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Extreme climate events such as droughts, cold snaps, and hurricanes can be powerful agents of natural selection, producing acute selective pressures very different from the everyday pressures acting on organisms. Yet, it remains unknown whether these infrequent but severe disruptions are quickly erased by quotidian selective forces, or whether they have the potential to durably shape biodiversity patterns across regions and clades. Here, we show that hurricanes have enduring evolutionary impacts on the morphology of anoles, a diverse Neotropical lizard clade. We first demonstrate a trans-generational effect of extreme selection on toepad area for two populations struck by hurricanes in 2017. Given this short-term effect of hurricanes, we then asked whether populations and species that more frequently experienced hurricanes have larger toepads. Using 70 years of historical hurricane data, we demonstrate that, indeed, toepad area positively correlates with hurricane activity for both 12 island populations of *Anolis sagrei* and 188 *Anolis* species throughout the Neotropics. Extreme climate events are intensifying due to climate change and may represent overlooked drivers of biogeographic and large-scale biodiversity patterns.

Keywords: Cyclones, Extreme Climate Events, Rapid Evolution, *Anolis*

Significance statement: Extreme climate events can act as agents of natural selection. We demonstrate that lizards hit by Hurricanes Irma and Maria in 2017 passed on their large, strong-gripping toepads to the next generation of lizards. Moreover, we found that across 12 insular populations of *A. sagrei*, and 188 *Anolis* species across the neotropics, those hit by more hurricanes in the last 70 years tended to have proportionately larger toepads. Our study suggests that hurricanes can have long-term and large-scale evolutionary impacts that transcend biogeographic and phylogenetic scales. As hurricanes become more severe due to climate change, these extreme climate events may have a much larger impact on the evolutionary trajectory of the affected ecological communities than previously appreciated.

Extreme climate events can be powerful agents of natural selection, but their consequences for large-scale biodiversity patterns are relatively unknown (1–3). Some theory predicts that infrequent, extreme selection events on ecological timescales will not have long-lasting evolutionary impacts on species (4). Few empirical studies have tested this prediction because extreme climate events are intrinsically rare (1, 5). Testing the long-term evolutionary effects of extreme climate events requires investigating two propositions: first, that extreme events actually impose strong selection and, second, that the evolutionary response to this selection is durable enough to shape large scale diversity patterns. To date, such data only exist for Darwin's finches on a small, isolated island (6). There, researchers observed that extreme wet or dry years drive strong selection, but that alternating extreme climate events reverse the direction of selection and erase the evolutionary trends on decadal timescales (6). An alternative approach to tracking evolutionary change over time is to compare it over space, with the prediction that if extreme events have long-lasting impact, then populations in areas more often affected by such events will exhibit traits different from those in less-affected areas. Here, we pair a cross-generational and spatial approach to investigate the evolutionary impact of hurricane-induced selection.

Immediately following Hurricanes Irma and Maria in 2017, we documented rapid, directional shifts in morphology in two island populations of a Caribbean anole (*Anolis scriptus*) in the Turks and Caicos Islands (TCI) (3). We found that post-hurricane populations had larger subdigital toepads—a key trait in anoles responsible for clinging performance (3, 7). However, it remained unclear whether this selection would lead to persistent phenotypic differences in the population through time.

In 2019, we revisited the *A. scriptus* populations on Pine and Water Cays (TCI) to determine whether the hurricane effect had persisted in the 18 months following the initial selective event. We resurveyed the populations following the same methods used in 2017 (see Methods). The relative surface areas of the fore- and hind limb toepads of the populations measured 18 months after the hurricanes were statistically indistinguishable from those of the hurricane survivors (forelimb: β ± s.e.: -0.009 ± 0.006, t_{290} = -1.37; P = 0.1709; hind limb: β ± s.e.: -0.007 ± 0.006, t_{291} = -1.278; P = 0.2024), and remained significantly larger than those of the pre-hurricane populations (forelimb: β ± s.e.: 0.050 ± 0.007, t_{290} = 7.117; $P < 0.0001$; hind limb: β ± s.e.: 0.038 ± 0.006, t_{291} = 6.074; $P < 0.0001$; Fig. 1; all analyses corrected for body size). Moreover, these patterns of selection (3) and persistence (shown here) were parallel across both island populations (see Appendix 1 for full model output).

To test whether these trait shifts transcended generations, we further analyzed these data, restricting the analyses to those individuals measured in 2019 that, based upon estimated growth rates, most likely hatched after the hurricane and thus were offspring of hurricane survivors (Supplemental Information). Results were unchanged: the relative surface area of the toepads of these next-generation lizards was indistinguishable from that of the hurricane survivors (forelimb: β ± s.e.: -0.006 ± 0.018, t_{267} = -0.332; P = 0.7401; hind limb: β ± s.e.: -0.011 ± 0.015,

t_{269} = -0.711; P = 0.4774), and remained significantly larger than the pre-hurricane populations (forelimb: $\beta \pm$ s.e.: 0.124 ± 0.020, t_{267} = 6.086; P < 0.0001; hind limb: $\beta \pm$ s.e.: 0.093 ± 0.017, t_{269} = 5.246; P < 0.0001; Fig. 1). The shifts were parallel on the two islands and robust for different growth rate estimates (Appendix 1).

These results demonstrate that changes following a catastrophic selective event were maintained over the short term. To test whether such events have longer-term impacts, we broadened our sampling and investigated whether variation in hurricane history across space correlated with variation in toepad characteristics at two geographical scales: within a single wide-spread species found on many Caribbean islands, and across the range of the *Anolis* genus.

To do so, we surveyed populations of the brown anole (*A. sagrei*), a species that is similar in ecology and morphology to *A. scriptus* (8). Across 12 islands that span the natural range of *A. sagrei* from the Bahamas to the Cayman Islands, the number of hurricane events in the preceding 70 years significantly predicted the surface area of an island population's toepads (forelimb: $\beta \pm$ s.e.: 0.050 ± 0.018, t_9 = 2.878; P = 0.0182; hind limb: $\beta \pm$ s.e.: 0.055 ± 0.014, t_9 = 3.881; P = 0.0037; Fig. 2; analyses accounted for body size and phylogenetic non-independence; see Methods for hurricane activity calculations and Appendix 2 for full model output). Island populations of *A. sagrei* that experienced more hurricanes have relatively larger toepads than those that experienced fewer hurricanes.

We next investigated whether the hurricane-driven pattern would hold true across the distribution of the *Anolis* genus as a whole. We measured toepad size for 188 species of *Anolis* lizards across the clade's distribution (Fig. 3). Species that experienced more hurricanes had relatively larger toepads on both forelimbs ($\beta \pm$ s.e.: 0.061 ± 0.012, t_{165} = 5.031; P < 0.0001) and hind limbs ($\beta \pm$ s.e.: 0.050 ± 0.013, t_{165} = 3.90; P = 0.0001; Fig 3; analyses accounted for body size and phylogenetic non-independence; Appendix 3). We tested additional potential explanatory variables across the range of the anoles including local maximum tree height, air temperature, and precipitation and found no significant correlations with toepad area (Appendix 4, Appendix 5). Eliminating mainland species – which typically experience fewer hurricanes than their insular counterparts – yielded a similar positive relationship (forelimb: $\beta \pm$ s.e.: 0.056 $\pm$ 0.013, $t_{121} = 4.467$; $P < 0.0001$; hind limb: $\beta \pm$ s.e.: 0.048 $\pm$ 0.012, $t_{121} = 3.882$; $P = 0.00017$; Appendix 3).

The correlation between toepad surface area and hurricane activity seen among populations of *A. sagrei* and across Neotropical *Anolis* could arise in two ways. On one hand, selection for larger toepads, as seen in *A. scriptus* in the Turks and Caicos, may have long-lasting consequences that are not erased by different selection pressures in periods between hurricanes. Alternatively, hurricanes may change the environment in ways that change selection pressures in subsequent years when hurricanes don't occur. However, given that hurricane-prone areas tend to have shorter trees (Appendix 4) and that a general positive correlation between perch height and toepad area exists (8), one might expect hurricane-prone areas to have smaller toepads, the opposite of the trend we observed. More detailed analysis of how hurricanes affect vegetation structure vis-à-vis anole habitat use, as well as long-term selection studies, are needed to clarify this mechanism.

Our demonstration that rare but extreme events can impact evolution raises the further question of what role such events play in shaping phylogenetic patterns of trait diversity compared to other selective factors. Caribbean anoles are an excellent group in which to investigate this pattern because of the well-documented replicated patterns of adaptive radiation across Greater Antillean islands (8, 9). Anoles have repeatedly diverged into multiple habitat specialist types, termed ecomorphs, that differ in morphological traits related to habitat use. In the context of this adaptive divergence, we can ask what effect hurricane activity has on this variation in relative toepad surface area. For all ecomorphs, species in areas more frequently hit by hurricanes have larger toepads (Appendix 3). One might predict that the effect of hurricanes would differ among habitats—more arboreal species, for example, might be more exposed to the storm's force. Our analyses, however, find that the response to hurricanes was consistent and positive across habitat specialist types (Appendix 3). Moreover, hurricane activity explains a substantial portion of variation in relative toepad area (Table 1), revealing a hitherto unsuspected driver of anole diversity and demonstrating that extreme events can be a major contributor to phenotypic diversity patterns at large phylogenetic and biogeographic scales.

More remains to be discovered about how variation in hurricane attributes (e.g., storm duration, prevailing direction, accompanying rain) affects the concurrent and post-hurricane selective landscape for anoles. A preliminary analysis found no relationship between time since last hurricane and toepad area in our *A. sagrei* samples (Appendix 2.2); however, repeated sampling following storms is needed to fully address this question. Moreover, toepads are only one of several traits in anoles linked to clinging capacity, and so future work comparing limb morphology (10) and claw shape (11, 12) may yet reveal new insights into the biomechanical predictors of survivorship during storms (13, 14) and the clade-wide impacts of hurricanes on the morphology in this genus.

Hurricanes are intensifying due to climate change (15–17) and can be powerful agents of natural selection (3). As such, they may represent overlooked drivers of biogeographic and phylogenetic patterns, necessitating a global, cooperative effort to determine their ecological and evolutionary effects (18). For anoles, hurricanes are severe selective events, leading to population-level changes in morphology that persist across generations. Moreover, as evidenced by the relationship between toepad surface area and hurricane activity within and among *Anolis* species, hurricanes can have long-lasting evolutionary effects. Our study therefore demonstrates that extreme climate events can have enduring evolutionary impacts that transcend phylogenetic and geographic scales.

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Factor	Forelimb R^2	Hind Limb R^2
Hurricane Activity + Ecomorph	0.50	0.40
Hurricane Activity	0.19	0.11
Ecomorph	0.29	0.26

Table 1: The explanatory power of ecomorph class and historical hurricane activity in the observed patterns of forelimb and hind limb toepad surface area (see Supplemental Material).

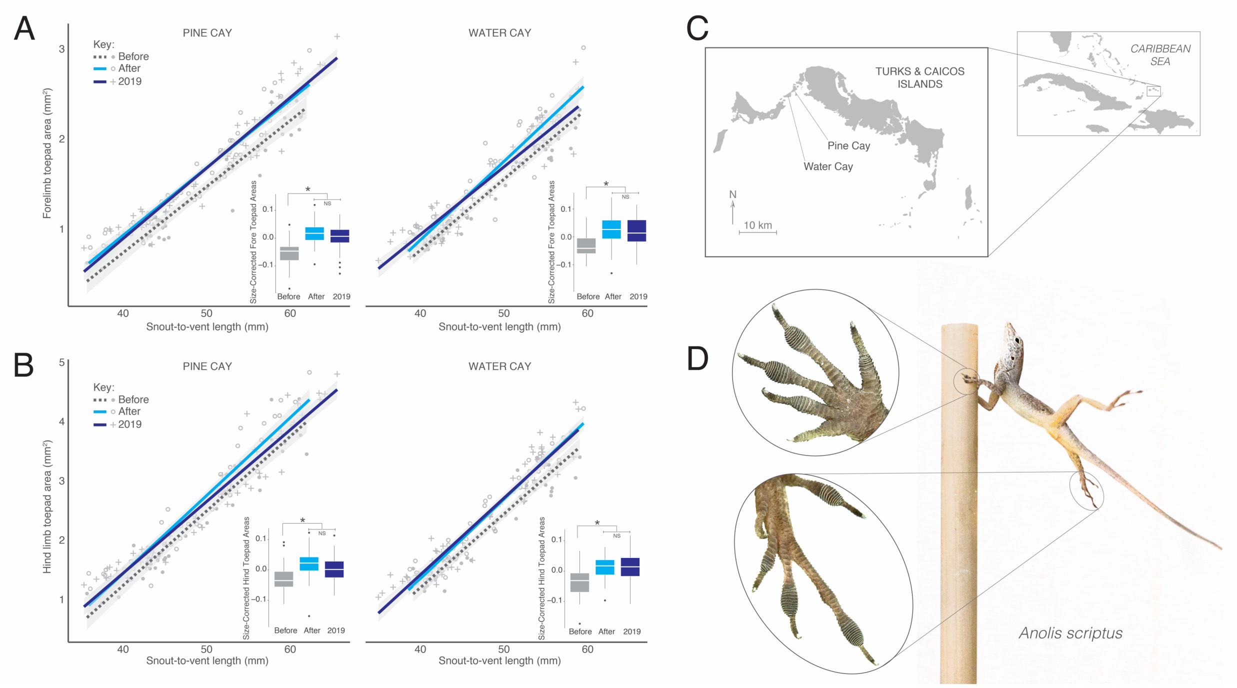

Fig 1. *Anolis scriptus*, like other anoles, use specialized toepads to cling to surfaces (D: inset images: a lizard clings to a perch while experiencing hurricane-force winds in a performance experiment, see *3*). Populations of *A. scriptus* on Pine and Water Cays in the Turks and Caicos Islands (C) that survived 2017's Hurricanes Irma and Maria had relatively larger toepads on average than the populations surveyed before the storms (*3*). When we resurveyed the populations in 2019 (A and B) following the storms, those body-size-corrected differences in toepad area persisted.

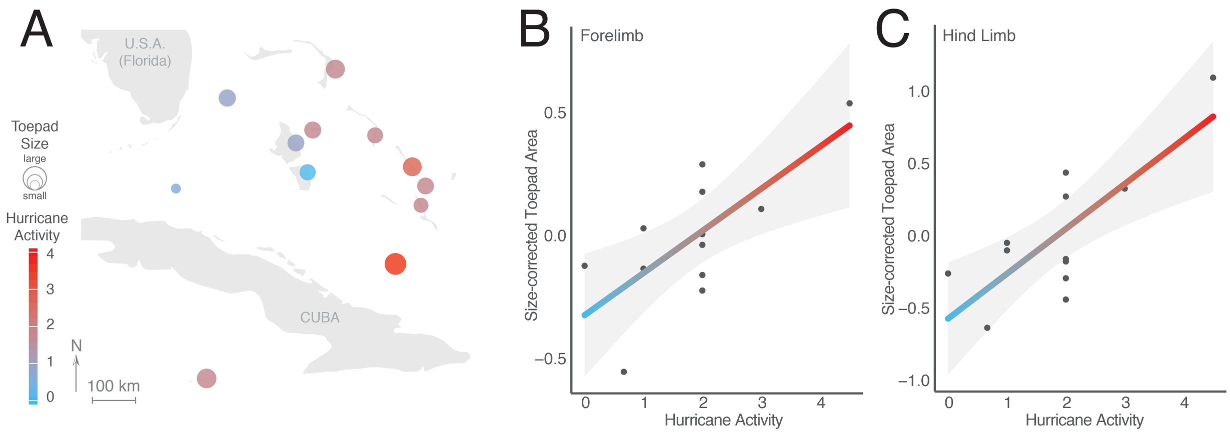

Fig 2. By measuring toepad areas of individuals from 12 populations of *A. sagrei* (A), we found that populations that experienced more hurricanes in the last 70 years (red) had larger toepads than those that were hit less often (blue). In the map, each point corresponds to an island population, the size of the point corresponds to the relative toepad surface area of that population, and the color to the number of hurricanes experienced in the last 70 years. Regressions are of phylogenetically and body-size-corrected toepad area residuals for forelimbs (B) and hind limbs (C). See Supplemental Information for additional detail about the hurricane activity calculation.

