *Anolis sagrei* in Florida: phenetics of a colonizing species. I. Meristic characters. Copeia 1985: 182-194.

Lee, J.C. 1987. *Anolis sagrei* in Florida: phonetics of a colonizing species. II. Morphometric characters. Copeia 1987: 458-469.

Lee, J.C. 1990. Sources of extraneous variation in the study of meristic characters: the effect of size and of inter-observer variability. Systematic Zoology 39: 31-39.

Lever, C. 2001. The Cane Toad. The History and Ecology of a Successful Colonist. Westbury Publishing, West Yorkshire, UK.

Lever, C. 2003. Naturalized reptiles and amphibians of the world. Oxford University Press, New York, USA. 318pp.

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.

Lobdell, R.N. 1936. Field and laboratory studies upon insect pests of south Florida with particular reference to method of control. Annual Report of the Agricultural Experiment Station., University of Florida, Gainesville, Florida, USA.

Losos, J.B., T.W. Schoener, K.I. Warheit, and D. Creer. 2001. Experimental studies of adaptive differentiation in Bahamian *Anolis* lizards. Genetica 112-113: 399-415.

Malhotra, A., and R.S. Thorpe. 1991. Microgeographic variation in Anolis oculatus, on the island of Dominica, West Indies. Journal of Evolutionary Biology 4:321-335.

Meshaka, W.E., Jr., R.M. Clouse, B.P. Butterfield, and J.B. Hauge. 1997. The Cuban green anole, Anolis porcatus: a new anole established in Florida. Herpetological Review 28:101-102.

Meshaka, W.E., B.P. Butterfield, and J.B. Hauge. 2004. The exotic amphibians and reptiles of Florida. Krieger Publishing Company, Malabar, Florida, USA.

Miyamoto, M.M., M.P. Hayes, and M.R. Tennant. 1986. Biochemical and morphological variation in Floridian populations of the bark anole (*Anolis distichus*). Copeia 1986: 76-86.

Myers, R.L., and J.J. Ewel. 1990b. Problems, prospects, and strategies for conservation. In R.L. Myers and J.J. Ewel, editors, *Ecosystems of Florida*. Orlando: University of Central Florida Press.

Neill, W.T. 1957. Historical biogeography of present-day Florida. Bulletin of the Florida State Museum, Biological Sciences 2:175-220.

Nicholson, K.E., R.E. Glor, J.J. Kolbe, A. Larson, S.B. Hedges, and J.B. Losos. 2005. Mainland colonization by island lizards. Journal of Biogeography 32: 929-938.

Ober, L.D. 1973. Introduction of the Haitian anole, *Anolis cybotes*, in the Miami area. HISS News-Journal 1:99.

Ogutu-Ohwayo, R. 1990. The decline of the native fishes of lakes Victoria and Kyoga (East Africa) and the impact of introduced species, especially the Nile perch, *Lates niloticus*, and the Nile tilapia, *Oreochromis niloticus*. Environmental Biology of Fishes 27: 81-96.

Oliver, J.A. 1948. The anoline lizards of Bimini, Bahamas. American Museum Novitates 1383: 1-36.

Oliver, J.A. 1950. *Anolis sagrei* in Florida. Copeia 1950:55-56.

Peterson, J.A., and E.E. Williams. 1981. A case history in retrograde evolution: The *onca* lineage in anoline lizards. II. Subdigital fine structure. Bulletin of the Museum of Comparative Zoology 149: 215-268.

Phillips, B.L., G.P. Brown, J. Webb and R. Shine. 2006. Invasion and the evolution of speed in toads. Nature 439: 803.

Pimentel, D., R. Zuniga, and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52: 273-288.

Powell, R., J.T. Collins, and E.D. Hooper, Jr. 1998. A key to amphibians and reptiles of the continental United States and Canada. University Press of Kansas, Lawrence, USA.

Roberts, M.F. 1977. All about chameleons and anoles. T. H. F. Publications, Inc., Neptune, New Jersey, USA. 79pp.

Rolls, E.C. 1969. They All Ran Wild. Angus and Robertson, Sydney, Australia. 546pp.

Ruibal, R. 1964. An annotated checklist and key to the anoline lizards of Cuba. Bulletin of the Museum of Comparative Zoology 130: 476-516.

Ruibal, R., and E.E. Williams. 1961. Two sympatric Cuban anoles of the *carolinensis* group. Bulletin of the Museum of Comparative Zoology 125: 183-208.

Ruibal, R., and V. Ernst. 1965. The structure of the digital setae of lizards. Journal of Morphology 117: 271-293.

