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Research Article

The Diet of the Non-Native Herbivore *Iguana Iguana* in Two Coastal Forests of Puerto Rico

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Abstract

One of the unintended consequences of human fascination, desire, and need to domesticate other species to have readily available food resources, working animals, and companionship (pets) is the widespread introduction of domesticated &and exotic species into new ecosystems worldwide. These practices often lead to the widespread introduction of former pets into novel territories as animals escape or are released by owners. This often results in many unintended negative consequences for native fauna and communities. Since the introduced species (particularly reptiles) are liberated from the regulatory pressures found in their native range. The green iguana (*Iguana iguana*) is commonly sold as an easy-to-care pet, and often it is the first exotic pet for many people. Green iguanas have been documented in Puerto Rico since 1970, and its population has spread across the island ever since. The primary goal of this study was to characterize the diet of the green iguana in two coastal forests of Puerto Rico. Second, determine if they are preferentially feeding on native plants like mangroves. Results showed that iguanas would feed on the most abundant plants in their habitat. Proportionally, males' stomach content contained a higher proportion of vegetation material from the trees they use for perching and displaying. Thus, where mangroves dominate the canopy, particularly male's iguanas will feed primarily on it. In comparison, the females ingested a more diverse diet including a higher proportion of leguminous plants. Green iguanas showed selectivity in their diet since all leaf material found in their stomach were young apical leaves regardless of plant or tree species.

Keywords: Caribbean Islands; Green Iguana; Herbivorous Reptile; Introduced Species; Mangrove

Introduction

Species range expansion and colonization of new foreign lands had occurred for eons. On many occasions, with the arrival of non-native species, the local community experienced drastic changes, even species loss (ref Buckley & Catforda[1]; Jeschke et al. [2] Sagoff [3]; Strauss et al [4]). But contrary to what we see in the Anthropocene period species, non-native species colonization of new territories and subsequent re-organization of natural communities were sort of infrequent, and they played out over long periods of time (Buckley & Catford [1]; Strauss et al. [4]). Since, many natural barriers reduce the probability of dispersal and colonization success. However, human dispersal across the planet has been by the introduction of many plants and animal species, and each region by humans. As well, the transformation and domestication of the landscape. But presently, in the Anthropocene, with our highly interconnected network of transportation of goods and people and the onset of industries like pet-trade industry, non-native species movement and introductions frequency across the planet have increased to unprecedented rates. Islands are among the most susceptible biomes to species introduction; since, often this non-native species introduce novel dynamcis (predator-prey, herbivore and so on), disease or simply

outcompete the native species which can have strong negative effects on the island native foodweb structure and dynamics.

Ecological generalists (e.g., diet, habitat) are believed to do well in all three settings, and indeed all three settings are associated with species bearing a number of common attributes (e.g., adaptability, tolerance of artificial habitats, high population density) including survive as invasive, pet or urban environment great adaptability (Rodda & Tyrell [5]). Green iguana (*Iguana iguana*, L.) is a tropical, arboreal herbivore, and diurnal ectotherm (Donoghue [6],van Marken Lichtenbelt, [7]). The native range of these arboreal herbivores extends from Mexico to northern Argentina in South America and islands within the Caribbean Sea including some of the Lesser Antilles (Falcón et al., [8]; Governor et al., [9]; Krysko et al., [10]; Malhotra et al., [11]; Rodríguez et al., [12]). Within the Lesser Antilles of the Caribbean green iguanas were described as natives of the islands of St. Vincent and the Grenadines, Grenada, Îles des Saintes, Montserrat, Saba, St. Lucia, and Trinidad and Tobago (Krysko et al., [10]). Still, genetic studies showed that native Lesser Antilles green iguanas have a distinct genetic marker different from those recently introduced via pet-trade (Malhotra et al., [11]; De Jesús Villanueva et al. [13]). As such its diet encompasses a broad spectrum of leaves, flowers & fruits in its native territory (Rodda & Tyrell [5]; Govener et al. [9], van Marken Lichtenbelt, [7]). Consumption from one food type to another may shift following seasonal availability (van Marken Lichtenbelt, [7]). However, observations from the non-native range occasionally report the consumption of animal protein (Governor et al., [9]; Krysko et al., [10]; López-Torres et al. [14]), but still primarily an herbivore. Excessive hunting and habitat destruction have decimated the local population in their native range (Baer, [15]; Perry et al., [16]). Due to its popularity in the pet-trade industry, and unintentional hitchhiking in horticultural plants and construction material, it resulted in the establishment of at least 25 countries (Perry et al., [16]). As an invasive species, the green iguana has a cosmopolitan distribution with a well-established population in the West Indies, Florida, Bahamas, and some parts of Asia (Falcón et al., [8]) where it has become a species of concern. Puerto Rico's green iguana was introduced in the 1970's with wild populations documented shortly after (Rivero, [17]; López-Torres et al. [14]). They are commonly found throughout most of the island and are particularly conspicuous in coastal forest zones and close to riverine habitats. Due to the lack of natural predators in many areas, they reach high density with ease (Terborgh et al., [18]; López-Torres et al. [14]). A similar pattern was documented by Terborgh et al. [18] where in the small island of Lake Guri in Venezuela, where vertebrate predators are absent the green iguana population was tenfold higher than in the nearby mainland. As such in Puerto Rico there have been many concerns related to how the feeding pattern of uncontrol iguana population and nested behavior will affect PR plant communities.