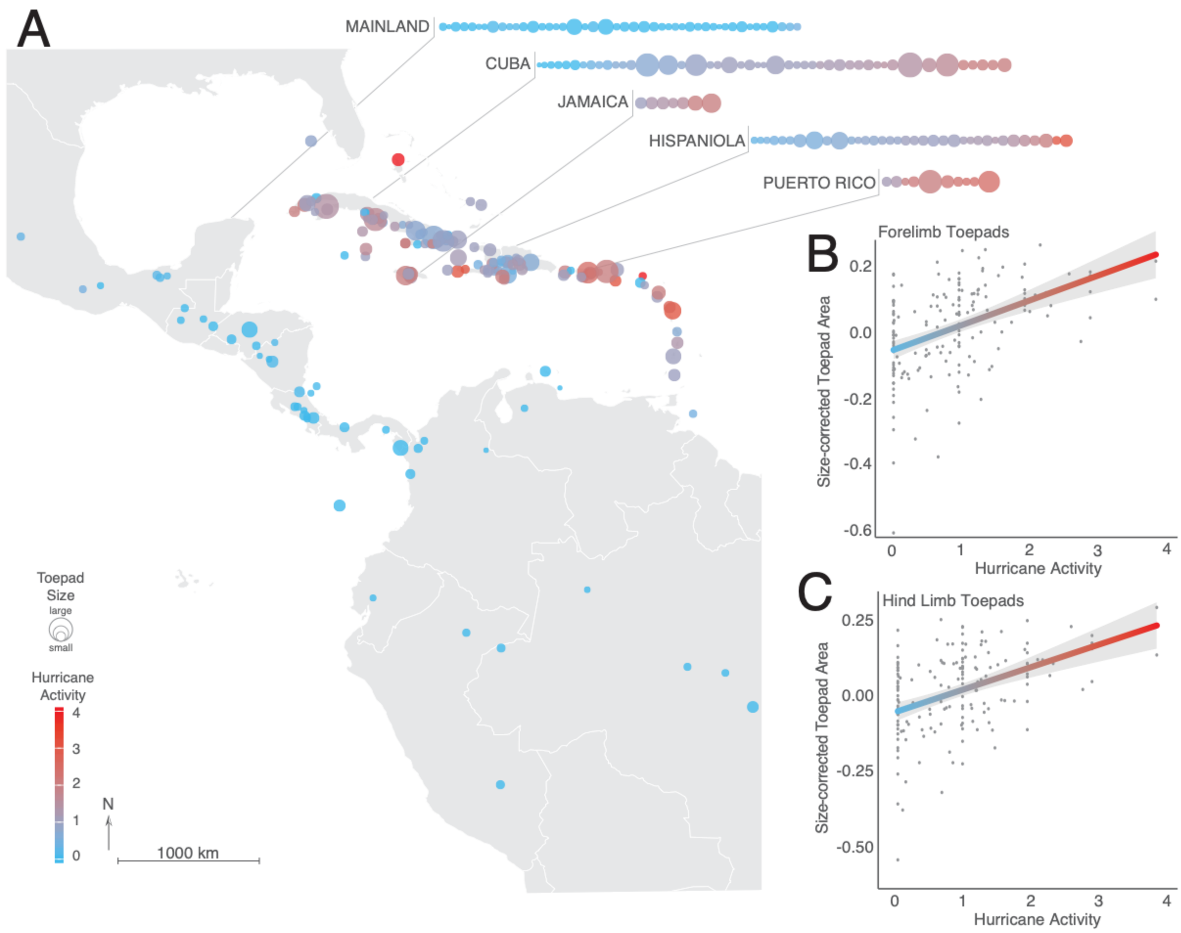

Fig 3. Across the full geographic expanse of the *Anolis* clade, here with each point representing one of 188 species, toepad area – accounting for phylogeny and body size – is significantly positively correlated with the number of hurricanes experienced by that species over the last 70 years. (A) Each point represents the centroid of a species range, the color of that point indicates the mean number of hurricanes experienced across the species' range, and the size of the point corresponds to the average body-size-corrected toepad area. For clarity, we highlighted the species on the mainland and on each of the Greater Antillean islands in callouts and ordered them by increasing hurricane activity. Size-corrected residuals of forelimb (B) and hind limb (C) toepad areas are positively related to hurricane activity.

Methods:

No statistical methods were used to pre-determine sample sizes for any aspect of this study.

***Anolis scriptus* in Turks and Caicos**

Pine Cay and Water Cay – two small islands in the Turks and Caicos Islands – are home to the endemic Turks and Caicos anole, *Anolis s. scriptus*. Both islands are relatively small (Pine Cay: 350 ha; Water Cay: 250 ha), flat, and covered by vegetation that averages between one and three meters in height. Adult Turks and Caicos anoles range in size between 40 – 65 mm in snout-to-vent length (SVL) and are sexually dimorphic: adult females are smaller than males. The species is conspicuous and abundant and can typically be found perched on small branches in the lower 1.5 m of the islands' vegetation (19).

Between 28 August and 4 September 2017, we surveyed the *A. scriptus* populations on Pine Cay and Water Cay to establish baselines for the populations in anticipation of a conservation project. Following a direct hit by Hurricane Irma (8 September 2017) and glancing blow by Hurricane Maria (22 September 2017), we revisited the islands between 16 October and 20 October 2017 to determine whether the surviving lizard populations differed significantly in morphology from the pre-hurricane populations (detailed in *3*).

We repeated those surveys 18 months (1 April to 8 April 2019) after our initial post-hurricane survey. For those revisits, the same researchers (CMD, A-CF, AH) walked the same, approximately two-km-long transect on each island and caught lizards by hand or with a pole and fishing line slipknot (following *3*). In this way, we caught 117 lizards in 2019 (See Table S1.1).

We repeated the morphological measurements from the pre- and post-hurricane sampling for those lizards caught in 2018 and 2019. In brief, the same researcher (AH) measured morphology using digital calipers (Mitutoyo 500-752), and CMD took a high-resolution photograph of the right fore- and hind feet of each lizard using an iPhone 7 with a Moment Macro Lens attachment (See *3* for additional details). Using ImageJ (v.1.51a., W. Rasband, National Institute of Health, Bethesda), CMD measured the toepad area of the longest toe (digit III on forelimb, digit IV on hind limb) on each lizard's right forelimb and hind limb to the first scale after the toepad begins to widen (Fig. M1).

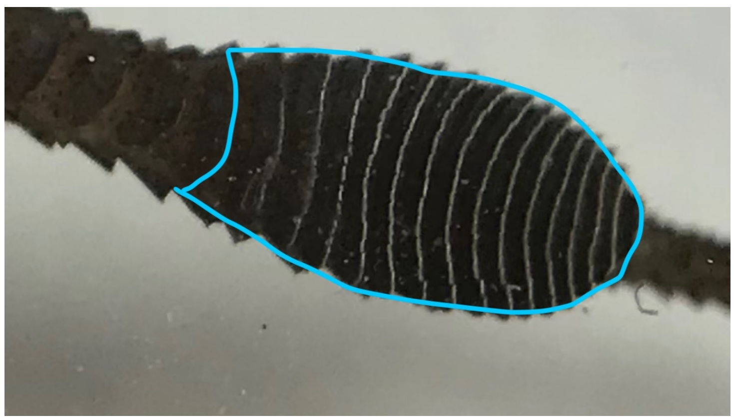

Fig. M1: An illustration of the toepad surface area measurement used for this study.

Identifying lizards hatched since the 2017 hurricanes

In order to determine whether the hurricanes had a sustained impact on the subsequent generation of *A. scriptus* on Pine Cay and Water Cay, we calculated an estimate for how large a lizard that hatched one year before the 2019 survey (and thus, necessarily the offspring of hurricane survivors) might have grown. We used a logistic-by-length model that previous researchers have demonstrated adequately characterizes growth for small-bodied anoles that are ecologically similar to *A. scriptus* (20–22).

$$L_2 = \frac{\alpha L_1}{L_1 + (\alpha - L_1)e^{-rD}}$$

This model estimates final estimated body size (L_2) based upon initial size (L_1), time elapsed (D), characteristic growth rates for the population (r) and the asymptotic maximum size (α). For initial size we used 19 mm, an average hatchling size for *A. sagrei* (23). We parameterized D as 365 days, signifying an April 1, 2018 hatch date. We used separate values of α for males and females using the largest *A. scriptus* individual of each sex we measured in any survey (male maximum SVL: 65.75 mm in 2019 sample; female maximum SVL: 49.74 mm in 2017, post-hurricane sample). As characteristic growth rate estimates have never been calculated for *A. scriptus*, we identified studies that have previously calculated growth rates in ecologically similar species (*A. sagrei*: *20, 22*, *A. acutus: 21*). For our primary analysis, we used the lowest, most conservative growth rates (male = 0.006, *21*, and female = 0.0083, *22*). Andrews' calculated female growth rate was 0.009 resulting in a slightly larger, less conservative, female body size estimate (Table S1.2). We re-analyzed the data using other growth rates and found the same results (Appendix 1). Using these parameters, we calculated the maximum size of an individual hatched on or after April 1, 2018 would be 46.13 mm for females and 51.55 mm for males during our 2019 survey. April 1, 2018 was chosen as the earliest included hatch date because lizards hatched earlier may have been derived from eggs that survived the hurricanes, even if their parents did not, or could be the result of sperm storage from a male who did not survive. We used these as cutoffs and analyzed all smaller lizards caught in 2019, assuming that these lizards had hatched within the previous year (Table S1.3). See Appendix 1 for additional data and details.

Data analysis

Our primary aim was to determine whether the toepads of the *A. scriptus* surveyed in 2019 were statistically different from those measured in 2017, either before or after the hurricanes. To do so we used general linear models (GLM) with the surface area of the forelimb toepads, or hind limb toepads as the response variable. We included body size – SVL – as a factor in the GLM to account for differences in body size between the sampling times. In addition, we added a factor for island of origin – Pine Cay or Water Cay – and an additional fixed effect for each of the three sampling periods: pre-hurricane, post-hurricane, and 2019. Both SVL and the toepad surface areas were log10 transformed to improve normality of the data. See Appendix 1 for complete model description. To evaluate differences between survey years, we used the 'lsmeans' (24) and 'effects' (25, 26), packages in R (R Core Team). We used the same analytical methods with the subset of lizards caught in 2019 and most likely having hatched within the previous year.

Comparative analyses among anole populations and species

Identifying lizard localities:

Anolis sagrei is a common and widespread anole and is ecologically similar to *A. scriptus* (8). It can be found on numerous islands in the West Indies, including the Bahamas, Cuba, Jamaica, and the Caymans. As part of an ongoing comparative study on *A. sagrei* across its range, CMD, AJG, and RGR collected data on individuals from 12 islands. All of these lizards were captured in similar closed-canopy coppice forest in 2016 and 2017. We recorded the GPS locations of these sampling sites during the collection surveys.

Locality data for the entire genus were drawn from a dataset published by Velasco et al. (27). These locality data were collected from multiple sources including the Global Biodiversity Information Facility (GBIF, http://gbif.org), HerpNET (http://herpnet.org) and previously published distribution datasets (see *27* for complete list of sources).

Calculating a hurricane activity measure

We used each of the lizard locality points – for field-caught *A. sagrei* and the Velasco et al. (27) records for the genus as a whole – to calculate the average number of hurricane hits for each species.

We first obtained the latitude-longitude position and maximum sustained wind speed for all tropical cyclones in the North Atlantic and eastern North Pacific basins between 1949 and 2017. Data from 1949 to 2016 were obtained from the International Best Track Archive for Climate Stewardship v03r10 (IBTrACS; *28*). Because 2017 IBTrACS data were not yet available, we obtained the 2017 data from the Tropical Cyclone Extended Best Track dataset (EBT; *29*). Both of these datasets provide position and maximum sustained wind speed data for each tropical cyclone every six hours at 0000, 0600, 1200, and 1800 UTC. IBTrACS also provides data for some storms at intermediate times such as landfall events. Because 2017 EBT data did not include these intermediate times, we added them using National Hurricane Center storm reports (30) to ensure consistency across the dataset.

After all tropical cyclone data were compiled, we interpolated the storm position and wind speed to 24 evenly spaced time intervals between each available data point. These interpolated points provide an estimate of each tropical cyclone's position and intensity every 15 minutes, or occasionally somewhat more frequently when intermediate time points (e.g., landfall time) are also recorded. We interpolated both position and windspeed to ensure a hit was counted: fast-moving storms may hit a population within the 6-hour window and yet exceed the distance threshold at the six-hour increment, and had we not interpolated, they would not have been counted.

For each of the anole locality points, we counted the number of tropical cyclones that passed within a radius (30, 50, or 100 km), while meeting or exceeding a windspeed intensity threshold (65, 80, 100 kt sustained winds; [1 kt = 0.514 ms^{-1}]) during the 1949-2017 period. We specified in our counting algorithm that each tropical cyclone could only produce a single hit at each GPS location, regardless of the number of time steps at which it satisfied the specified distance and intensity criteria, or whether the storm reversed direction and hit a locality a second time. We used MATLAB to calculate these hurricane counts (The MathWorks Inc., 2019; Appendix 8). Using these data, we then calculated the mean hurricane hits for each species by averaging the hurricane counts for each locality recorded for each species. This resulted in a continuous hurricane activity measure. For our main analyses, we focused on strong hurricanes reaching or exceeding 80 knots of sustained wind speed (see Appendix 6 for additional thresholds), as we previously found in laboratory conditions that *A. scriptus* lizards were, on average, blown off perches at 74.3 ± 2.3 knots (3). We also focused on direct hits, within 30 km of a GPS point in the spatial database. We conducted a sensitivity analysis to investigate how different windspeeds and radii thresholds affected our models (Appendix 6). In general, we found that increasing the threshold radius decreased the explanatory power for our model, *ergo* very distant hurricanes did not substantially affect populations. We also found that more powerful hurricanes (windspeed reaching or exceeding 100 kts) had a stronger effect than weaker storms (Appendix 6).

A consideration inherent to this dataset is that longer-term hurricane frequency at each location almost certainly differs from the frequency during the seven-decade dataset available for study (1949-2017). Direct strikes from hurricanes, especially strong hurricanes, are infrequent events; thus, it is likely that some vulnerable locations did not experience any direct strikes during this seven-decade window, even though they have experienced hurricanes on longer timescales.

Beyond the infrequent, stochastic nature of hurricane strikes, hurricane activity throughout the North Atlantic basin varies on time scales that are not well-reflected in this seven-decade dataset. Atlantic hurricane activity is modulated on multidecadal scales by the Atlantic Multidecadal Oscillation (AMO; *31*), which affects North Atlantic sea-surface temperatures and sea-level pressures. Positive (warm) AMO phases are associated with more numerous and intense North Atlantic hurricanes (32). The interval covered in this study spans 44 years of positive AMO (1949-1969; 1995-2017) and 25 years of negative AMO (1970-1994).

Research on prehistoric hurricanes has also revealed that North Atlantic hurricane activity has also varied across much longer timescales. Using both sedimentary records and a statistical model based on past climate reconstructions, Mann et al. (33) found a period of enhanced North Atlantic hurricane activity approximately 1000 years Before Present (BP), with a relatively quiescent period following it. Paleotempestological records also indicate low-frequency variations in the locations impacted by hurricanes. Liu and Fearn (34) showed that catastrophic hurricane strikes in northwest Florida were three to five times more frequent between 3400-1000 years BP, compared to 5000-3400 years and 1000-0 years BP. Elsner et al. (35) concluded that variations in the position and strength of the Bermuda High, associated with the North Atlantic Oscillation, affected hurricane tracks and thus the regions impacted by hurricanes. They found that periods of enhanced Gulf of Mexico hurricane activity coincided with suppressed activity on the United States northeast coast on several time scales. Similarly, McCloskey and Liu (36) found that periods of higher hurricane frequency in Nicaragua showed lower hurricane frequency in the northern Caribbean and North American Atlantic coast, whereas Baldini et al. (37) concluded that North Atlantic hurricane tracks have gradually shifted northward during the last five centuries from natural, and more recently, anthropogenic processes. Therefore, we do not assume that hurricane frequency at a point in the North Atlantic basin during the 1949-2017 period is necessarily representative of hurricane frequency at that location on longer time scales.

Calculating mean tree heights

Using the same locality database employed in calculating the number of hurricanes for each species, we calculated the mean height of trees at that location using a tree heights dataset published by Simard et al. in which they used 2005 satellite-based lidar to estimate global tree heights (38). We calculated mean tree heights within a 30, 50, and 100 km radius of each locality. The radii were chosen to match the radii of the hurricane activity algorithm. We then averaged these tree heights for each radius and each locality to calculate a mean tree height for every species in the database.

Measuring toepads

Toepad images of 10 *A. sagrei* individuals per island population were collected in the field by RGR, AJG, and CMD and from museum specimens of all other species by DLM, HKF and assistants using a flatbed scanner (Epson Perfection V500 Photo or Canon CanoScan LiDE 70). The preserved *Anolis* specimens used for this study are from the collections of the Harvard Museum of Comparative Zoology, Field Museum of Natural History, Institute of Ecology and Systematics (Havana, Cuba), and Drs. Steven Poe and Richard Glor. For all species in the interspecific dataset, CMD measured toepad surface area (ImageJ) of the third toe on the forelimb and the fourth (longest) toe on the hind limb following the same methods as the *A. sagrei* and *A. scriptus* analyses (Fig. M1). Three adult individuals were measured for each of 175 species, and those measurements were averaged to calculate a species mean. For five additional species, only two specimens were available, and eight species in the dataset had only one available specimen. While these species with fewer than three specimens were included in the published results, repeating the analysis with only those subsets of species with exactly three specimens yielded similar significant results. Because mismatches between a species' average toepad characteristics as estimated from our sample, and the average hurricanes experienced by that species were potentially systematically exacerbated for wide-spread species, we repeated the whole-genus analysis without the seven most widespread species (Appendix 7). We found the same significant results.

Data analysis

Phylogenetic methods

The phylogeny of *Anolis sagrei* populations (Fig. S2.1) was generated by pruning a larger tree previously inferred by van de Schoot (39). Briefly, the mitochondrial-encoded locus NADPH Dehydrogenase Subunit 2 (plus some post-terminal tRNA-encoding sequence) was amplified and sequenced for specimens of *Anolis sagrei* from across the species' natural range. Contig assembly and manual alignment was performed using Geneious R9.1 (https://www.geneious.com). The optimal partitioning scheme, and the model of molecular evolution best fitting each partition was determined using PartitionFinder v1.1.1 (40). van de Schoot used Bayesian Inference to estimate the phylogeny of this group using MrBayes v3.2.6 (41) and found all of the islands included in our sample to be monophyletic; therefore, for the present study we pruned the phylogeny down to a single individual per island. For most islands the individual used for the pruned phylogeny was a lizard for which we had also collected morphological data. To represent the remaining islands (Eleuthera, South Bimini, Cay Sal, Cayman Brac) in the phylogeny, we selected an individual collected from the same site and at the same time as the lizards that were measured. For the phylogenetic comparative analyses spanning the entire genus, we used a recent tree by Poe et al (42).

To account for phylogenetic non-independence in our comparative datasets, either between the 12 *A. sagrei* populations or across the genus as a whole, we used phylogenetic comparative linear models evaluated using the phytools (43), caper (44), GEIGER (45), ape (46), and picante (47) packages in R (R core team).

Our phylogenetic generalized least squares models took the form:

$$log_{10}(toepad\ area) \sim log_{10}(SVL) + Hurricane\ Activity$$

with delta, and kappa transformations set to 1 and the lambda phylogenetic signal parameter freely estimated (“ML”).