Savidge, J.A. 1987. Extinction of an Island Forest Avifauna by an Introduced Snake. Ecology 68: 660-668.

Schettino, L.R., editor. 1999. The iguanid lizards of Cuba. University of Florida Press, Gainesville, Florida, USA. 428pp.

Schoener, T.W., and G.C. Gorman. 1968. Some niche differences in three Lesser Antillean lizards of the genus *Anolis*. Ecology 49: 819-830.

Schwartz, A. 1971. *Anolis distichus* Cope. Bark anole. Catalogue of American Amphibians and Reptiles 108. 1-4.

Schwartz, A., and R. Thomas. 1975. A check-list of West Indian amphibians and reptiles. Carnegie Museum of Natural History, Special Publication No. 1. 216pp.

Schwartz, A., and R.W. Henderson. 1991. Amphibians and reptiles of the West Indies: descriptions, distributions, and natural history. University of Florida Press, Gainesville, Florida, USA. 720pp.

Seigel, B.J., N.A. Seigel, and R.A. Seigel. 1999. Geographic distribution: *Anolis cristatellus* (Puerto Rican crested anole). Herpetological Review 30: 173.

Simberloff, D. 1986. Introduced insects: A biogeographic and systematic perspective. Pages 3-26 *in* H.A. Mooney and J.A. Drake, editors. Ecology of Biological Invasions of North America and Hawaii. Springer-Verlag. New York, New York, USA.

Simberloff, D. 1997. The Biology of Invasions. Pages 3-17 *in* D. Simberloff, D. C. Schmitz, and T. C. Brown, editors. Strangers in paradise. Impact and management of nonindigenous species in Florida. Island Press, Covelo, California, USA.

Smith, C.A., and K.L. Krysko. 2007. Distributional comments on the teiid lizards (Squamata: Teiidae) of Florida with a key to the species. Caribbean Journal of Science 43: 260-265.

Smith, H.M., and R.H. McCauly. 1948. Another new anole from south Florida. Proceedings of the Biological Society of Washington 61: 159-166.

TIGR Reptile Database. [TIGR]. 2010. TIGR Homepage. http://www.reptile-database.org/. Accessed 8 October 2010.

Van Rooijen, J., and G. Vogel. 2009. A multivariate investigation into the population systematics of *Dendrelaphis tristis* (Daudin, 1803) and *Dendrelaphis tristis* (Kuhl, 1820): revalidation of *Dendrophis chairecacos* Boie, 1827 (Serpentes: Colubridae). Herpetological Journal 19: 193-200.

Vance, T. 1987. The Cuban green anole (*Anolis porcatus*): a colonizing species. Bulletin of the Maryland Herpetological Society 23: 105-108.

Weber, W. 1983. Photosensitivity of chromatophores. American Zoologist 23: 495-506.

Williams, E.E. 1969. The ecology of colonization as seen in the zoogeography of anoline lizards on small islands. Quarterly Review of Biology 44: 345-389.

Williams, E.E. 1983. Ecomorphs, faunas, island size, and diverse end points in island radiations of *Anolis*. Pages 326-370 *in* R. B. Huey, E. R. Pianka, and T. W. Schoener, editors. Lizard ecology: studies of a model organism. Harvard University Press, Cambridge, MA, USA.

Wilson, L.D., and L. Porras. 1983. The ecological impact of man on the south Florida herpetofauna. University of Kansas Museum of Natural History, Special Publication No. 9, Lawrence, Kansas, USA. 89pp.

BIOGRAPHICAL SKETCH

Brian Joseph Camposano was born in 1983 in Naples, Florida. The oldest of three children, he grew up on Marco Island, Florida, graduating from Lely High School in 2001. He earned his B.S. in Wildlife Ecology and Conservation from the University of Florida in 2005. He was also a member of the Lambda Chi Alpha fraternity, serving as the treasurer from 2002 to 2004.

Upon beginning his research towards a M.S. in interdisciplinary ecology, Brian began working as a part-time biologist for the Florida Forest Service at Goethe State Forest in Dunnellon, Florida. There he worked conducting surveys for various reptile and amphibian species, assisted in monitoring red-cockaded woodpecker populations, and also took an active role in the prescribed burning program.

In 2010, Brian accepted a full time position with the Florida Forest Service as a District Biologist for the Jacksonville District. He continues to enjoy many different facets of land management, and graduated from Wildland Fire School in November 2011. Upon completion of his M.S. degree, Brian will continue to serve as District Biologist and take an active role in wildfire prevention and suppression.