Some of the factors that have facilitated the colonization process of this non-native species in Puerto Rico (PR) are the similarity in climate to the climate found in its natural range, and the release from its natural predators. In addition to multiple introduction events (geographically and temporally) has been part of the exotic fauna pet trade (Falcon et al., [8]) Human activities and disturbances in Puerto Rican natural communities have created a series of novel natural communities dominated by non-native plant species which facilitated non-native species population establishment. In addition to all these factors, the plasticity of this reptile diet may be the key factor ensuring their prevalence (Rodda & Tyrell, [5]) in Puerto Rican coastal and lowland forest communities.

Generalist herbivores face a wider variety of food resources and food availability, both in quantity and quality, than carnivores during the year (van Marken Lichtenbelt, [19]). Generalist feeders are usually suitable colonizer species since they can readily adapt their diet to what is available in their habitat while selectively exploiting more nutritious resources (flowers, fruits) when available. Furthermore, iguanas of different ages typically occupy different habitats, adults dwell in the exposed part of the forest canopy, juveniles dwell in the inner branches of the canopy, and the hatchlings in low vegetation. As such, their impact on the recently colonized communities is highly variable. Upon its introduction, the I. iguana, a large-bodied arboreal herbivore, was introduced to a habitat that shares a similar climate and a similar and diverse plant-food source; it may have experienced little to no competition for food resources and predation by native predators including humans, Large reptilian herbivores like the green iguanas *(I. iguana)* could potentially have a strong impact on vulnerable plant species either by directly feeding on them or by feeding on other competitor plant species. The objectives of this study were: first to characterize the diet of the green iguana *(I. iguana)* in two coastal zones in Puerto Rico (P. R.) and determine if they are consuming mangroves and what percentage of their diet it comprises. Second, determine if there is a difference in dietary choice between sexes and life stages (juvenile vs adult). Finally, address the possible impacts of this organism on the island flora if they are preferentially feeding on endemic and endangered plants of PR.

Methods

Study Site

Green iguanas were collected at two localities in the eastern side of PR: the San Juan International Airport Luis Muñoz Marin (SJU)and the Humacao Nature Reserve (HNP), Figure 1. The International Airport Luis Muñoz Marin in Isla Verde (referred to as Airport from here on), was established in the1966 on reclaimed lands that were initially part of the northeastern inland mangrove forest. The north-eastern inland mangrove forest, PR's largest and continuous inland mangrove forest, surrounds Airport's east and south borders. Thus, the canopy is dominated by *Rhizophora mangle*, along the east and south borders. The northern border is surrounded by a mixture of native and non-native trees and understory vegetation, a common occurrence reflecting past and present human-driven forest fragmentation and deforestation disturbances. The western border lacks trees, and vegetation cover is a mixture of grass, forbs, legumes, and small shrubs since that part is wedged between the PR-26 road and the landing tracks of the Airport.

The Humacao Nature Reserve (refer from here on as Nature Reserve) is in the southeast part of Puerto Rico, known as Punta

Santiago at Humacao town. The habitat/ landscape is a mixture of freshwater and brackish water lagoons connected by channels surrounded by coastal inland mangrove forest-stand (three species of mangroves reported), grass marshes, palm, and novel forest stands where the canopy is dominated by a mixture of non-natives trees and natives' coastal trees species. Changes in the economic activity in the region during the 20th century resulted in marked habitat alterations including the coastal lagoon system, which was drained and maintained for multiple decades using pumps to allow sugar cane cultivation, and cattle grazing primarily. Thus, the successional forest that emerged after the abandonment of agricultural and ranching practices resulted in a canopy dominated by a mixture of native and non-native tree species heterogeneously distributed across the landscape. Moreover, tree stands are heterogeneously distributed across a fragmented landscape by suburban communities.