Spatial Autocorrelation

For the A. *sagrei* and genus-wide analyses, we tested whether phylogenetic regression results were potentially influenced by residual spatial autocorrelation by constructing Moran’s I correlograms. We calculated Moran’s I using 25km lag distances, e.g. all points separated by less than 25km (in any direction), then points between 25km and 50km apart, and so on to a maximum of 600km. We tested for significance using randomization tests. Correlograms were generated using the correlog() function in the ncf package (48). We found no significant spatial autocorrelation in residuals of any regression model at any lag distance ($P > 0.10$ in all cases), suggesting that phylogenetic autocorrelation and hurricane activity can account for spatial patterns in toepads and regression results are not confounded by spatial autocorrelation. Thus, we did not consider spatial autocorrelation further (Fig. S2.2; S3.1, S3.6).

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Author Contributions:

CMD initiated the study; CMD, AH, and A-CF collected *A. scriptus* field data, CMD, AJG, and RGR collected *A. sagrei* field data; additional datasets were contributed by AK (hurricane activity), HKF, DLM with help from SB (*Anolis*-wide toepad photos), AA, JV (*Anolis* distribution), AA (tree heights), and AJG (*A. sagrei* phylogeny); CMD, DLM, AA, and RWB analyzed the data; CMD prepared figures; CMD, JTS, and JBL wrote the manuscript; all authors contributed to improving the final manuscript draft.

Competing Interests: The authors declare no competing interests.

Data and Materials Availability: Upon publication, all data will be made available on the DRYAD digital repository.

Supplementary Materials for:

Hurricane Effects on Neotropical Lizards Span Geographic and Phylogenetic Scales

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This PDF file includes:

Appendix 1: ***Anolis scriptus***

Table S1.1: Number of *Anolis scriptus* on Pine Cay and Water Cay measured during the three surveys.

	Pine Cay		Water Cay	
	Female	**Male**	**Female**	**Male**
Pre-Hurricane, 2017	19	18	20	20
Post-Hurricane, 2017	24	29	28	25
2019	26	33	31	27

Table S1.2: Parameters used for estimating the logistic-by-length growth rate cut-offs for *A. scriptus* on Pine Cay and Water Cay that had most likely hatched within one year of the 2019 survey (and therefore parented by hurricane survivors). Three parameters were employed based upon our data and question (D, L_1, α). A characteristic growth rate has never been calculated for *A. scriptus*, and so we instead used four published estimates for males and females of ecologically similar anoles (*A. sagrei, A. acutus*). Using these parameters, we calculated SVL estimates (see logistic-by-length equation in-text or *20*). We then used the most conservative male and female SVL estimates to serve as our cutoff for subsequent analyses.

Growth Estimate Parameters					
D =	365	Time since hatching (days)			
L_1 =	19	Hatching size (mm)			
α =	65.75	Male asymptote (mm)			
α =	49.74	Female asymptote (mm)			
r =	(Published Growth Rates)				
	Male	**Female**	**Species**	***notes***	***citation***
r_1=	0.0143	0.0116	*A. sagrei*		*(20)* Schoener & Schoener 1978
r_2=	0.006	0.009	*A. acutus*		*(21)* Andrews 1976
r_3=	0.0109		*A. sagrei*	*Nutrient-Subsidized*	*(22)* Wright et al. 2013
r_4=	0.0083		*A. sagrei*	*Nutrient-Unsubsidized*	*(22)* Wright et al. 2013

SVL Estimates		
	Male	**Female**
r_1=	64.89	48.60
r_2=	**51.55**	46.90
r_3=	62.86	48.28
r_4=	58.76	**46.13**

Table S1.3: The number of individuals on Pine Cay and Water Cay caught in 2019 that were smaller than the maximum body size estimated for a one-year-old individual based on the growth estimates calculated in Table S1.2. The conservative growth rate for males (r_2) led to a dramatic reduction in male sample size. The second most conservative threshold (r_4) led to a much higher inclusion rate in the dataset (2019*). The change in sample sizes, however, did not change the outcome of the results: the lizards measured in 2019 most likely to have had hurricane-survivor parents were statistically indistinguishable from the population measured immediately post-hurricane and were significantly different from those measured immediately before the hurricanes.

	Pine Cay		Water Cay	
	Female	Male	Female	Male
2019 (r_2)	25	4	30	5
2019* (r_4)	25	20	30	26

Supplemental Analysis 1.1:

The conservative SVL cutoff used in the manuscript (r_2) for males dramatically decreased sample sizes for the 2019 lizards (Table S1.3). As this was the lowest, most conservative relevant growth rate we found in the literature, we used it for the primary reported analyses in the manuscript. However, including only nine males between the two islands means that this analysis may be unduly skewed by outliers or atypical individuals. We thus repeated the analysis with the second most conservative growth rate (r_4). This growth estimate included more of the lizards measured in 2019 (Table S1.3) and a proportion of the male individuals that was more in-line with the proportion identified for females. The (r_4) rate for males was still substantially lower than two other growth rates in the literature, and in our opinion still represents a reasonable conservative estimate for the growth rate of *A. scriptus* in the year preceding the 2019 survey.

Regardless of the growth rate used, the analysis yielded the same results. The lizards measured in 2019 that had most likely hatched in the year preceding the survey were statistically indistinguishable from the lizards that survived the hurricanes and had significantly larger toepads than those measured before the hurricanes.

For all subsequent analyses our model took the form:

$$log_{10}(toepad\ area) \sim log_{10}(SVL) + Hurricane\ [Before|After|2018|2019] + Origin[Pine\ Cay|WaterCay] + Sex[Male|Female]$$

Growth rate (r_2): Forelimb Toepads:

```
Coefficients:
                Estimate Std. Error t value Pr(>|t|)    
(Intercept)     -8.21243    0.25007 -32.840  < 2e-16 ***
log(SVL)         2.20223    0.06806  32.357  < 2e-16 ***
HurricaneAfter   0.00597    0.01798   0.332   0.7401    
HurricaneBefore -0.12409    0.02039  -6.086 4.01e-09 ***
OriginWater Cay  0.03714    0.01396   2.660   0.0083 ** 
SexMale          0.09733    0.01875   5.192 4.13e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1142 on 267 degrees of freedom
  (5 observations deleted due to missingness)
Multiple R-squared:  0.9094,  Adjusted R-squared:  0.9077 
F-statistic:   536 on 5 and 267 DF,  p-value: < 2.2e-16

contrast       estimate     SE  df t.ratio p.value
 2019 - After   -0.00597 0.0180 267 -0.332  0.7401
 2019 - Before   0.12409 0.0204 267  6.086  <.0001
 After - Before  0.13006 0.0173 267  7.535  <.0001

Results are averaged over the levels of: Origin, Sex 
Results are given on the log (not the response) scale. 
P value adjustment: holm method for 3 tests 

Anova Table (Type III tests)

Response: log(FingerArea)
             Sum Sq  Df   F value    Pr(>F)    
(Intercept) 14.0727   1 1078.4629 < 2.2e-16 ***
log(SVL)    13.6620   1 1046.9871 < 2.2e-16 ***
Hurricane    0.8094   2   31.0125 7.748e-13 ***
Origin       0.0923   1    7.0733  0.008297 ** 
Sex          0.3517   1   26.9535 4.134e-07 ***
Residuals    3.4840 267                        
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Growth rate (r_4): Forelimb Toepads:

```
Coefficients:
                 Estimate Std. Error t value Pr(>|t|)    
(Intercept)      -8.13035    0.22437 -36.237  < 2e-16 ***
log(SVL)          2.17945    0.06061  35.961  < 2e-16 ***
HurricaneAfter    0.01195    0.01498   0.798  0.42570    
HurricaneBefore -0.11722    0.01719  -6.818 4.97e-11 ***
OriginWater Cay  0.03531    0.01284   2.750  0.00633 ** 
SexMale          0.09830    0.01833   5.364 1.62e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.112 on 304 degrees of freedom
  (5 observations deleted due to missingness)
Multiple R-squared:  0.9173,  Adjusted R-squared:  0.916 
F-statistic: 674.7 on 5 and 304 DF,  p-value: < 2.2e-16

contrast       estimate     SE  df t.ratio p.value
 2019 - After    -0.0119 0.0150 304 -0.798  0.4257
 2019 - Before    0.1172 0.0172 304  6.818  <.0001
 After - Before   0.1292 0.0169 304  7.644  <.0001

Results are averaged over the levels of: Origin, Sex 
Results are given on the log (not the response) scale. 
P value adjustment: holm method for 3 tests 

Anova Table (Type III tests)

Response: log(FingerArea)
             Sum Sq  Df   F value    Pr(>F)    
(Intercept) 16.4824   1 1313.1265 < 2.2e-16 ***
log(SVL)    16.2318   1 1293.1633 < 2.2e-16 ***
Hurricane    0.8244   2   32.8399 1.223e-13 ***
Origin       0.0949   1    7.5599  0.006325 ** 
Sex          0.3611   1   28.7699 1.617e-07 ***
Residuals    3.8158 304                        
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Growth rate (r_2): Hind Limb Toepads:

```
Coefficients:
                Estimate Std. Error t value Pr(>|t|)    
(Intercept)     -7.92374    0.21839 -36.283  < 2e-16 ***
log(SVL)         2.25173    0.05943  37.889  < 2e-16 ***
HurricaneAfter   0.01118    0.01571   0.711    0.477    
HurricaneBefore -0.09296    0.01772  -5.246 3.15e-07 ***
OriginWater Cay -0.01374    0.01222  -1.124    0.262    
SexMale          0.09603    0.01641   5.851 1.42e-08 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1003 on 269 degrees of freedom
  (3 observations deleted due to missingness)
Multiple R-squared:  0.9327,  Adjusted R-squared:  0.9314 
F-statistic: 745.3 on 5 and 269 DF,  p-value: < 2.2e-16

contrast       estimate     SE  df t.ratio p.value
 2019 - After    -0.0112 0.0157 269 -0.711  0.4774 
 2019 - Before    0.0930 0.0177 269  5.246  <.0001 
 After - Before   0.1041 0.0151 269  6.905  <.0001 

Results are averaged over the levels of: Origin, Sex 
Results are given on the log (not the response) scale. 
P value adjustment: holm method for 3 tests 

Anova Table (Type III tests)

Response: log(ToeArea)
             Sum Sq  Df   F value    Pr(>F)    
(Intercept) 13.2476   1 1316.4639 < 2.2e-16 ***
log(SVL)    14.4463   1 1435.5815 < 2.2e-16 ***
Hurricane    0.5098   2   25.3305 8.335e-11 ***
Origin       0.0127   1    1.2645    0.2618    
Sex          0.3445   1   34.2303 1.418e-08 ***
Residuals    2.7070 269                        
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Growth rate (r_4): Hind Limb Toepads:

```
Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)      -7.941659   0.200262 -39.656  < 2e-16 ***
log(SVL)          2.255307   0.054103  41.685  < 2e-16 ***
HurricaneAfter    0.010978   0.013412   0.819    0.414
HurricaneBefore -0.093615   0.015308  -6.115 2.95e-09 ***
OriginWater Cay -0.005056   0.011477  -0.441    0.660
SexMale           0.096399   0.016351   5.896 9.88e-09 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1003 on 305 degrees of freedom
  (4 observations deleted due to missingness)
Multiple R-squared:  0.9366,  Adjusted R-squared:  0.9356
F-statistic: 901.7 on 5 and 305 DF,  p-value: < 2.2e-16

contrast       estimate     SE  df t.ratio p.value
 2019 - After    -0.0110 0.0134 305 -0.819  0.4137
 2019 - Before    0.0936 0.0153 305  6.115  <.0001
 After - Before   0.1046 0.0151 305  6.949  <.0001

Results are averaged over the levels of: Origin, Sex
Results are given on the log (not the response) scale.
P value adjustment: holm method for 3 tests

Anova Table (Type III tests)

Response: log(ToeArea)
             Sum Sq  Df   F value    Pr(>F)
(Intercept) 15.8060   1 1572.6226 < 2.2e-16 ***
log(SVL)    17.4646   1 1737.6464 < 2.2e-16 ***
Hurricane    0.5418   2   26.9518 1.666e-11 ***
Origin       0.0020   1    0.1941    0.6599
Sex          0.3494   1   34.7600 9.881e-09 ***
Residuals    3.0655 305
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Appendix 2: *Anolis sagrei*

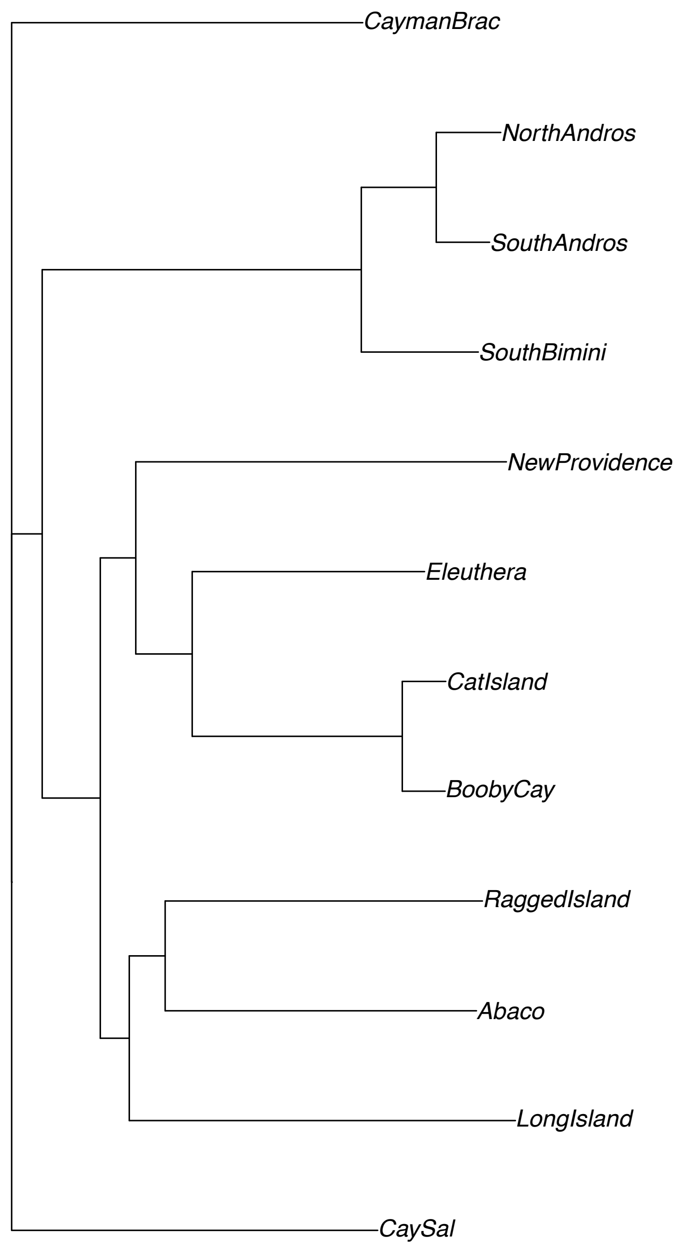


Fig. S2.1: The *A. sagrei* tree used for the phylogenetic comparative analyses. Branch ends are the island names where each population resides.

Forelimb Toepad Area:

Variable codes are:
fore_area: forelimb toepad area
log10svl: log-transformed body length
h80_30: number of hurricanes exceeding 80 knots of wind within 30 km of site

```
pgls(formula = log10(fore_area) ~ log10svl + h80_30, data = comp_sagrei_dat,
    lambda = "ML", kappa = 1, delta = 1, bounds = list(delta = c(1e-06,
        3)))

Residuals:
     Min       1Q   Median       3Q      Max
-0.26757 -0.04259  0.09646  0.20087  0.34285

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.000
   lower bound : 0.000, p = 1
   upper bound : 1.000, p = 0.035505
   95.0% CI    : (NA, 0.972)
delta  [Fix]  : 1.000

Coefficients:
             Estimate Std. Error t value  Pr(>|t|)
(Intercept) -3.622045   0.649606 -5.5758 0.0003448 ***
log10svl     2.181836   0.389431  5.6026 0.0003332 ***
h80_30       0.050485   0.017542  2.8780 0.0182381 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2123 on 9 degrees of freedom
Multiple R-squared: 0.8708,   Adjusted R-squared: 0.842
F-statistic: 30.32 on 2 and 9 DF,  p-value: 0.0001003
```

Hind Limb Toepad Area:

Variable codes are:
hind_area: hind limb toepad area
log10svl: log-transformed body length
h80_30: number of hurricanes exceeding 80 knots of wind within 30 km of site

The PGLS model with delta = 1 fails to converge. Using ML to estimate delta and lambda simultaneously suggests the following relationship:

```
pgls(formula = log10(hind_area) ~ log10svl + h80_30, data = comp_sagrei_dat,
    lambda = "ML", kappa = 1, delta = "ML", bounds = list(delta = c(1e-06,
        3)))

Residuals:
     Min       1Q   Median       3Q      Max
-0.08356 -0.02510  0.01249  0.05534  0.12437

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.000
   lower bound : 0.000, p = 1
   upper bound : 1.000, p = 0.041964
   95.0% CI   : (NA, 0.982)
delta  [ ML]  : 0.304
   lower bound : 0.000, p = 3.956e-08
   upper bound : 3.000, p = 0.1186
   95.0% CI   : (0.008, NA)

Coefficients:
             Estimate Std. Error t value  Pr(>|t|)
(Intercept) -3.507083   0.527917 -6.6432 9.447e-05 ***
log10svl     2.225089   0.317047  7.0182 6.199e-05 ***
h80_30       0.055628   0.014333  3.8810  0.003725 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.07283 on 9 degrees of freedom
Multiple R-squared: 0.9203,   Adjusted R-squared: 0.9026
F-statistic: 51.97 on 2 and 9 DF,  p-value: 1.139e-05
```

For in-text results, delta was parameterized as 0.3, lambda as ML.

```
pgls(formula = log10(hind_area) ~ log10svl + h80_30, data = comp_sagrei_dat,
    lambda = "ML", kappa = 1, delta = 0.3, bounds = list(delta = c(1e-06,
        3)))

Residuals:
      Min        1Q    Median        3Q       Max
-0.078264 -0.019476 -0.002275  0.061900  0.123725

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.000
   lower bound : 0.000, p = 1
   upper bound : 1.000, p = 0.041081
   95.0% CI    : (NA, 0.980)
delta  [Fix]  : 0.300

Coefficients:
             Estimate Std. Error t value  Pr(>|t|)
(Intercept) -3.507257   0.527843 -6.6445 9.433e-05 ***
log10svl     2.225201   0.317000  7.0196 6.190e-05 ***
h80_30       0.055630   0.014332  3.8814  0.003723 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.07251 on 9 degrees of freedom
Multiple R-squared: 0.9203,   Adjusted R-squared: 0.9026
F-statistic: 51.99 on 2 and 9 DF,  p-value: 1.137e-05
```

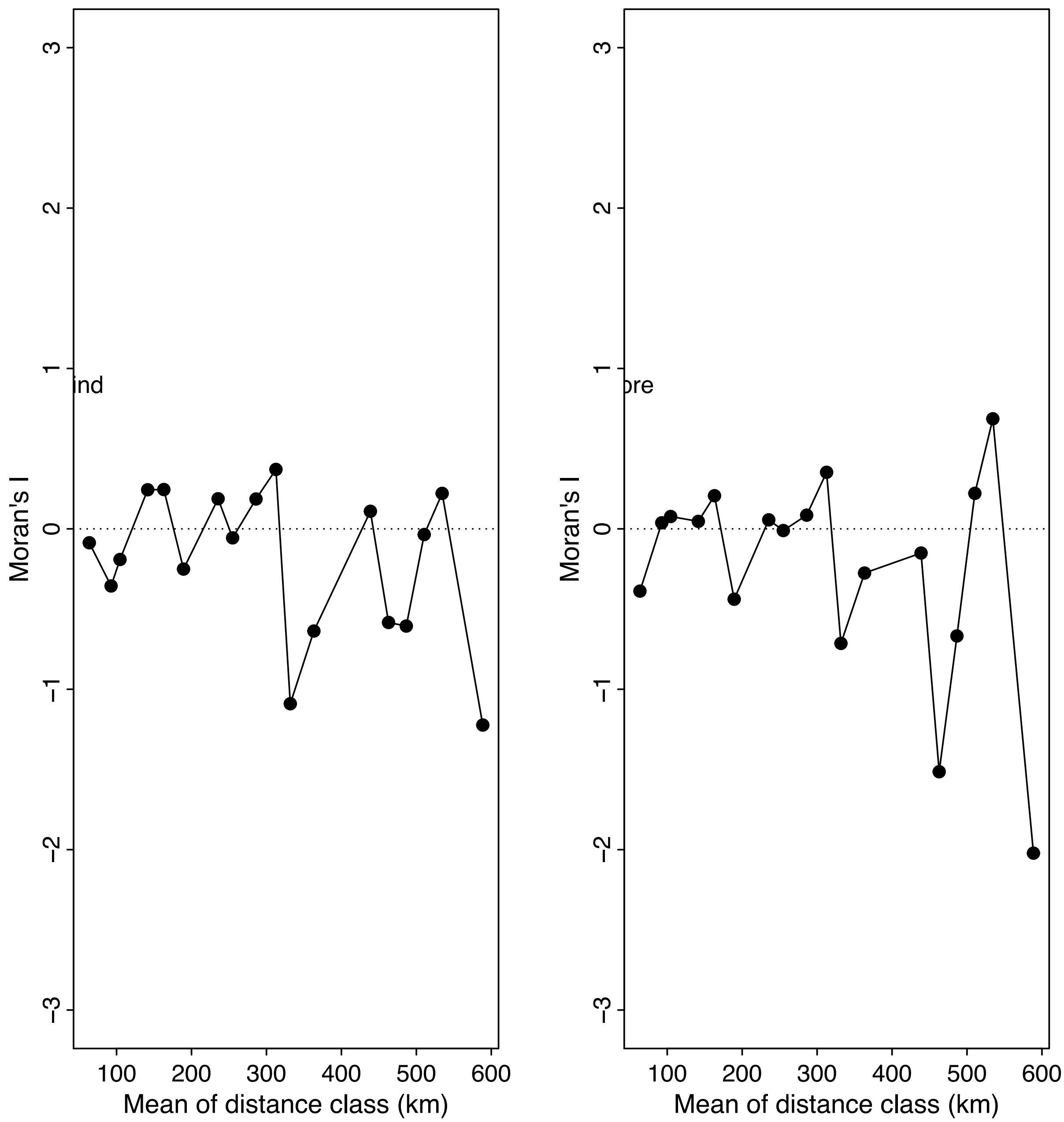


Fig. S2.2: Plot of Moran's I correlograms of hind limb toepad area (left) and forelimb toepad area (right) for 12 populations of *A. sagrei*. We found no structure in the residuals to indicate spatial autocorrelation in the data.

Appendix 2.2 Analyzing hurricane characteristics as a predictor of toepad area in *A. sagrei*

An open question is whether the time elapsed since the last hurricane or the strength of that hurricane affects the observed pattern in fore- and hind limb toepad area. We predicted, *a priori* that there might be a negative relationship between time since last hurricane and toepad areas – populations more recently hit by a hurricane would have relatively larger toepads whereas populations with a relatively longer elapsed time since the last hurricane strike might have proportionally smaller toepads. Moreover, we also predicted that populations experiencing a stronger recent hurricane would have relatively larger toepads than those experiencing a weaker hurricane at a similar time.

Due to gaps in collection dates and GPS localities in the cross-genus comparative analysis (Appendix 3) we are unable to satisfactorily address this question for the genus as a whole. Our *A. sagrei* collections, in contrast, have both high-resolution GPS coordinates and known collection times, and so are suited for a preliminary exploration of this question.

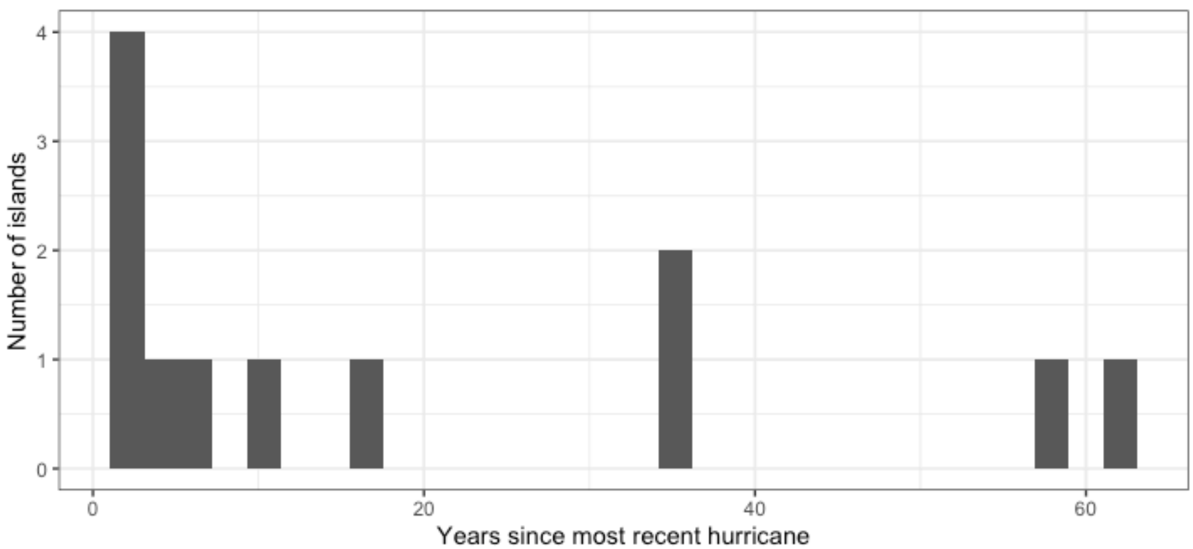


Figure 1 (above) shows the distribution of years since the last hurricane for the 12 Caribbean populations of *A. sagrei* used in this study. Eight of the island populations have had a direct hit by a tropical cyclone (within 30 km of the sampling area and by a storm exceeding 64 kts, the minimum windspeed threshold of NOAA's database) within the last 20 years.

We then analyzed whether time since most recent hurricane predicted variation in toepad area across these twelve populations. We did not find a statistically significant relationship:

Forelimb toepad area:

```
log10(Forelimb Toepad Area) ~ log10(SVL) + Time_elapsed
Coefficients:
              Estimate    Std. Error   t value  Pr(>|t|)
(Intercept)  -4.2042556   0.8730033    -4.816   0.000952 ***
log10(SVL)    2.5868819   0.5083294     5.089   0.000655 ***
Time_elapsed -0.0006062   0.0011944    -0.507   0.624009
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.07983 on 9 degrees of freedom
Multiple R-squared:  0.7934,  Adjusted R-squared:  0.7475
F-statistic: 17.29 on 2 and 9 DF,  p-value: 0.0008272
```

Hindlimb toepad area:

```
log10(Hind Limb Toepad Area) ~ log10(SVL) + Time_elapsed
Coefficients:
              Estimate   Std. Error   t value   Pr(>|t|)
(Intercept)  -4.0571486  0.8664043   -4.683     0.001148 **
log10(SVL)    2.6180992  0.5044870    5.190     0.000572 ***
Time_elapsed -0.000732   0.0011854   -0.618     0.551971
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.07923 on 9 degrees of freedom
Multiple R-squared:  0.8028,  Adjusted R-squared:  0.7589
F-statistic: 18.32 on 2 and 9 DF,  p-value: 0.0006721
```

In addition, we did not find a statistically significant relationship between the strength (windspeed at time of impact: “H1_VMAX”) of the most recent hurricane and the relative size of the fore- or hind limb toepads.

Forelimb toepad area:

```
log10(Forelimb Toepad Area) ~ log10(SVL) + H1_VMAX

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -4.103339   0.720896  -5.692 0.000297 ***
log10(SVL)   2.407560   0.447679   5.378 0.000446 ***
H1_VMAX      0.002228   0.001375   1.621 0.139452
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.07123 on 9 degrees of freedom
Multiple R-squared:  0.8356,  Adjusted R-squared:  0.799
F-statistic: 22.86 on 2 and 9 DF,  p-value: 0.0002966
```

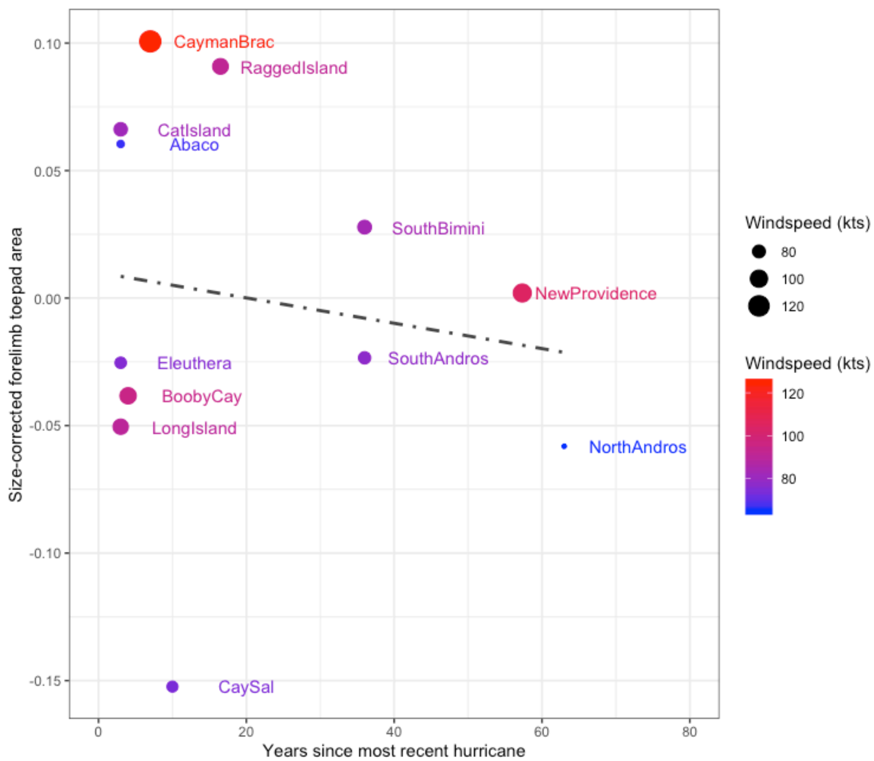
Hind limb toepad area:

```
log10(Hind Limb Toepad Area) ~ log10(SVL) + H1_VMAX

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -4.074072   0.765698  -5.321 0.000481 ***
log10(SVL)   2.535630   0.475502   5.333 0.000473 ***
H1_VMAX      0.001657   0.001460   1.135 0.285748
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.07566 on 9 degrees of freedom
Multiple R-squared:  0.8201,  Adjusted R-squared:  0.7802
F-statistic: 20.52 on 2 and 9 DF,  p-value: 0.0004438
```

This result can also be seen in the following figures:



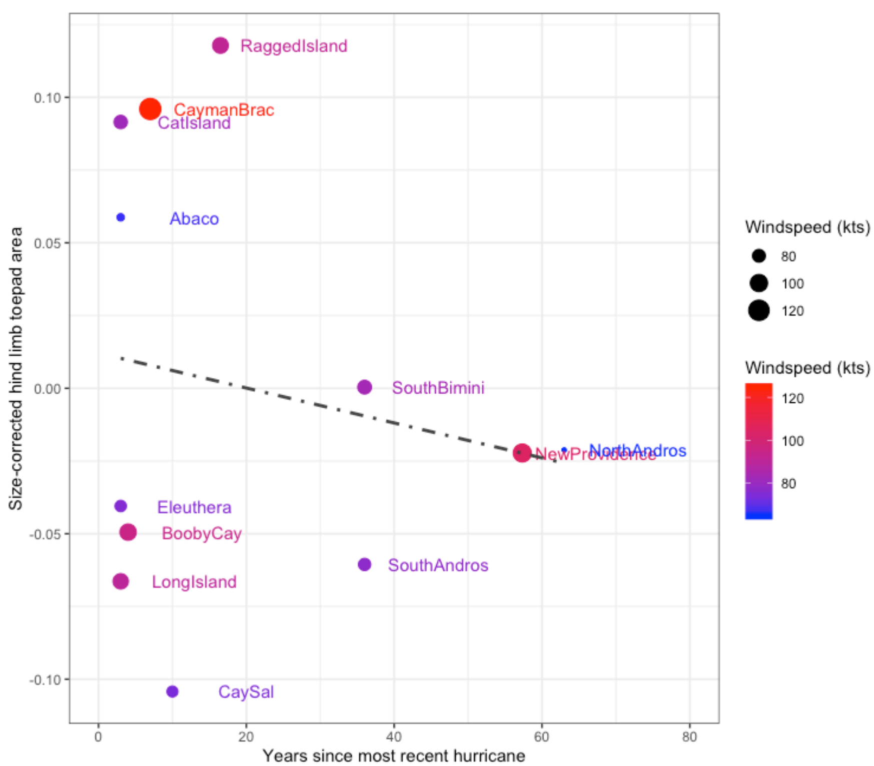


Figure 2 and 3: Relative forelimb and hind limb toepad area plotted against time elapsed since the most recent hurricane. Colors and size of the points correspond to the windspeed of the hurricane when it hit the study site (within 30 km). Dashed trend lines were added for illustration, though no statistically significant relationship was found.

This analysis implies no relationship between time since last hurricane and toepad area. One interpretation of this result is a slow relaxation of selection on toepads following the hurricanes. That said, this analysis would be substantially improved by repeated sampling within islands enabling a gradient of time-since-hurricane measurements. As of yet, we feel this result is preliminary and warrants further work to better understand the dynamics of the relaxation of selection following a hurricane.