Iguana Iguana collection

The *Iguana iguana* specimens from the Airport were collected by U.S. Fish and Wildlife Service, as part of their population control program to reduce air traffic danger and donated them to the Zoology Museum at the University of Puerto Rico, Río Piedras Campus (Spring: 2004). The specimens from the Humacao Nature Reserve were donated by local hunters between November 2006 and February 2007 and were euthanized at the preserve. The donated specimens were placed in a cooler with ice in the field and transported to the University of Puerto Rico, Río Piedras Campus. Then the specimens were placed in a -200F deep freezer for a period of eight hours to stop bacterial activity within the specimen corpse before dissecting them.

Statistical Analysis

The sex of the specimens was determined using sexual dimorphism in head morphology and cloaca scales. The size of the individuals was recorded in cm as the snout-to-vent measure. SVL: snout to vent length and tail length were not recorded as it is well-known that iguanas can lose and regenerate their tails which could skew our size estimation. Then, during dissection, the gravid females' eggs were counted. To preserve the plant samples within the stomachs we tied the stomach at the end of the esophagus and at the initial part of the intestine. Then the stomach was removed from the abdominal cavity and preserved in formaldehyde.

Diet characterization

Based on leaf morphology, the stomach content was separated and classified into morpho species. Reference plant specimens were collected from each site, and a literature description was used to identify plant morpho species found within the iguana stomachs to the lowest taxonomic level possible. We compared leaf morphological attributes to identify the morpho species: leaf morphology, edge type, venation type, and leaf arrangement. Also, when we collected the reference specimens, we collected multiple sizes of leaves (apical to mature leaf) for each plant and tree species, since our stomach samples were comprised of apical leaf material. In addition to identifying the plant morphospecies to the lowest taxonomical level possible, each morphospecies was classified into one of the following plant types (PT): trees, forbs, legumes, grasses, and non-foliar tissue. Afterward, stomach-vegetative material was dried in an oven at 600C for 72hrs and weighed in order to establish the amount eaten in grams per plant type by an individual and calculate in what proportion of each plant morphospecies was consumed by each sex per population.

Figure 1: Localities where the iguana specimens were collected. SJU stands for San Juan International Airport also known as Luis Muñoz Marin Airport, located in the Northeast of PR. HNP stands for Humacao Nature Preserve a system of coastal lagoons and forested habitat located in the Southeast of Puerto Rico.

Statistical Analysis assess if diet differed between sex per population, we performed a 2-way analysis of covariance (ANCOVA) where the predictor variable was sex and plant species identity, covariate variable was the animal body size reported as (SVL: snout to vent length). The response variable is the amount of vegetation consumed per plant species reported as a percentage. Each population (Airport & Nature Reserve) was analyzed separately due to little non-overlap in plant species composition found within the stomach content of the specimens studied for each population followed by a pairwise t-test with the Bejamini-Hochberg correction for the reported p-value. In order to compare the diet of I. iguana between these two coastal populations, instead of focusing on plant species we focused on the amount of vegetation consumed per plant type (PT). Thus, we performed a 3-way ANOVA where the predictor variables were Population, Sex, and Plant type response was the Percentage of vegetation eaten per plant type. A post-hoc pairwise t-test with the Holm-Bonferroni adjustment for the reported p-values followed the 3-way ANOVA test. All analysis and associated figures used R 4.2.3 (R Core Team 2013) Figure 1.

Results

Sample Composition

The sample of donated iguanas from the Airport consisted of 50 individuals, of which 34 were females, and 16 were males; no juveniles were sampled in this population. Female's size (SVL) ranged from 22.6 cm to 38.2cm. We have two gravid females within the sample, and we counted 10 and 38 developed eggs per female. The male SVL size for the Airport sample ranged from 20.9 to 36.2 cm. A total of 30 individuals were collected from the Nature Reserve, we had 14 females and 16 males. The SVL of the females ranged from 26.1 cm to 41cm and the male's size ranged from 28.2cm to 49.5cm. Six out of fourteen females were gravid and egg masses within females ranged from 36 eggs on a female with SVL of 37.3cm (40 eggs on a female with 35 cm of SVL) to 70 eggs on a female with SVL of 41cm. One male was excluded from the statistical analysis since he had an empty stomach. As such, the stomach content for 79 individuals (50 from Airport y 29 from Nature Reserve) was analyzed.