Appendix 3: *Anolis* Across Its Range:

Appendix 3.1 The full *Anolis* radiation

Forelimb Toepad Area:

Variable codes are:
fore_area: forelimb toepad area
log10svl: log-transformed body length
h80_30: number of hurricanes exceeding 80 knots of wind within 30 km of site

```
pgls(formula = log10(fore_area) ~ log10svl + h80_30, data = comp_toepad_data,
    lambda = "ML", kappa = 1, delta = 1, bounds = list(delta = c(1e-06,
        15)))

Residuals:
     Min       1Q   Median       3Q      Max
-1.42270 -0.31776 -0.04874  0.31395  1.55929

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.615
   lower bound : 0.000, p = 2.7845e-07
   upper bound : 1.000, p = 5.5511e-16
   95.0% CI   : (0.383, 0.794)
delta  [Fix]  : 1.000

Coefficients:
             Estimate Std. Error  t value  Pr(>|t|)
(Intercept) -4.117143   0.128793 -31.9672 < 2.2e-16 ***
log10svl     2.420760   0.070677  34.2509 < 2.2e-16 ***
h80_30       0.060627   0.012050   5.0314 1.261e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4916 on 165 degrees of freedom
Multiple R-squared: 0.8832,   Adjusted R-squared: 0.8818
F-statistic: 623.9 on 2 and 165 DF,  p-value: < 2.2e-16
```

Hind Limb Toepad Area:

Variable codes are:
hind_area: hind limb toepad area
log10svl: log-transformed body length
h80_30: number of hurricanes exceeding 80 knots of wind within 30 km of site

```
pgls(formula = log10(hind_area) ~ log10svl + h80_30, data = comp_toepad_data,
    lambda = "ML", kappa = 1, delta = 1, bounds = list(delta = c(1e-06,
        15)))

Residuals:
     Min       1Q   Median       3Q      Max
-1.47947 -0.32750 -0.02448  0.30392  1.38938

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.624
   lower bound : 0.000, p = 6.9777e-06
   upper bound : 1.000, p = < 2.22e-16
   95.0% CI   : (0.369, 0.809)
delta  [Fix]  : 1.000

Coefficients:
             Estimate Std. Error  t value  Pr(>|t|)
(Intercept) -3.682054   0.138500 -26.5852 < 2.2e-16 ***
log10svl     2.279498   0.075986  29.9988 < 2.2e-16 ***
h80_30       0.050417   0.012920   3.9023 0.0001385 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.5292 on 165 degrees of freedom
Multiple R-squared: 0.852,    Adjusted R-squared: 0.8502
F-statistic: 475.1 on 2 and 165 DF,  p-value: < 2.2e-16
```

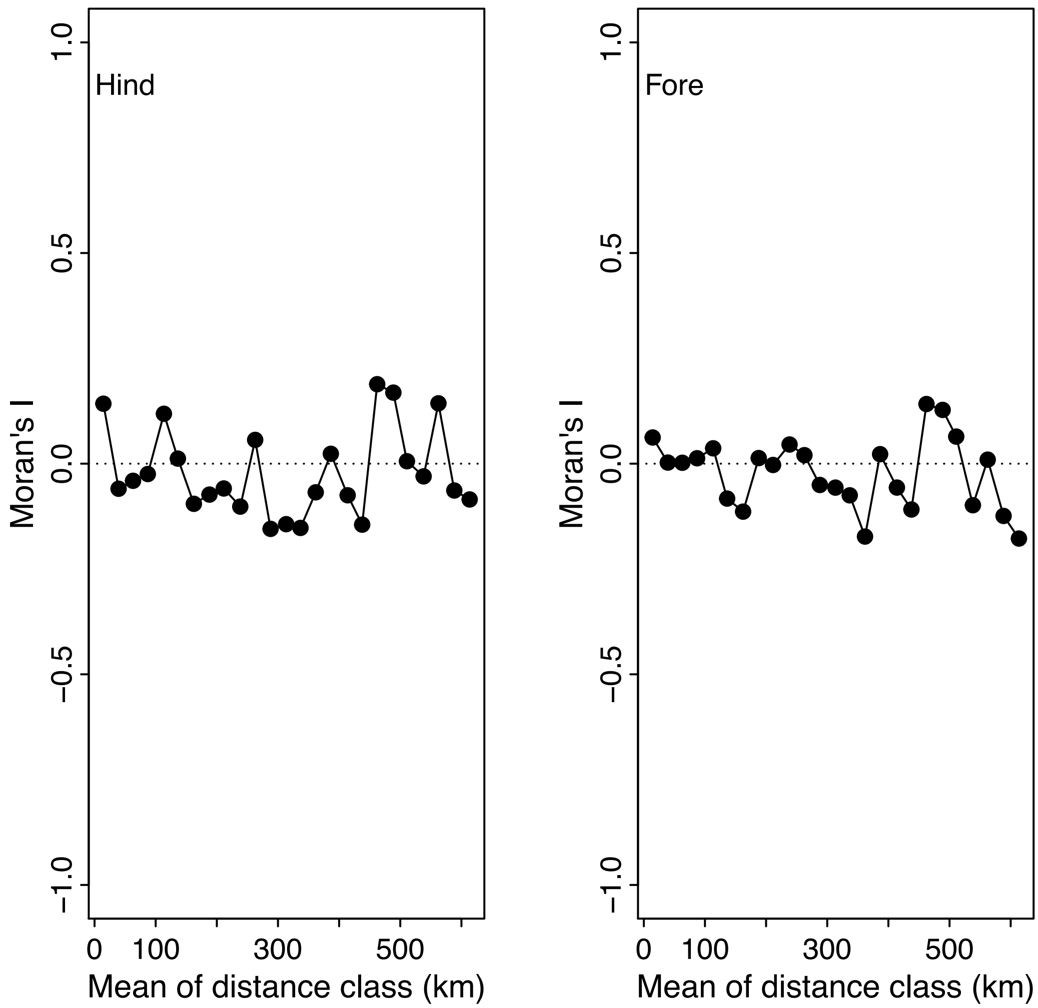


Fig. S3.1: Plot of Moran's I correlograms of hind limb toepad area (left) and forelimb toepad area (right) for all of the anole species in the dataset. We found no structure in the residuals to indicate spatial autocorrelation in the data.

Appendix 3.2: The Insular Fauna:

Mainland anoles naturally experience far fewer hurricanes than insular anoles. As a result, we analyzed solely the insular fauna in our dataset to determine if the relationship with hurricane activity was maintained, and to rule out the possibility that the mainland fauna, with its dearth of hurricane events over the period examined, was anchoring our regressions.

We determined that the insular species in our dataset had the same positive relationship with hurricane activity as seen in the genus-wide analysis presented in the manuscript.

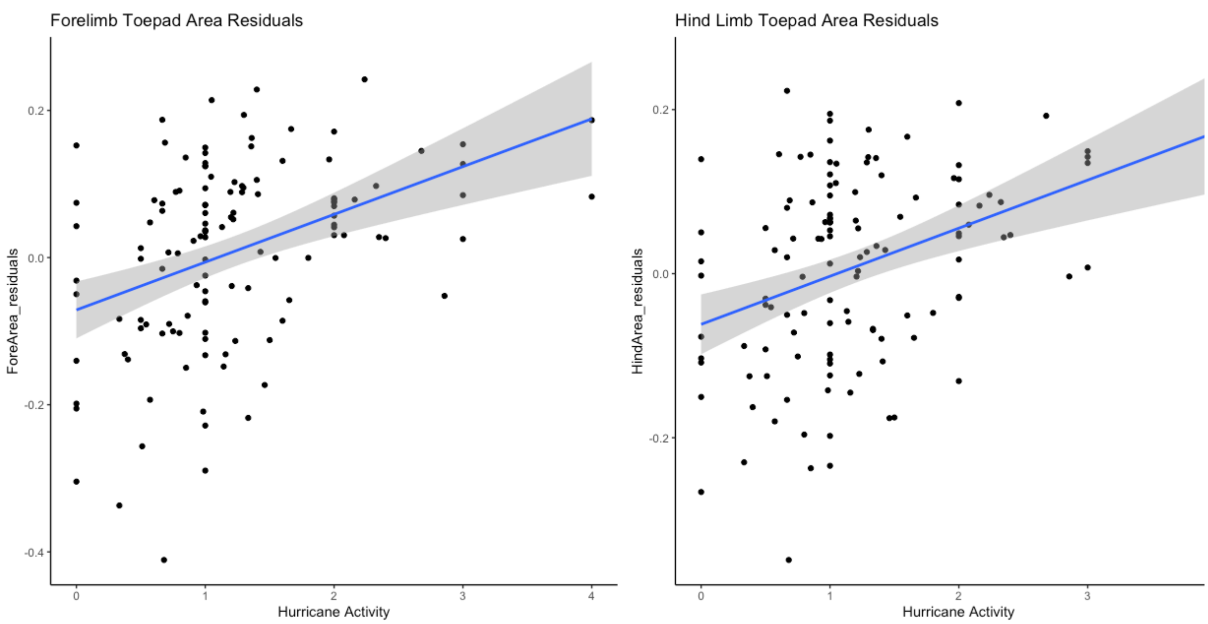


Fig. S3.2: The positive trend for the insular anoles between size-corrected forelimb (left) and hind limb (right) toepad surface area across species of different hurricane activity histories.

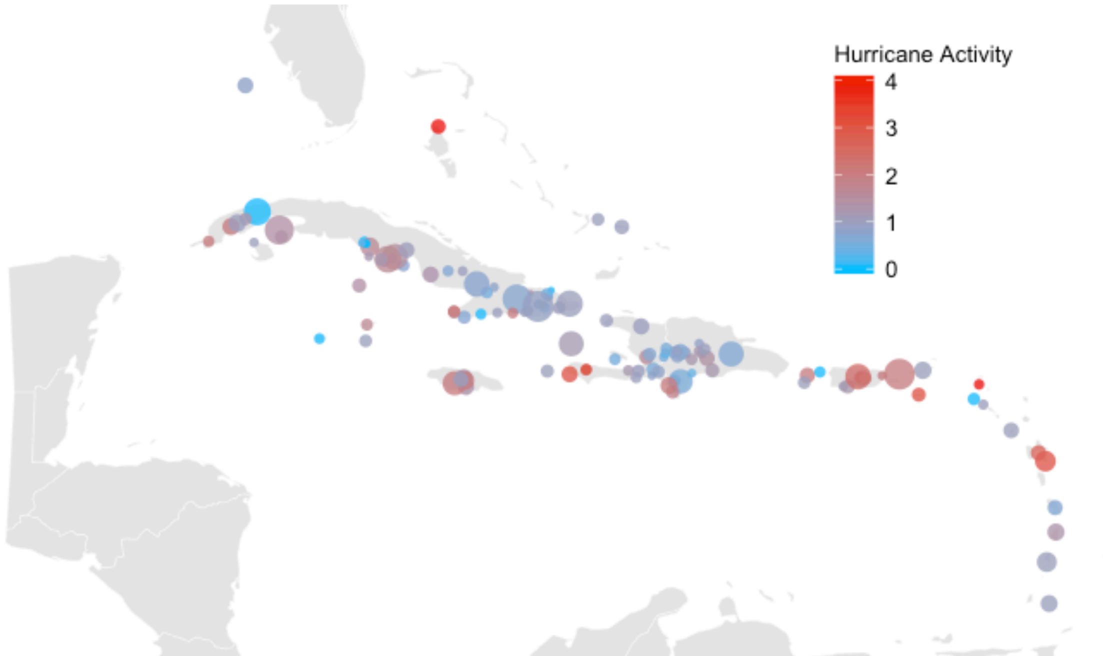


Fig. S3.3: A map showing the distribution of the insular anoles used for this analysis. Each point represents a species of anole. Point color reflects the hurricane history experienced by that species. Point size reflects the relative size of the toepads of those individuals.

Forelimb Toepad Area:

Variable codes are:
fore_area: forelimb toepad area
log10svl: log-transformed body length
h80_30: number of hurricanes exceeding 80 knots of wind within 30 km of site

```
pgls(formula = log10(fore_area) ~ log10svl + h80_30, data =
comp_island2_toepad_data,
    lambda = "ML", kappa = 1, delta = 1, bounds = list(delta = c(1e-06,
        15)))

Residuals:
     Min       1Q   Median       3Q      Max
-1.13797 -0.20468  0.03106  0.34670  1.29712

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.501
   lower bound : 0.000, p = 4.5294e-05
   upper bound : 1.000, p = 2.3315e-15
   95.0% CI   : (0.227, 0.745)
delta  [Fix]  : 1.000

Coefficients:
             Estimate Std. Error  t value  Pr(>|t|)
(Intercept) -4.230743   0.135325 -31.2635 < 2.2e-16 ***
log10svl     2.490762   0.075040  33.1923 < 2.2e-16 ***
h80_30       0.056232   0.012589   4.4667 1.798e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4555 on 121 degrees of freedom
Multiple R-squared: 0.9066,   Adjusted R-squared: 0.9051
F-statistic: 587.5 on 2 and 121 DF,  p-value: < 2.2e-16
```

Hind Limb Toepad Area:

Variable codes are:
hind_area: hind limb toepad area
log10svl: log-transformed body length
h80_30: number of hurricanes exceeding 80 knots of wind within 30 km of site

```
pgls(formula = log10(hind_area) ~ log10svl + h80_30, data =
comp_island2_toepad_data,
    lambda = "ML", kappa = 1, delta = 1, bounds = list(delta = c(1e-06,
        15)))

Residuals:
     Min       1Q   Median       3Q      Max
-1.11777 -0.23710  0.04711  0.34731  1.18748

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.383
   lower bound : 0.000, p = 0.0022307
   upper bound : 1.000, p = < 2.22e-16
   95.0% CI   : (0.109, 0.670)
delta  [Fix]  : 1.000

Coefficients:
             Estimate Std. Error  t value  Pr(>|t|)
(Intercept) -3.823156   0.125874 -30.3729 < 2.2e-16 ***
log10svl     2.365806   0.069936  33.8284 < 2.2e-16 ***
h80_30       0.047897   0.012339   3.8817 0.0001694 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4282 on 121 degrees of freedom
Multiple R-squared: 0.9087,   Adjusted R-squared: 0.9072
F-statistic: 602.5 on 2 and 121 DF,  p-value: < 2.2e-16
```

Appendix 3.3 The Insular Fauna: Ecomorphs

Anole species in the Greater Antilles have repeatedly evolved a suite of morphologically similar types called "ecomorphs" (8, 9). Different ecomorphs specialize in different microhabitats, for example, so-called "twig" anoles have adapted to living on the thinnest branches of trees, "trunk-crown" anoles tend to spend the majority of their time where the tree trunk meets the canopy, and "trunk-ground" anoles split their time between the base of trees and the forest floor (8, 9). Ecomorphs differ in toepad characteristics with more arboreal species tending to have larger toepads (7, 8). We again examined the relationship between hurricane activity and toepad size for each of the ecomorphs to determine whether the positive relationship seen across all of the species was maintained for each ecomorph. We found that it was (Fig. S3.4, S3.5).

In order to contextualize the explanatory power of hurricanes *vis-à-vis* ecomorph class we have presented the adjusted R^2 values of three models predicting size-corrected fore- and hind limb toepad area: a full model containing both the hurricane count and ecomorph assignment, and two additional models with each factor alone. These models cannot be directly compared because the estimated phylogenetic covariance of the model's errors will vary between models according to the factors being tested, which can have a scaling effect on the likelihood. That said, all three models indicate that hurricane activity is a significant predictor of variation in both fore- and hind limb toepads of anoles.

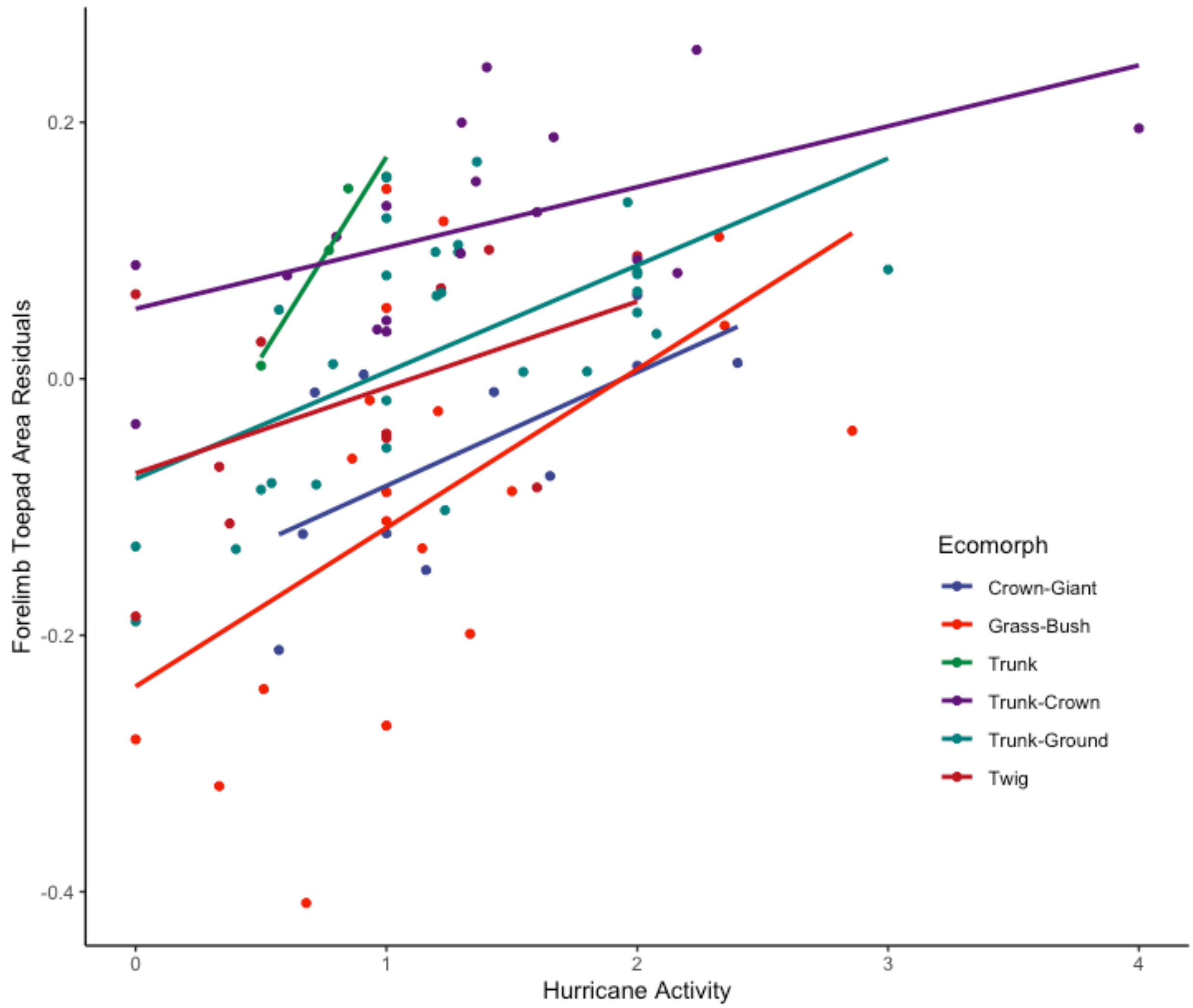


Fig. S3.4: The relationship between the size-corrected forelimb toepad surface area and hurricane activity for each of the six ecomorph classes in the Greater Antillean anole fauna. All six show a significant positive relationship with hurricane activity.

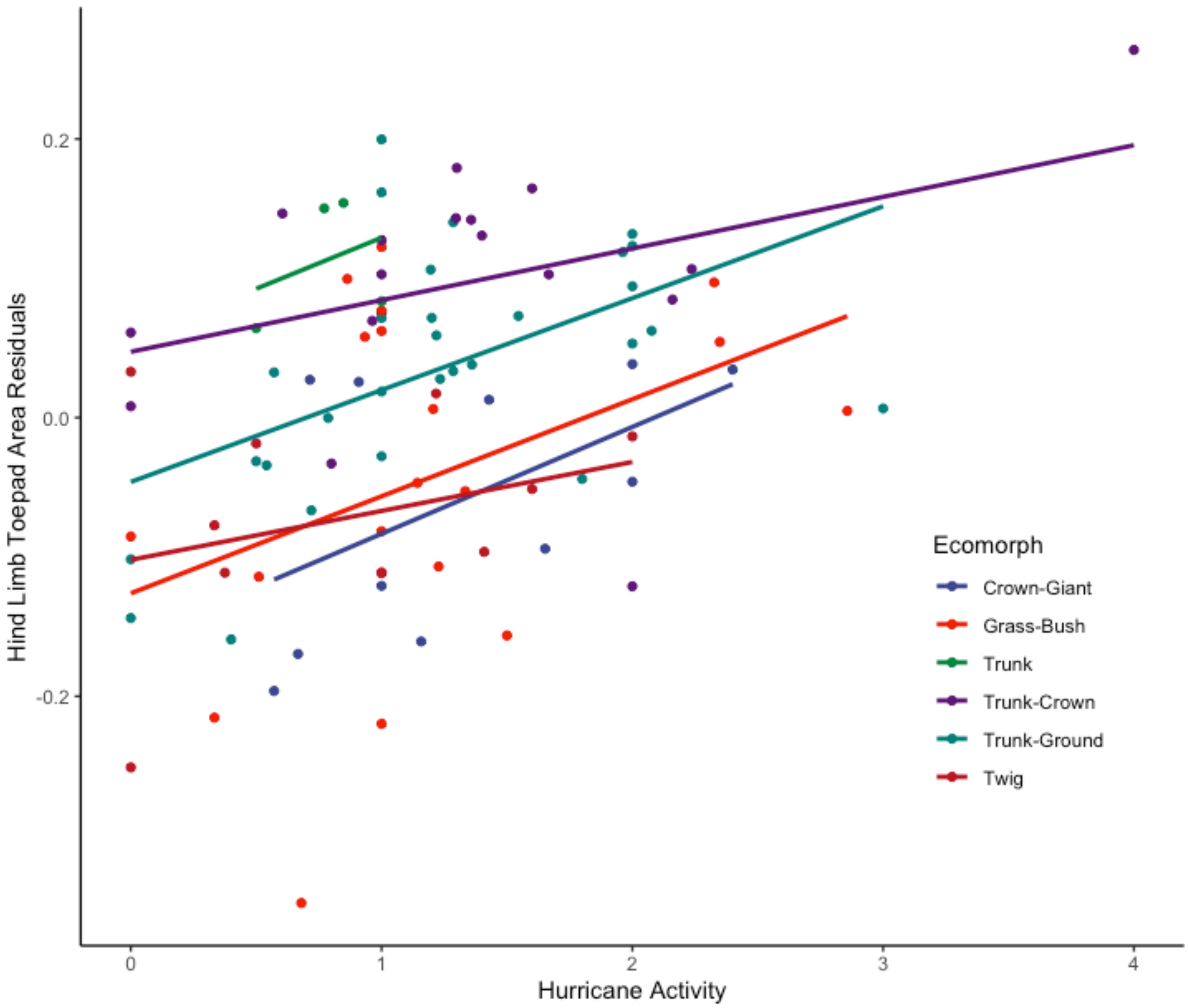


Fig. S3.5: The relationship between the size-corrected hind limb toepad surface area and hurricane activity for each of the six ecomorph classes in the Greater Antillean anole fauna. All six show a significant positive relationship with hurricane activity.

Testing for an interaction between ecomorph class and hurricane activity for forelimb toepad area:

Variable codes are:
fore_resid: body-size corrected forelimb toepad area residuals
ecomorph: categorical variable corresponding to ecomorph class
h80_30: number of hurricanes exceeding 80 knots of wind within 30 km of site

```
pgls(formula = fore_resid ~ ecomorph * h80_30, data =
comp_ecomorph_toepad_data,
    lambda = "ML", kappa = 1, delta = 1, bounds = list(delta = c(1e-06,
        15)))

Residuals:
     Min       1Q   Median       3Q      Max
-0.67004 -0.22425 -0.04799  0.24982  0.88564

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.000
   lower bound : 0.000, p = 1
   upper bound : 1.000, p = < 2.22e-16
   95.0% CI   : (NA, 0.316)
delta  [Fix]  : 1.000

Residual standard error: 0.3505 on 80 degrees of freedom
Multiple R-squared: 0.5628,   Adjusted R-squared: 0.5027
F-statistic: 9.363 on 11 and 80 DF,  p-value: 1.448e-10

Analysis of Variance Table
Sequential SS for pgls: lambda = 0.00, delta = 1.00, kappa = 1.00

Response: fore_resid
                Df Sum Sq Mean Sq F value Pr(>F)
ecomorph         5   7.78    1.56   12.67 <2e-16 ***
h80_30           1   4.27    4.27   34.76 <2e-16 ***
ecomorph:h80_30  5   0.60    0.12    0.97   0.44
Residuals       80   9.83    0.12
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Testing for an interaction between ecomorph class and hurricane activity for hind limb toepad area:

Variable codes are:
hind_resid: body-size corrected hind limb toepad area residuals
ecomorph: categorical variable corresponding to ecomorph class
h80_30: number of hurricanes exceeding 80 knots of wind within 30 km of site

```
pgls(formula = hind_resid ~ ecomorph * h80_30, data =
comp_ecomorph_toepad_data,
    lambda = "ML", kappa = 1, delta = 1, bounds = list(delta = c(1e-06,
        15)))

Residuals:
     Min       1Q   Median       3Q      Max
-0.53856 -0.20017  0.00711  0.26009  0.76183

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.000
   lower bound : 0.000, p = 1
   upper bound : 1.000, p = < 2.22e-16
   95.0% CI    : (NA, 0.332)
delta  [Fix]  : 1.000

Residual standard error: 0.346 on 80 degrees of freedom
Multiple R-squared: 0.4521,   Adjusted R-squared: 0.3768
F-statistic: 6.001 on 11 and 80 DF,  p-value: 4.737e-07

Analysis of Variance Table
Sequential SS for pgls: lambda = 0.00, delta = 1.00, kappa = 1.00

Response: hind_resid
                Df Sum Sq Mean Sq F value Pr(>F)
ecomorph         5   5.65    1.13    9.43 <2e-16 ***
h80_30           1   2.09    2.09   17.45 <2e-16 ***
ecomorph:h80_30  5   0.17    0.03    0.28   0.92
Residuals       80   9.58    0.12
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

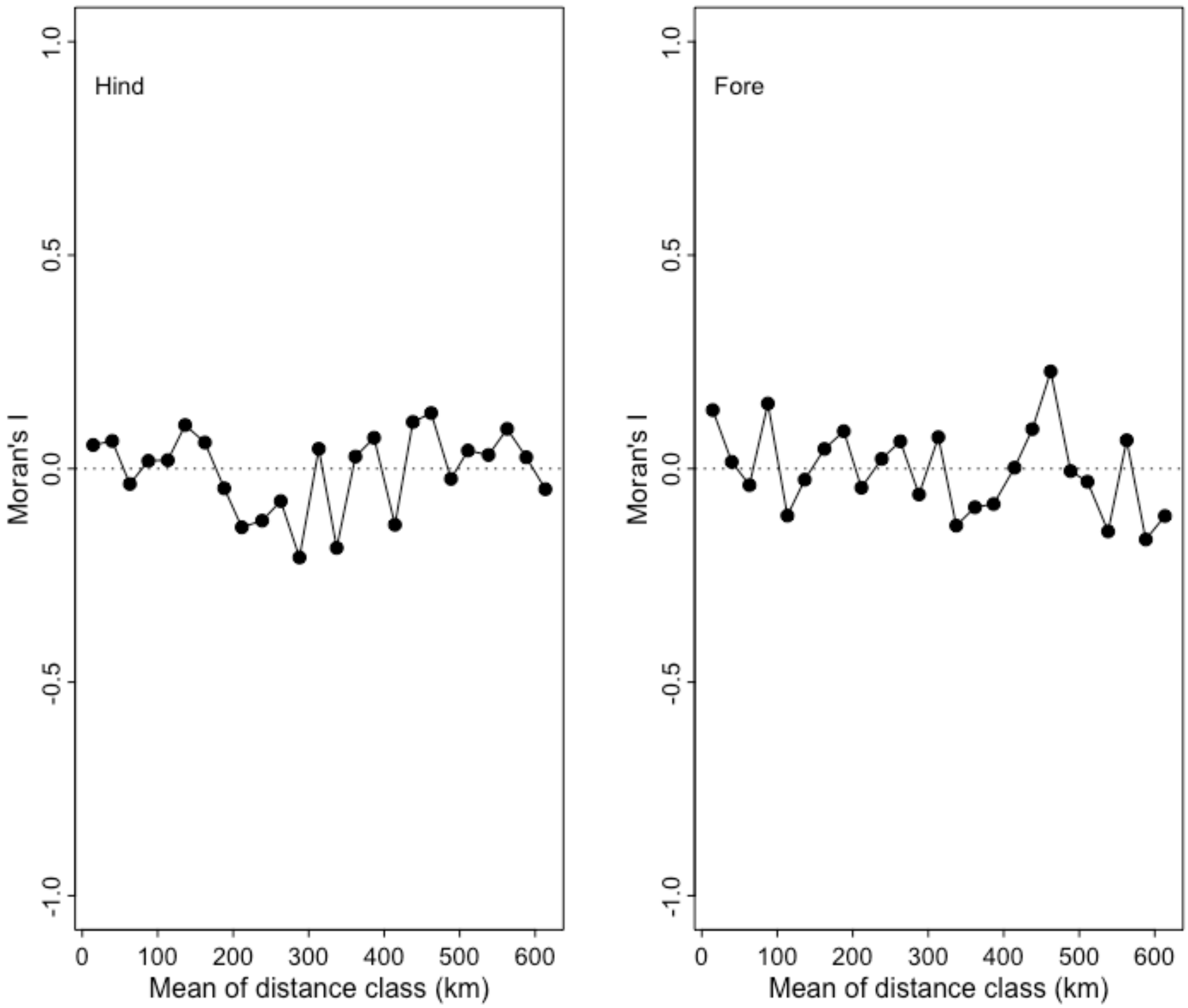


Fig. S3.6: Plot of Moran's I correlograms of hind limb toepad area (left) and forelimb toepad area (right) for the insular anole species. We found no structure in the residuals to indicate spatial autocorrelation in the data.

Appendix 4: Tree Heights

Supplemental Analysis 4.1:

Anole species that are more arboreal tend to have larger toepads (7, 8). This is a potential alternative explanation for the biogeographic patterns observed across the species in our dataset. We therefore tested whether variation in tree heights calculated using LiDAR (see Methods; 38) correlated with the observed pattern in toepad area. We found tree height was not a significant predictor of anole toepad area in this dataset.

Forelimb Toepad Area:

Variable codes are:
fore_area: forelimb toepad area
log10svl: log-transformed body length
h80_30: number of hurricanes exceeding 80 knots of wind within 30 km of site
trht.30: mean tree hight within 30 km of site according to LIDAR data

```
pgls(formula = log10(fore_area) ~ log10svl + h80_30 + trht.30,
    data = comp_toepad_data, lambda = "ML", kappa = 1, delta = 1,
    bounds = list(delta = c(1e-06, 15)))

Residuals:
    Min      1Q  Median      3Q     Max
-1.3512 -0.3695 -0.0241  0.2571  1.5543

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.616
   lower bound : 0.000, p = 2.6328e-07
   upper bound : 1.000, p = 6.6613e-16
   95.0% CI   : (0.384, 0.795)
delta  [Fix]  : 1.000

Coefficients:
               Estimate  Std. Error  t value  Pr(>|t|)
(Intercept) -4.12682415  0.13193896 -31.2783 < 2.2e-16 ***
log10svl     2.42037709  0.07088469  34.1453 < 2.2e-16 ***
h80_30       0.06104561  0.01214000   5.0285 1.285e-06 ***
trht.30      0.00062595  0.00172428   0.3630    0.7171
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.493 on 164 degrees of freedom
Multiple R-squared: 0.8833,   Adjusted R-squared: 0.8811
F-statistic: 413.6 on 3 and 164 DF,  p-value: < 2.2e-16
```

Hind Limb Toepad Area:

Variable codes are:
hind_area: hind limb toepad area
log10svl: log-transformed body length
h80_30: number of hurricanes exceeding 80 knots of wind within 30 km of site
trht.30: mean tree hight within 30 km of site according to LIDAR data

```
pgls(formula = log10(hind_area) ~ log10svl + h80_30 + trht.30,
    data = comp_toepad_data, lambda = "ML", kappa = 1, delta = 1,
    bounds = list(delta = c(1e-06, 15)))

Residuals:
    Min      1Q  Median      3Q     Max
-1.4929 -0.3342  0.0140  0.3381  1.1276

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.626
   lower bound : 0.000, p = 6.7106e-06
   upper bound : 1.000, p = < 2.22e-16
   95.0% CI   : (0.371, 0.809)
delta  [Fix]  : 1.000

Coefficients:
               Estimate  Std. Error  t value  Pr(>|t|)
(Intercept) -3.66694067  0.14180056 -25.8598 < 2.2e-16 ***
log10svl     2.28001516  0.07618018  29.9292 < 2.2e-16 ***
h80_30       0.04974107  0.01300725   3.8241 0.0001862 ***
trht.30     -0.00096674  0.00185025  -0.5225 0.6020339
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5306 on 164 degrees of freedom
Multiple R-squared: 0.8522,   Adjusted R-squared: 0.8495
F-statistic: 315.3 on 3 and 164 DF,  p-value: < 2.2e-16
```

Appendix 4.1 Tree Heights and Hurricanes:

Using our dataset we investigated whether there was a relationship between hurricane frequency and average tree heights. While this is a subject for thorough future study we found that, generally, there was a negative correlation: localities with more hurricanes tended to have, on average, shorter maximum tree heights.

```
lm(formula = trht.30 ~ h80_30, data = dat_toepad)

Residuals:
    Min      1Q  Median      3Q     Max 
-18.448  -3.240  -0.106   4.308  14.741 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  18.4477     0.5310  34.744  < 2e-16 ***
h80_30       -3.5198     0.4623  -7.613 7.91e-13 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 5.992 on 219 degrees of freedom
Multiple R-squared:  0.2093,  Adjusted R-squared:  0.2057 
F-statistic: 57.96 on 1 and 219 DF,  p-value: 7.914e-13
```

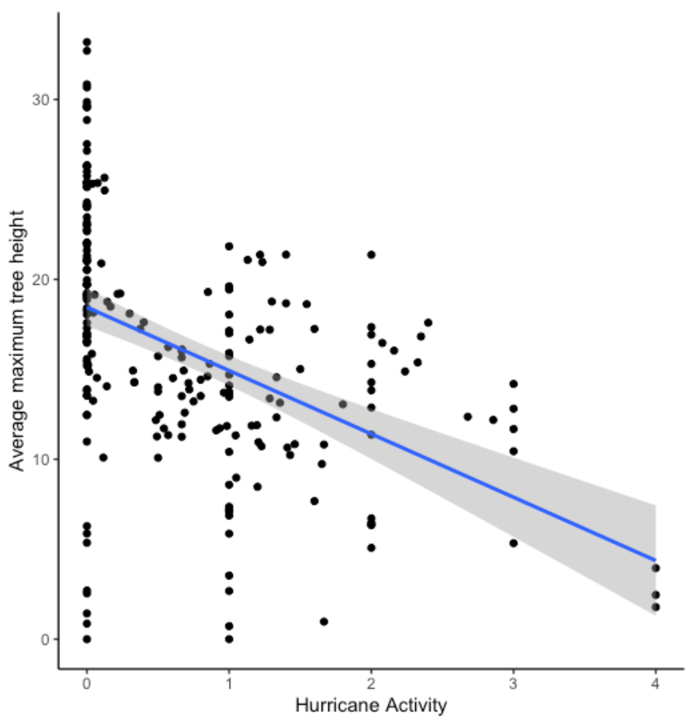


Fig 4.1: The relationship between tree height and hurricane activity was significantly negative in our dataset. Additional sampling and analysis are needed to conclusively test hurricanes' effects on vegetation structure

Appendix 5: Bioclimatic Data

We tested whether toepad size was related to air temperature or precipitation across the 188 species in our dataset. We found no relationship for either variable.

Air temperature:

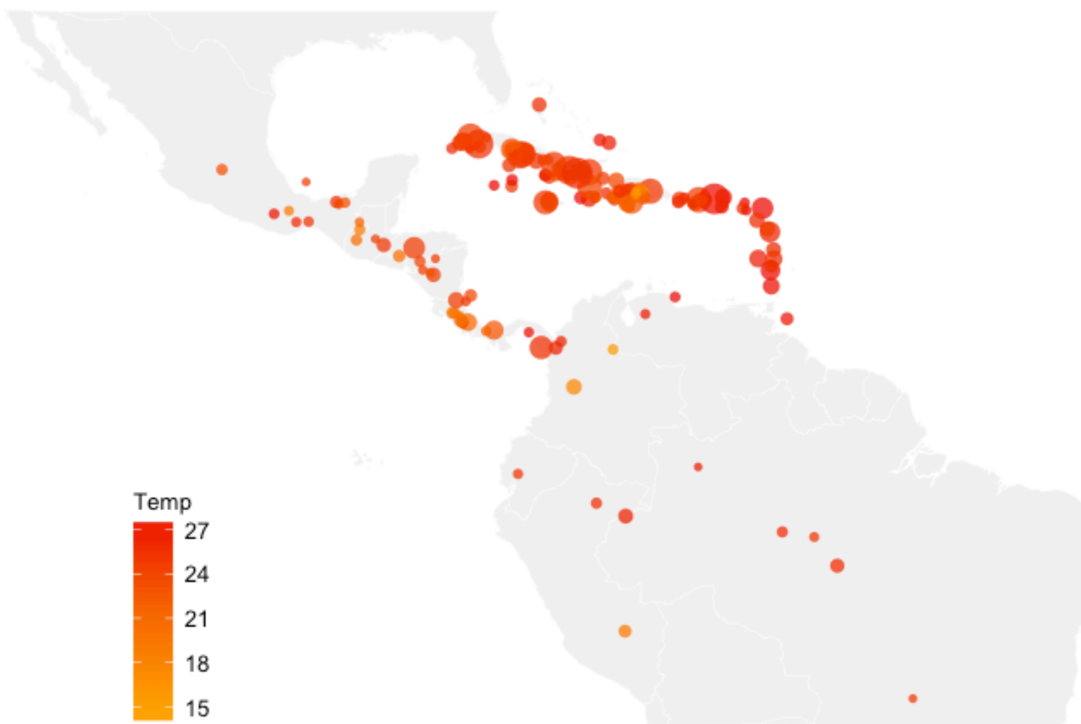


Fig. S5.1: A representation of the average mean air temperature experienced by the lizard species in this dataset. Each point corresponds to a species of anole. The size of the circle corresponds to the toepad size of that species. The color of the point corresponds to the average mean air temperature (°C).