Diet composition

Our result showed the feeding plasticity of the green iguana since it feeds on the most common plants found at the sampling localities (Figures 2 & 3). A total of 26 morphospecies were identified in the Airport population, from which only 2 of those morphospecies were trees. Of the 26 morphospecies found within the stomach content, only 10 were identified correctly to genus or species level. The rest were classified into their own morpho and plant types based on foliage attributes as described in the methods. In contrast the diet of the Nature Reserve population was composed of 6 plant species with the exception of vegetation material from Ipomea spp., all of which were trees. Additionally, iguanas showed a high capacity for visual selection and discrimination since all the leaf material found on the stomach content of 79 individuals was only young leaves from the apical shoots.

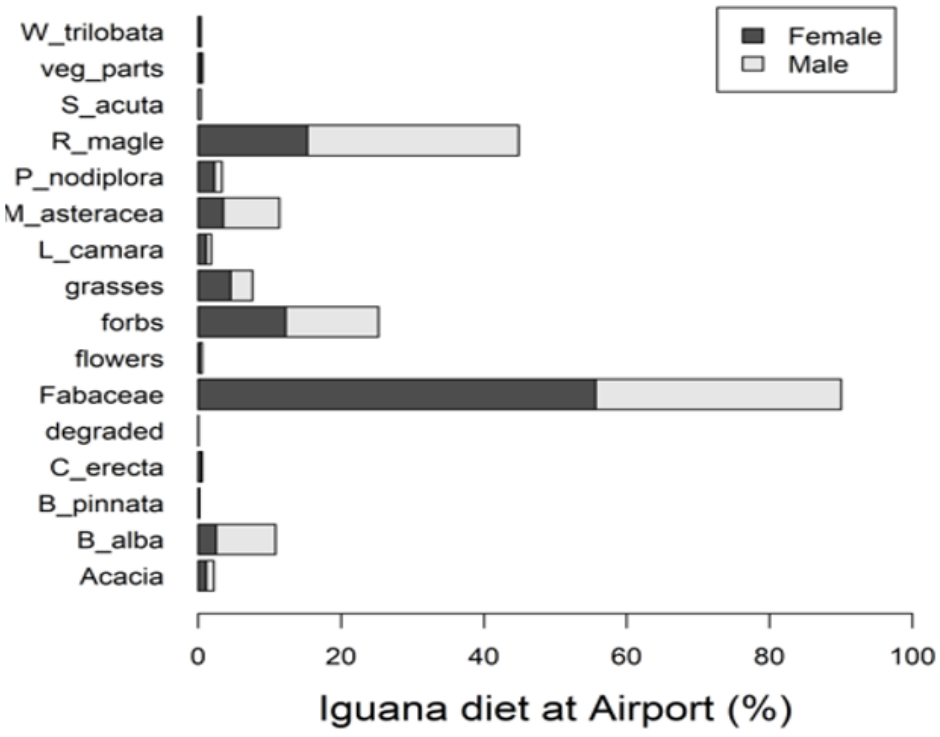

Figure 2: The diet of green iguanas around the San Juan International Airport (SJU).