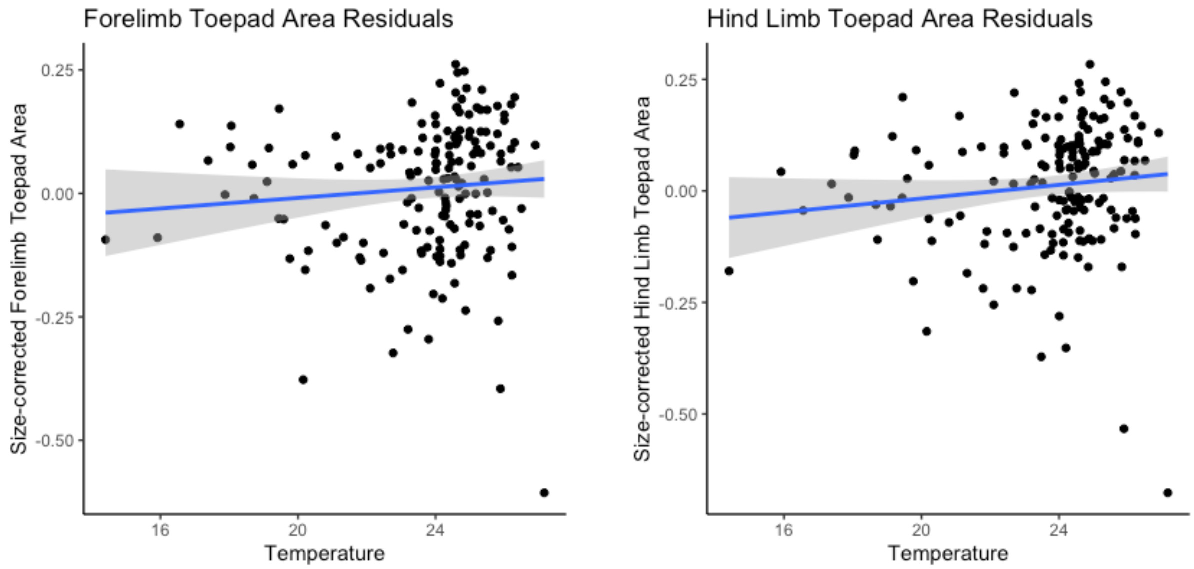


Fig. S5.2: We found no relationship between air temperature (°C) and either forelimb (left) or hind limb (right) toepad surface area.

Forelimb Toepad Area:

Variable codes are:
fore_area: forelimb toepad area
log10svl: log-transformed body length
Temp: mean annual air temperature at site

```
pgls(formula = log10(fore_area) ~ log10svl + Temp, data = comp_toepad_data,
    lambda = "ML", kappa = 1, delta = 1, bounds = list(delta = c(1e-06,
        15)))

Residuals:
     Min       1Q   Median       3Q      Max 
-1.60561 -0.31937 -0.00097  0.32683  1.18628 

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.672
   lower bound : 0.000, p = 4.3931e-10
   upper bound : 1.000, p = 9.2593e-14
   95.0% CI   : (0.460, 0.834)
delta  [Fix]  : 1.000

Coefficients:
               Estimate  Std. Error  t value Pr(>|t|)    
(Intercept) -4.16807382  0.16764639 -24.8623   <2e-16 ***
log10svl     2.45190636  0.07698547  31.8490   <2e-16 ***
Temp         0.00020803  0.00047748   0.4357   0.6636    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.5386 on 165 degrees of freedom
Multiple R-squared: 0.8627,   Adjusted R-squared: 0.8611 
F-statistic: 518.5 on 2 and 165 DF,  p-value: < 2.2e-16
```

Hind Limb Toepad Area:

Variable codes are:
hind_area: hind limb toepad area
log10svl: log-transformed body length
Temp: mean annual air temperature at site

```
pgls(formula = log10(hind_area) ~ log10svl + Temp, data = comp_toepad_data,
    lambda = "ML", kappa = 1, delta = 1, bounds = list(delta = c(1e-06,
        15)))

Residuals:
     Min       1Q   Median       3Q      Max
-1.20185 -0.44473  0.01279  0.36158  2.10072

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.688
   lower bound : 0.000, p = 1.4217e-09
   upper bound : 1.000, p = 2.9976e-15
   95.0% CI   : (0.469, 0.845)
delta  [Fix]  : 1.000

Coefficients:
               Estimate  Std. Error  t value Pr(>|t|)
(Intercept) -3.81321748  0.17492200 -21.7995   <2e-16 ***
log10svl     2.29686973  0.08025691  28.6190   <2e-16 ***
Temp         0.00061996  0.00049732   1.2466   0.2143
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5636 on 165 degrees of freedom
Multiple R-squared: 0.8366,   Adjusted R-squared: 0.8347
F-statistic: 422.5 on 2 and 165 DF,  p-value: < 2.2e-16
```

Precipitation:

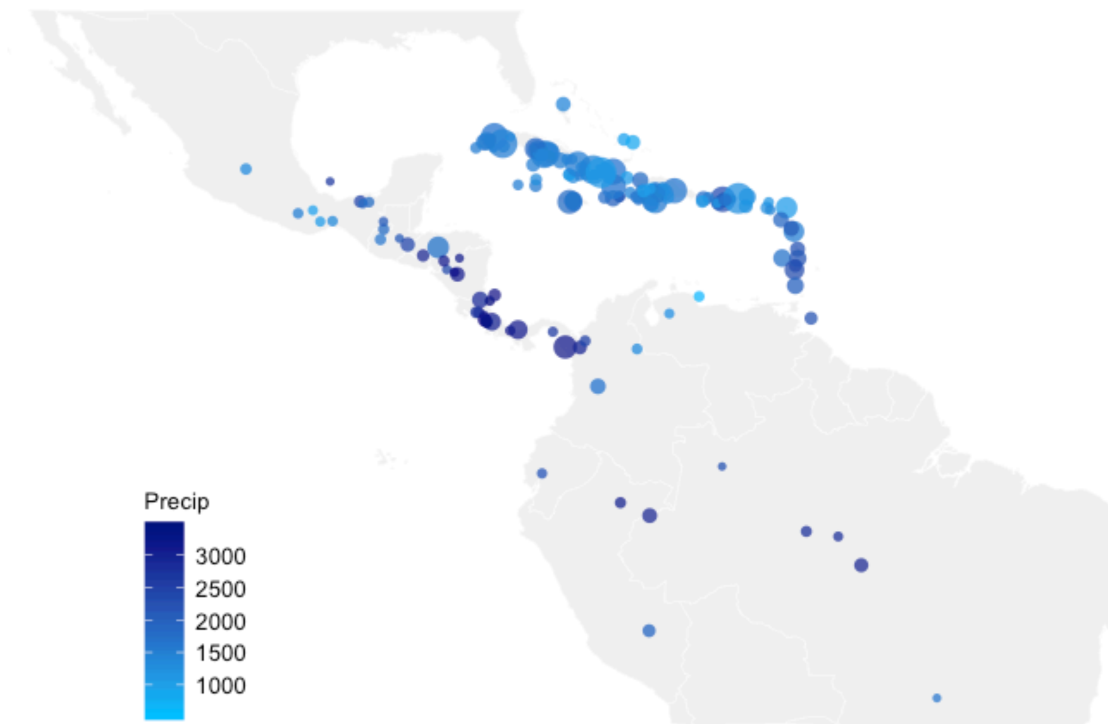


Fig. S5.3: A representation of the average of annual mean precipitation experienced by the lizard species in this dataset. Each point corresponds to a species of anole. The size of the circle corresponds to the toepad size of that species. The color of the point corresponds to the average mean precipitation (mm)

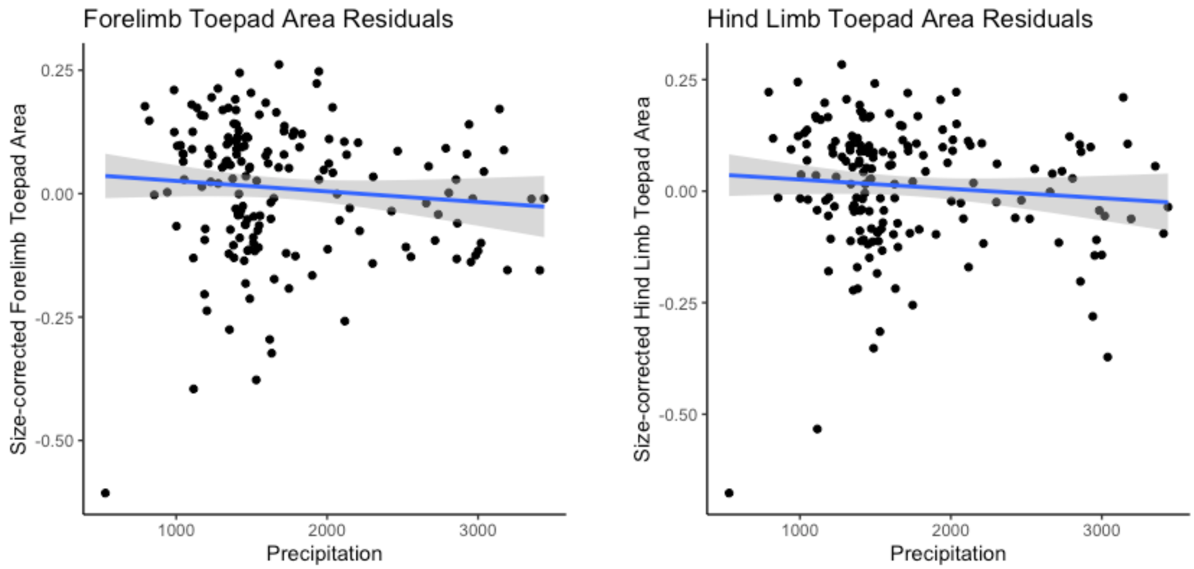


Fig. S5.4: We found no relationship between precipitation (mm) and either forelimb (left) or hind limb (right) toepad surface area.

Forelimb Toepad Area:

Variable codes are:
fore_area: forelimb toepad area
log10svl: log-transformed body length
Precip: Mean annual precipitation at site

```
pgls(formula = log10(fore_area) ~ log10svl + Precip, data = comp_toepad_data,
    lambda = "ML", kappa = 1, delta = 1, bounds = list(delta = c(1e-06,
        15)))

Residuals:
     Min       1Q   Median       3Q      Max
-1.26611 -0.34229 -0.06379  0.29962  2.18959

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.688
   lower bound : 0.000, p = 3.2091e-10
   upper bound : 1.000, p = 1.853e-13
   95.0% CI   : (0.479, 0.845)
delta  [Fix]  : 1.000

Coefficients:
               Estimate  Std. Error  t value Pr(>|t|)
(Intercept) -4.1607e+00  1.4396e-01 -28.9020   <2e-16 ***
log10svl     2.4514e+00  7.6479e-02  32.0528   <2e-16 ***
Precip       2.3973e-05  2.3418e-05   1.0237   0.3075
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.541 on 165 degrees of freedom
Multiple R-squared: 0.8626,   Adjusted R-squared: 0.8609
F-statistic:   518 on 2 and 165 DF,  p-value: < 2.2e-16
```

Hind Limb Toepad Area:

Variable codes are:
hind_area: hind limb toepad area
log10svl: log-transformed body length
Precip: mean annual precipitation at site

```
pgls(formula = log10(hind_area) ~ log10svl + Precip, data = comp_toepad_data,
    lambda = "ML", kappa = 1, delta = 1, bounds = list(delta = c(1e-06,
        15)))

Residuals:
     Min       1Q   Median       3Q      Max
-1.53539 -0.38082  0.01389  0.39747  1.85101

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.696
   lower bound : 0.000, p = 1.1855e-09
   upper bound : 1.000, p = 4.6629e-15
   95.0% CI    : (0.479, 0.850)
delta  [Fix]  : 1.000

Coefficients:
               Estimate  Std. Error  t value Pr(>|t|)
(Intercept) -3.7231e+00  1.5062e-01 -24.7194   <2e-16 ***
log10svl     2.3060e+00  7.9997e-02  28.8256   <2e-16 ***
Precip       2.1404e-05  2.4513e-05   0.8731   0.3839
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.5668 on 165 degrees of freedom
Multiple R-squared: 0.8354,   Adjusted R-squared: 0.8334
F-statistic: 418.8 on 2 and 165 DF,  p-value: < 2.2e-16
```

Appendix 6: Sensitivity Analysis

For our main-text analyses, we counted a hurricane strike if it passed within 30 km of a lizard locality in our spatial dataset with maximum wind speed at or exceeding 80 knots. To determine how sensitive our model was to these two parameters we adjusted our algorithm to count hurricanes at larger radii and different windspeed threshold cutoffs. In general, larger distance thresholds showed smaller effects on the toepads of lizards. Another general pattern was that higher intensity thresholds had a more significant effect than lower thresholds.

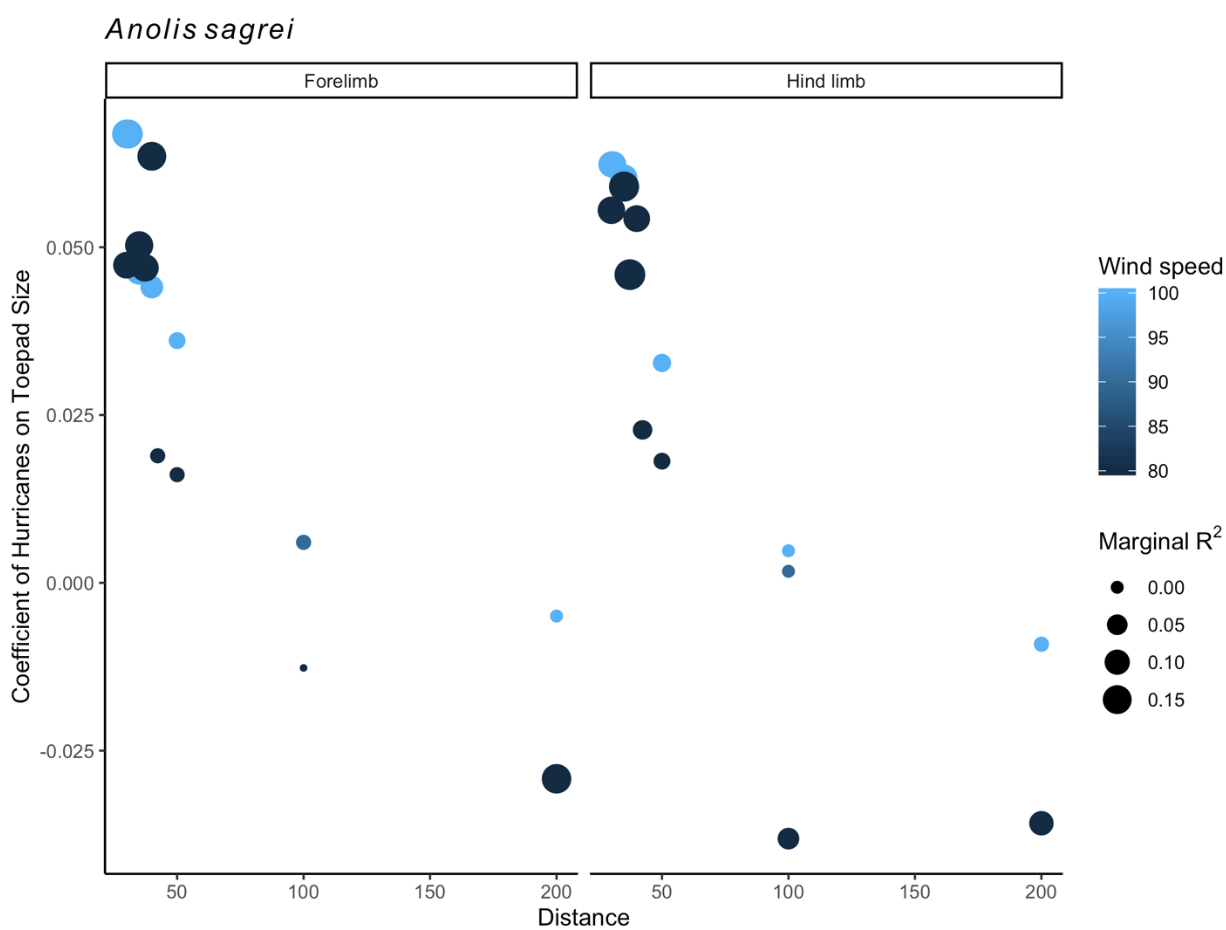


Fig. S6.1: *Anolis sagrei* sensitivity to hurricane distance and windspeed thresholds.

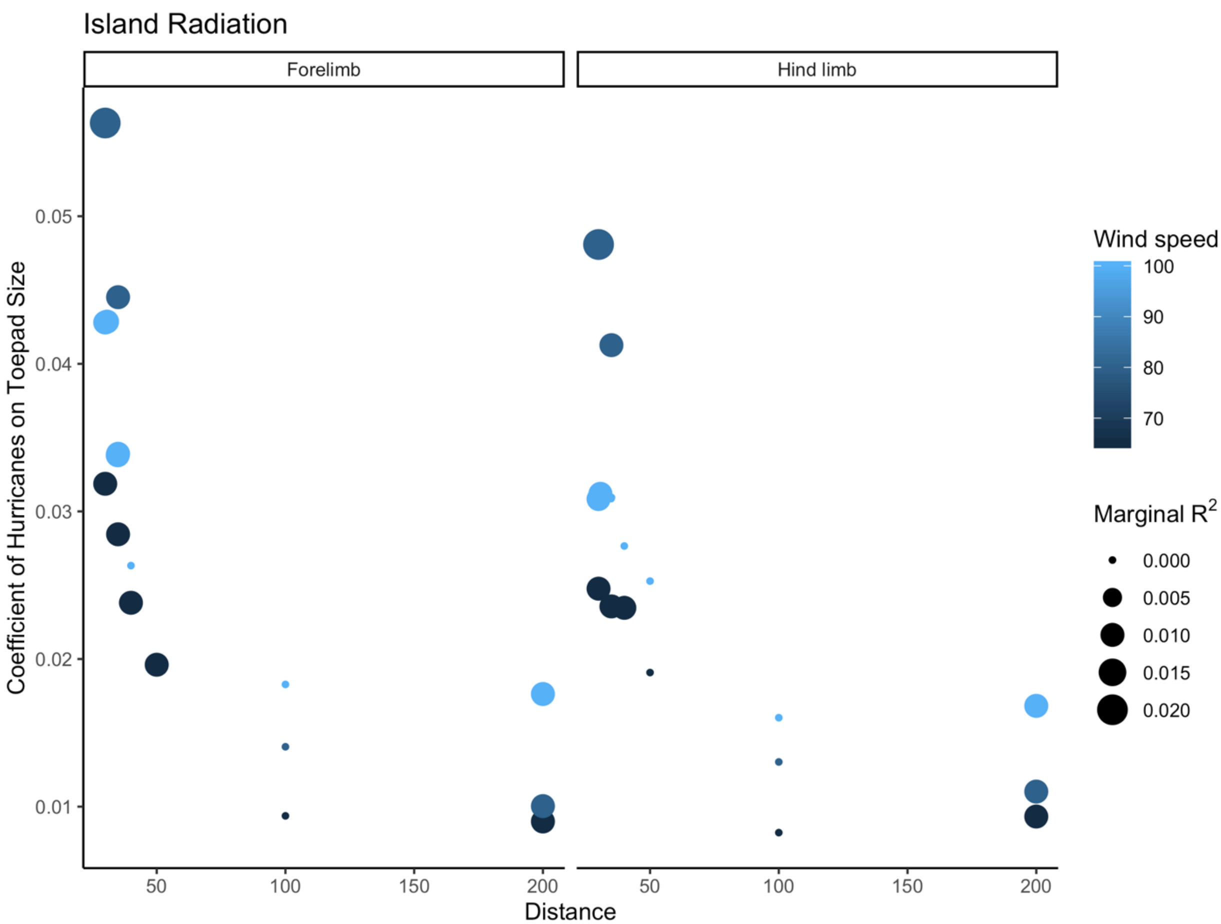


Fig. S6.2: Sensitivity of insular anoles to hurricane distance and windspeed thresholds.

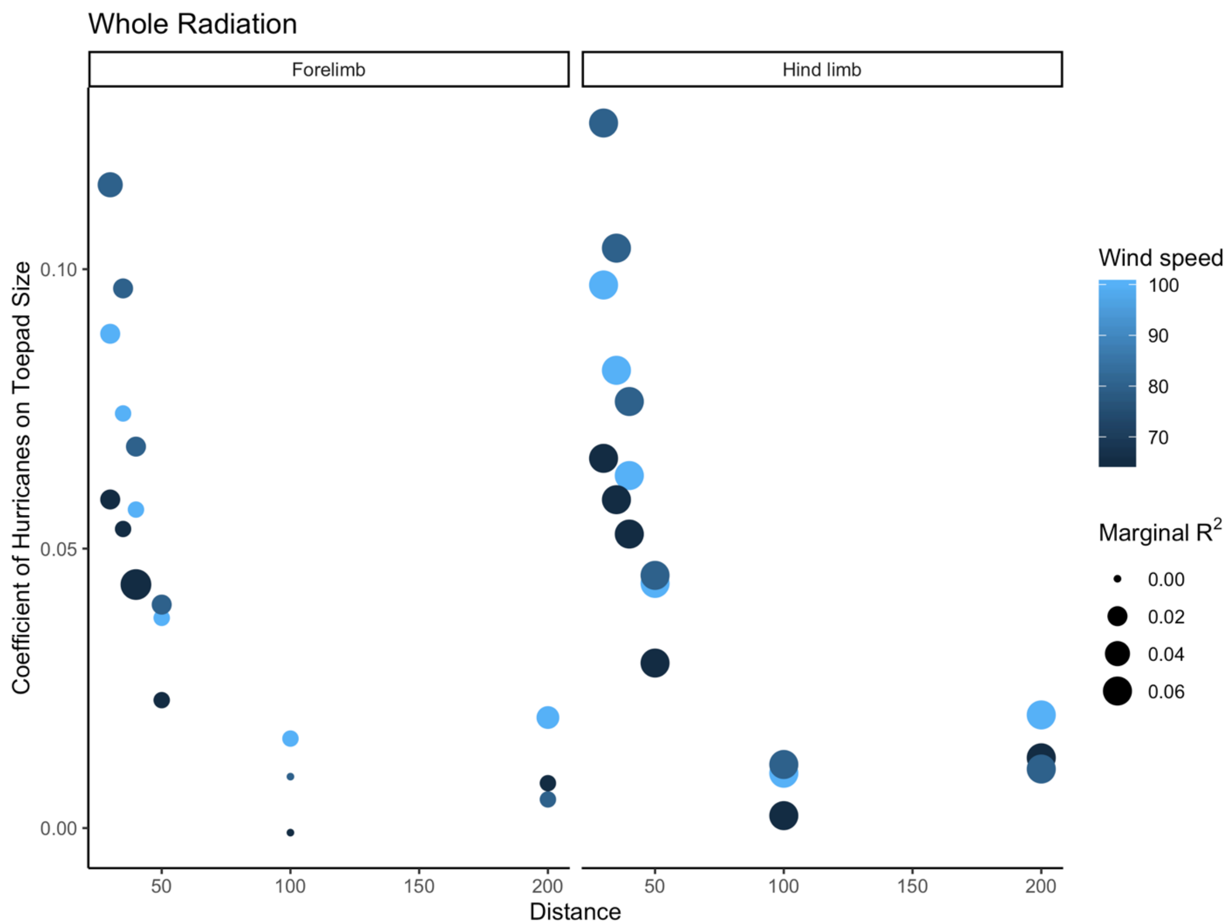


Fig. S6.3: Sensitivity of the entire genus model to hurricane distance and windspeed thresholds.

Appendix 7: Species Sampling

Because widespread species are only represented by three individuals in this dataset, it is possible that those individuals were from a population that does not best reflect the hurricane history of that species. While these potential mismatches should increase variation and thus decrease the strength of the regression, we tested whether excluding especially widespread species affected the conclusions of our macroevolutionary comparison. For this restricted analysis we excluded: *A. carolinensis, A. sagrei, A. distichus, A. cybotes, A. porcatus, A. cristatellus,* and *A. biporcatus*. We found that restricting these widespread species did not change the qualitative patterns of the results and, as predicted, increased the strength of the relationship. For the manuscript analysis we relate the results of the full model including the seven widespread species.

Forelimb toepads:

Variable codes are:
fore_area: forelimb toepad area
log10svl: log-transformed body length
h80_30: number of hurricanes exceeding 80 knots of wind within 30 km of site

```
pgls(formula = log10(fore_area) ~ log10svl + h80_30, data = comp_toepad_data,
    lambda = "ML", kappa = 1, delta = 1, bounds = list(delta = c(1e-06,
        15)))

Residuals:
    Min      1Q  Median      3Q     Max
-1.3175 -0.3636 -0.0230  0.3492  1.3646

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.609
   lower bound : 0.000, p = 1.1903e-06
   upper bound : 1.000, p = 1.9984e-15
   95.0% CI    : (0.366, 0.796)
delta  [Fix]  : 1.000

Coefficients:
             Estimate Std. Error  t value  Pr(>|t|)
(Intercept) -4.102809   0.131694 -31.1541 < 2.2e-16 ***
log10svl     2.412324   0.072412  33.3141 < 2.2e-16 ***
h80_30       0.060345   0.012325   4.8961 2.383e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4962 on 159 degrees of freedom
Multiple R-squared: 0.8814,   Adjusted R-squared: 0.8799
F-statistic: 590.7 on 2 and 159 DF,  p-value: < 2.2e-16
```

Hind limb toepads:

Variable codes are:
hind_area: hind limb toepad area
log10svl: log-transformed body length
h80_30: number of hurricanes exceeding 80 knots of wind within 30 km of site

```
pgls(formula = log10(hind_area) ~ log10svl + h80_30, data = comp_toepad_data,
    lambda = "ML", kappa = 1, delta = 1, bounds = list(delta = c(1e-06,
        15)))

Residuals:
     Min       1Q   Median       3Q      Max
-1.98097 -0.28502 -0.00109  0.32048  1.55236

Branch length transformations:

kappa  [Fix]  : 1.000
lambda [ ML]  : 0.605
   lower bound : 0.000, p = 3.6719e-05
   upper bound : 1.000, p = < 2.22e-16
   95.0% CI   : (0.335, 0.802)
delta  [Fix]  : 1.000

Coefficients:
             Estimate Std. Error  t value  Pr(>|t|)
(Intercept) -3.677753   0.141471 -25.9966 < 2.2e-16 ***
log10svl     2.276742   0.077794  29.2663 < 2.2e-16 ***
h80_30       0.050536   0.013255   3.8127 0.0001963 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.5329 on 159 degrees of freedom
Multiple R-squared: 0.8505,   Adjusted R-squared: 0.8486
F-statistic: 452.3 on 2 and 159 DF,  p-value: < 2.2e-16
```

Appendix 8: MATLAB code for calculating hurricane strikes.

Data sources:

Tropical cyclone track data from 1851-2016 (North Atlantic) and 1949-2016 (Eastern North Pacific) are obtained from the International Best Track Archive for Climate Stewardship (IBTrACS). These data are available at:

https://www.ncdc.noaa.gov/ibtracs/index.php?name=ibtracs-data

When we obtained the tracks, IBTrACS data were not available for 2017. Therefore, we obtained 2017 North Atlantic and Eastern Pacific tracks from the tropical cyclone extended best track dataset:

http://rammb.cira.colostate.edu/research/tropical_cyclones/tc_extended_best_track_dataset/

In both datasets, data are provided at 6-hour intervals at 0000, 0600, 1200, and 1800 UTC. Sometimes, data between these 6-hr points are provided for special events in the tropical cyclone lifecycle (usually landfall).

Interpolation:

Before calculating the number of hurricane strikes at each location, we interpolated the data to 15-minute frequency. To do this, the TC position between two time points (e.g. 0000 UTC and 0600 UTC) was interpolated to 23 15-minute time points between these two times (0015 UTC, 0030 UTC,…, 0530 UTC, 0545 UTC).

The reason for interpolating between time points is to avoid instances where storms “skip over” a location. For example, say we are determining whether a storm passes within 30 km of a specific location. At 0000 UTC, the storm is 40 km east of the location. At 0600 UTC, the storm is 40 km west of the location. But this hypothetical storm passes over the location between these two times, so we want it recognized. Thus, we interpolate to time points between 0000 UTC and 0600 UTC.

As noted above, there are some time points that fall between 6-hour intervals. We did not remove these time points, as they give precise landfall locations. Therefore, interpolations involving these time points provide data at intervals shorter than 15 minutes.

Note that this method may technically miss some very marginal data, for example, if a storm is 30.01 km from a chosen location at 0445 UTC and at 0500 UTC, but only 29.99 km from the location at 0452 UTC. In this case, the storm would not be considered a "hit" within 30 km. However, practically, it is impossible to estimate tropical cyclone position with that level of precision.

Wind speed interpolation

Wind speed data are also provided at 6-hour intervals (and sometime also at landfall times). Typically, tropical cyclone wind speed is taken as the wind speed at the most recent time point. (e.g. the wind speed at 0500 UTC is given as the wind speed at 0000 UTC, not the wind speed at 0600 UTC).

This typical analysis method can cause problems for storms that strengthen/weaken rapidly, especially when making landfall. Therefore, we interpolated both the storm position and wind speed between time points.

Interpolation code:

```
clear

test=load('NATL_1851.m');
size1=size(test);
```

```
rows=size1(1);
rm1=rows-1;
inum=24;

testcell=mat2cell(test,rows,7);

for n = 1:rm1
% n = 1:rm1
    if testcell{1}(n,3)==testcell{1}(n+1,3) &
testcell{1}(n,2)==testcell{1}(n+1,2)
    for o=1:inum
      intcell{1}(n*24-(24-o),1:7)=testcell{1}(n,1:7)*(24-
o+1)/24+testcell{1}(n+1,1:7)*(o-1)/24
    end
    else
        intcell{1}(n*24-23,:)=testcell{1}(n,:);
      end
     end
intcell{1}(n*24+1,:)=testcell{1}(n+1,:)*(24)/24;

intmat=intcell{1};

TF1=intmat(:,1)==0 & intmat(:,2)==0 & intmat(:,3)==0 & intmat(:,4)==0 &
intmat(:,5)==0;

intmat(TF1,:)=[];
NATL_int15min_wwind=intmat;

save('NATL_interp15m_wwind','NATL_int15min_wwind')
```

Threshold counting code:

```
clear

pir=3.1415926535/180;

%Set minimum wind speed threshold (kt)
WT=100;
%Set maximum distance threshold (km)
DT=30;

locs=load('../../../../Anole_locs.m');
load('../../../../Data_1949.mat');
TCs=NATL_int15min_1949;
sizeTCs=size(TCs);
rowTCs=sizeTCs(1);
sizelocs=size(locs);
rowlocs=sizelocs(1);
collocs=sizelocs(2);
locscell=mat2cell(locs,rowlocs,collocs);

%for m=1:rowlocs
for m=1:rowlocs
for n=1:rowTCs

dist(n,1)=acos(sin((locscell{:}(m,2))*pir)*sin((TCs(n,4))*pir)+cos((locscell{
:}(m,2))*pir)*cos((TCs(n,4))*pir)*cos((TCs(n,5))*pir-
(locscell{:}(m,1)*pir)))*6371;
```

```
end

TC_dist1=TCs;
TC_dist1(:,8)=dist;
TCd=TC_dist1;

%sumtest=sum(TC_dist1{:}(:,6) > 79 & TC_dist1{:}(:,8) < 500)
%EXT_test= TC_dist1((TC_dist1{:}(:,6) > 79 & (TC_dist1{:}(:,8) < 500),:);
Ext=TCd((TCd(:,6)>=WT) & (TCd(:,8)<=DT),:);

C=unique(Ext(:,2:3),'rows');
sizeC=size(C);
numstorm=sizeC(1)

% Next print value (but to a cell array or matrix?)

A_1949_100_30(m,1)=numstorm;

end
save('NATL_1949_nowind','A_1949_100_30','-append')
```

Combining all output files into a final hurricane count dataset:

```
clear

load('NATL_1949_nowind.mat');
load('../../ENP/No_wind/ENP_1949_nowind.mat')

T_100_30=A_1949_100_30+E_1949_100_30;
T_100_35=A_1949_100_35+E_1949_100_35;
T_100_40=A_1949_100_40+E_1949_100_40;
T_100_50=A_1949_100_50+E_1949_100_50;
T_100_100=A_1949_100_100+E_1949_100_100;
T_100_200=A_1949_100_200+E_1949_100_200;

T_90_30=A_1949_90_30+E_1949_90_30;
T_90_35=A_1949_90_35+E_1949_90_35;
T_90_40=A_1949_90_40+E_1949_90_40;
T_90_50=A_1949_90_50+E_1949_90_50;
T_90_100=A_1949_90_100+E_1949_90_100;
T_90_200=A_1949_90_200+E_1949_90_200;

T_80_30=A_1949_80_30+E_1949_80_30;
T_80_35=A_1949_80_35+E_1949_80_35;
T_80_40=A_1949_80_40+E_1949_80_40;
T_80_50=A_1949_80_50+E_1949_80_50;
T_80_100=A_1949_80_100+E_1949_80_100;
T_80_200=A_1949_80_200+E_1949_80_200;

T_80_3731_3110=A_1949_80_3731+E_1949_80_3110;
T_80_4232_3110=A_1949_80_4232+E_1949_80_3110;

T_90_3294_3045=A_1949_90_3294+E_1949_90_3045;
T_90_3764_3045=A_1949_90_3764+E_1949_90_3045;

T_100_3072_2969=A_1949_100_3072+E_1949_100_2969;
```

```
T_100_3486_2969=A_1949_100_3486+E_1949_100_2969;

Num_liz_comb=[T_80_30,T_80_35,T_80_40,T_80_50,T_80_100,T_80_200,T_90_30,T_90_
35,T_90_40,T_90_50,T_90_100,T_90_200,T_100_30,T_100_35,T_100_40,T_100_50,T_10
0_100,T_100_200,T_80_3731_3110,T_80_4232_3110,T_90_3294_3045,T_90_3764_3045,T
_100_3072_2969,T_100_3486_2969];

dlmwrite('Data_Total_1949_Nowind.txt',Num_liz_comb)

clear
```