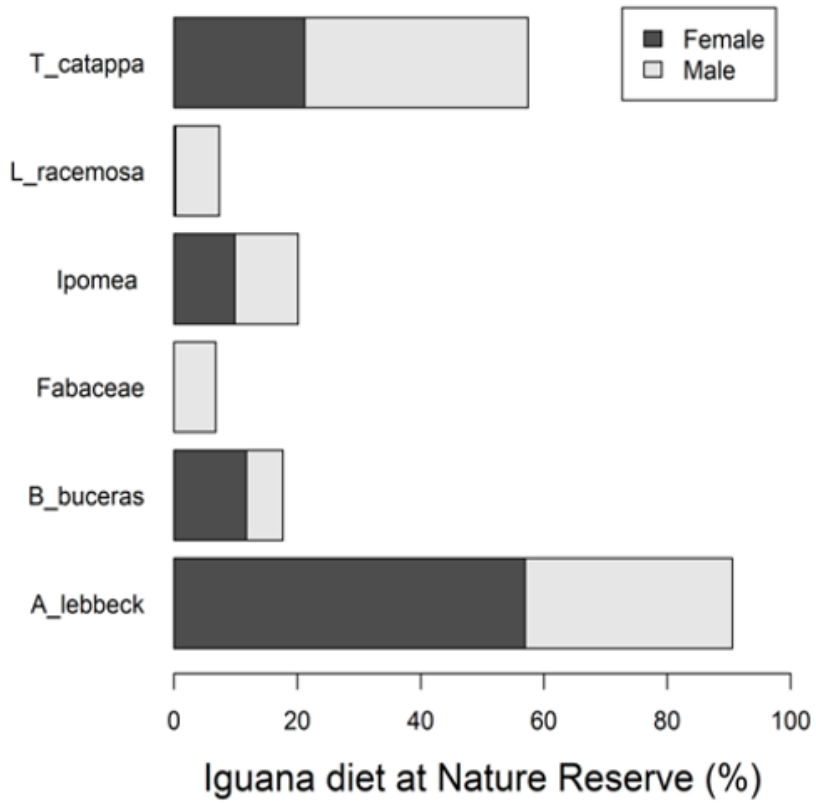

Figure 3: The diet of green iguanas around the western lagoons of the Humacao Nature Reserve (HNP).

Results from the 2-way ANCOVA at the Airport show a significant interaction between plant species and sex (F_{16}, 8_{15}=3.15, p<0.0001); thus indicating that male and female iguanas consumed certain species in different proportions. Post hoc pairwise T t-test showed statistically significant (α ≤ 0.05) differences in the consumption of certain plant species iguanas at this locality. We found that females consumed legume plants (Family: Fabaceae or Leguminosae) more than males, representing up to 56% of the leaves in the gut content (p= 7.55e-10). While for males' legumes, foliage accounted for approx. 30% of their diet (Figure 2). In contrast, males consumed in more significant proportion than females the foliage of *Rhizophora mangle*, *Bidens alba*, and *Matiricaria asteracea*, up to twice more, α=0.05 (Figure 2).

At the Nature Reserve 2-way ANCOVA results show that diet is influenced by plant species ($F_{5,161}$=7.05, p= 5.46e-6), but no significant difference between sex and or interaction was detected. The trees *Albizia lebbeck* and *Terminalia catappa* consumption were significantly higher (α ≤ 0.05) than any other species for both males and females (Figure 3). Post-hoc pairwise T-test showed that *A. lebbeck* consumption significantly differed from all other five species found on the iguana stomachs in the Nature Reserve, at α ≤ 0.05. Similarly, *T. catappa* differed from all other species except for *Ipomoea spp*. That there wasn't a significant difference. Even though sex wasn't a statistically significant factor for this population some trends can be derived; these two trees' species Albizia lebbeck and Terminalia catappa represented approximately 2/3 of the food ingested by male iguanas and were consumed in an almost even ratio (Figure 4). In contrast, for females *A. lebbeck* seems to be their preferred food item since by itself represented 57%, followed by *T catappa* with 21% (Figure 3).

The 3-way ANOVA showed significant 2-way interactions in which the predictor variables were Plant Type and Population ($F_{4, 375}$= 8.7, p= 1.01 e-6); post-hoc pairwise t-test showed that the consumption of legumes was significantly different (α ≤ 0.05) from all other plant types except forbs (Figure 4) To be specific the Airport population is the one that consumed legumes in a great proportion since it seems legumes occurred in low abundance or were not consumed as often by the Nature Reserve population. Similarly, the consumption of foliage from common trees at each locality significantly differed from all other plant groups at α ≤ 0.05 (Figure 4). At the Nature Reserve population, tree foliage consumption was higher than any other plant type. While at the Airport tree consumption was higher than grasses and nonfoliar tissues, but it was lower than legumes and not different from forbs at α ≤ 0.05 (Figure 4).

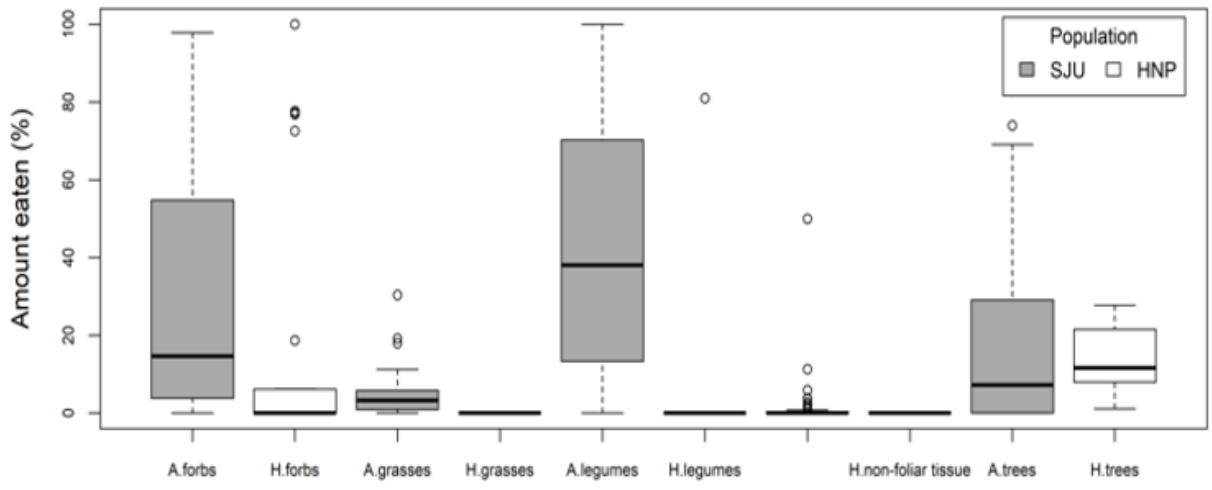

Figure 4: Comparing green iguana diets by plant types for both populations.

Discussion

Our findings showed that the green *iguana* diet is quite malleable. Where they feed primarily on plants available in their habitat, results showed that males feed principally on common tree species found at each coastal site, used for territorial and mating display, or used as basking areas. While females feed in a greater proportion of understory vegetation in both populations. Additionally, and very interestingly, we documented that green iguanas can visually discriminate and don't find all leaves in the foliage equally desirable since all leaf content found within the stomach was composed entirely of the young leaves from the apical shoots. Probably, as individual leaves age, their nutrient content may decline and the amount of secondary compounds may increased, reducing the palatability of the leave for herbivores (Farmsworth & Ellison, [20]).

In a study realized by Rand and collaborators [21] they found that green iguanas had small home ranges in Perico and Flamenco islands at the Pacific entrance of Panama Canal since vegetation is not completely homogeneous, diet composition differed at the individual home range level. The leaves eaten with more frequency came from the common species of trees and vines found in an individual's home range, often the stomach content of *Iguana iguana* was entirely comprised of a single plant on which they have fed consecutively for multiple days (Rand, [21]). We observed a similar pattern on the iguanas captured at Humacao Nature Preserve. Also, Rand and collaborators (1990) found that green iguanas moved from one tree to another to feed but at the same time ignored many leaves. This suggests that the iguanas do not find all the leaves equally desirable or digestible. Our findings support the notion that green iguanas can be selective and don't find all leaves within foliage are equally desirable. Since the vegetation material that was found in our samples came for apical meristems. Similarly, most of the stomachs dissected contained just a few plant species per stomach. In the case of male iguanas, the stomach content usually reflected which trees they used for basking and display reflecting the species that dominated the canopy at each location. As such, for the Airport population male stomach content was primarily dominated by the native tree species *Rhizophora mangle*; since it is the dominant tree surrounding the periphery of the airport which forms the western border of the northeastern mangrove forest. Besides that, the Airport iguana population tends to consume a wider variety of leguminous and herbaceous plants, the common vegetation around airplane tracks. While the population from Nature Reserve feeds on trees and two understory plant species that are abundant at the edges of water channels and lagoons.

Less common plants are sought out and consumed because of nutritional importance and/or have detoxifying properties (Rand 1990) during times of prior time stress like dry periods when they have less access to water supplies, and prior mating season, or after laying eggs which occurs during the dry season in its native range (van Marken Lichtenbelt, W. D. [19]). Similarly, it has been documented that green iguanas will key in on flowers and fruits when available to help increase water intake during dry period (van Marken Lichtenbelt, [19].). For example, we observed iguanas gorging on flowers during the small-time window some trees were flowering like tropical almonds (*T. catappa*). This shows their high visual capacity for selecting and discriminating food resources within the canopy. Also, our results showed that there were differences in diet preferences between males and females. We documented that females feed on a greater proportion of leguminous plants in both localities, representing at least 50% of the vegetation consumed by female iguanas. At the Airport location, females feed on leguminous plants found primarily at ground level; since the leguminous foliage was commonly found intermixed with grass foliage it's reasonable to assume these individuals were feeding around the plane tracks. While at the Nature Reserve, females forage intensively over the tree *Albizia lebbeck* which is part of the Fabaceae family; Thus, it makes sense that female iguanas are keying into consumed plants with potentially higher

nutritional value in order to recover from the metabolic demands associated with their reproduction. Instead, growing iguanas select diets higher in digestible protein and digest the same food 1.3X to 2X more rapidly than adults (Troyer, [23]). Young iguanas may accomplish their shorter food transit times by maintaining higher body temperatures (Troyer, [23]).

Iguanas & Mangrove Trees

Over the last couple of decades since its introduction, the green iguana population has grown and expanded across the lowlands and coastal regions of Puerto Rico. Green iguanas can achieve high abundance in different parts of the islands, becoming a conspicuous component of the fauna like in coastal forests and wetlands. Since iguanas can achieve high populations abundances and once they reach adults size they have few natural predators and survive up to 12-15yrs in the wild it poses a threat to native plant species with limited, distribution and/or occurs in low abundance or low recruitment capacity. Thus, there is a need to understand green iguanas' role as a large-bodied herbivore in PR natural and secondary forest communities. As such, one of our goals was to document if green iguanas were consuming mangrove and if so which species and how much. Since, mangrove forest historically have been one of the forest biomes that had suffered a drastic reduction in coverage area due to human resources exploitation and land conversion for humans' settlement and economics activities. From the mangrove species found in Puerto Rico, the tree species that this herbivorous reptile could negatively impact is the *Rhizophora mangle*. Particularly at the Airport where males feed primarily on this tree. Additionally, the result of the comparison between male and female body size for the Airport population don't show a difference in size between sexes this suggests captured were adult females and young males that spend more time in the lower vegetation and tend to use the plane tracks has basking rocks during the early morning and late in the afternoon. The large male iguanas spend most of their time displaying and feeding on the *Rhizophora mangle* stands beyond the Airport terrain limits and may have not been targeted as strongly by the Iguana task force of the Airport. Since, they were beyond the area of concern for the airport safety issues.

The diet of male iguanas at Humacao Nature Reserve revealed a mixture of foliage reflected the species that dominate the canopy with little to no gut content evidence of mangrove tree consumption regardless of the species. Even though, we have observed on many occasions' green iguanas, both males and females, feeding on red (*Rhizophora mangle*) and white (*Laguncularia racemosa*) mangrove trees on the eastern side of Nature Reserve which is the part with the highest tourist visitation. However, hunters are not allowed to hunt animals on that side of the Nature Reserve due to the risk of injuring a person. Some reasons for which mangrove consumption was misrepresented on the side that hunters were allowed to hunt included: red mangrove (*Rhizophora mangle*) stands on that side of the Nature Reserve were in the center of the lagoon or adjacent to private lands. Second, once green iguanas became aware they were being hunted they fled into the waters of the lagoons and channels, many times even before we had a chance to be close enough to aim; once submerged, it was difficult to track the animals and personal communications. This may result in a slight underrepresentation of the red mangrove (*Rhizophora mangle*) in the iguana's diet from the area the animals were collected. While males did consume *Laguncularia racemosa* and only accounted for less than 10% of the diet on this site. A plausible explanation for why it represented such a small proportion is that *L. racemosa* trees at the channels and lagoons edges where they collected the iguanas were young trees still forming part of the understory. Thus, adult iguanas may spend less time on those trees, since they don't have branches with optimal exposition a for animals to bask, thermoregulate or display. Since, these were young trees with relative short stature may had been used by younger juvenile iguanas which we didn't sampled. Simi have documented that iguana perch height increases as their size (SNVL) (Henderson, [24]). But, from personal observations of growing visiting Humacao Nature Reserve for almost 20 years, green iguanas due feed on both red () and white (*Laguncularia racemosa*) mangrove trees at these localities, and some trees have clear signs of being experiencing intense and frequent herbivory pressure.

As such, the Humacao population primarily feeds on introduced tree species, a dominant component of forest diversity in this secondary-growth coastal forest, after the legacy of agricultural activities. Both our data and field observations at this locality show that diet diversity and/or the proportions of species in the diet of these herbivores can vary quickly reflecting the local plant species composition, even at a relatively small spatial scale. The findings of this study show how malleable and adaptable green iguanas are at exploiting available food resources in any given locality, a trait that improves their chances of colonizing new territories.

The Green Iguana Within Puerto Rico Communities

Non-native species can have detrimental effects on native communities via top-down effects like when novel predators are introduced. But non-native herbivores can re-structure native communities via bottom-up dynamics by altering plant species composition or altering the availability of key producers' resources like habitat structure, food availability, pollen, and so on through the landscape. These community changes can be driven by the non-native direct consumption and disturbance of the habitat or by direct competition and/or interference with native herbivores. For example, besides damaging plants through feeding, which can result in defoliated plants and or increased mortality trees when iguana abundance is too high like black mangrove (*Laguncularia racemosa*) at the San Juan Bay Estuary (Carlo and García-Quijano [25]; López-Torres et al., [14]). They can negatively impact plants and tree's fitness through mechanical damage as they move and rest at the edge of branches, particularly on young trees. Factors that can affect plant fitness, flower, and seed production or even depress their survivorship in response to herbivory pressure and physical disturbances if they are beyond the capacity of the plant to reallocate resources to replace the lost tissue.

Besides altering plant communities through feeding and mechanical disturbances, non-native species can alter plant

community composition by altering plant recruitment. Green iguana's ecological distribution and diet make it an alternative method of transporting and distributing seeds after digesting them. Their body size permits them to ingest and disperse a wide range of seed sizes, dispersing seeds up to 14.9 mm long and with a width between 3.6 and 9.2 mm (de A. Moura et al., [28]). Their capacity to disperse viable seeds depends on how much damage the seed receives through the mechanical and chemical processes of digestion. For example, Burgos-Rodríguez [26] documented that up to 47% of iguana scat contained seeds that were relatively intact, still, the germination rate was species-dependent. He also reported that the 4 species (*Anona glagra, Peltophorum pterocarpum, Ficus sp. & Pterocarpus sp*.) found in the scat of green iguanas collected at the Humacao Nature Reserve, exhibited reduced germination, which contrary to what has been reported within its native range (Burgos-Rodríguez, [26]). Another, key finding from Burgos-Rodríguez [26] study was that on average iguanas dispersed seeds beyond their parent tree canopy, including in directions where air and water dispersal cannot disperse these seeds. As such, large-bodied herbivores like the green iguanas could negatively impact native plant communities via multiple types of disturbances, like altering the plant species distribution via scat dispersal.

Similarly, further studies are needed to understand how iguana selective herbivory on apical leaves, flowers, and fruits affects seed production and recruitment between native and non-native tree species and in turn how that could affect coastal forest structure through plant recruitment and succession. Also, studies are needed to understand how green iguanas feeding on non-native trees in secondary coastal forests influence mangrove tree's stand establishment and growth.

In the absence of predators iguanas population increases dramatically (Terborgh et al., [18]), like it was documented in the island of Lake Guri, Venezuela, part of its native range. The absence of predators often is a major factor that facilitates the establishment of non-natives reptiles and amphibians in novel territories. But this have been changing over the last couple decades as many anecdotal observations and from personal observation, we have documented a series of species found on island successfully predating on iguanas at different life stages. As usual the younger the iguana the more susceptible to predators. Hatchling and small-juveniles iguanas have been reported to be predated by domestic dogs & cats, American Kestrel (*Falco sparverius*), Great Egret (*Ardea alba*) (Krysko et al., [10]; López-Torres et al., [14]). I have personally observed "small Indian mongoose" (*Urva auropunctata*), a mammalian predator introduced in PR in the 19th century to control Black rat (*Rattus rattus*), hunt and kill juvenile green iguanas at the Humacao Nature Reserve. Another, predators documented by Krysko et al. [10] and found in P.R. are the Osprey (*Pandion haliaetus*), Night-heron (*Nyctanassa violacea*) and the Spectacled Caiman (Caiman crocodilus) but the caiman is also another introduced species in the island. Juveniles and sub-adult iguanas are many hunts domestic and feral cats, domestic and feral dogs, & Indian mongoose, but adults are often killed only by dogs and potentially by Spectacle caimans. Also, humans have started to hunt iguanas as a measure of pest control and a source of "exotic protein". But most of the non-human predators are also non-native species, so a non-native regulating a non-native.

Which begs the question is this non-native species occupying an empty niche in Puerto Rican historical natural communities or simply a new player within the process of the formation of novel-food webs due to the introduction of many species at multiple trophic levels?

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