The Pinocchio Lizard (*Anolis proboscis*): Conserving Mindo's Hidden Anole, 2019 to 2034

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Male Pinocchio lizard (*Anolis proboscis)*; Photo by Alejandro Arteaga

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EXECUTIVE SUMMARY

The Pinocchio lizard (*Anolis proboscis*) is a cryptic, arboreal anole with in the *laevies* species group characterized by the unique rostral appendage. Rediscovered in 2005 in Mindo, Ecuador, our understanding of species is limited. The International Union for Conservation of Nature (IUCN) currently lists the species as endangered for its limited extant range within the Andean cloud forests near Mindo (Pichincha). Their reliance on canopy cover with branchy twigs makes habitat loss the greatest ecological concern. Anthropomorphic influences such as agriculture, urban development, and oil industry continue to increase the rate of deforestation. The goal of this plan is to provide protection and recover the populations of Pinocchio lizards within 15 years. The following objectives are designed to achieve this goal. (1) Determine population size estimates and detailed suitable habitat requirements of the Pinocchio lizard within 2-3 years. (2) Implement an education and awareness campaign in Mindo within 1 year. (3) Establish the Mindo as a National Park within the next 5 years. (4) Increase survivorship of all life stages within 3 years. Research is needed to develop a detailed understanding is needed to make informed decisions to achieve objectives. Establishing the extant range of the species as a National Park will discourage provide habitat and legal protection. Implementing a captive

breeding and reintroduction program will increase immature life stages needed to increase wild populations. If objectives are met successfully, the species will be federally protected throughout its extant range, the population will be stabilized, and will be delisted from the IUCN red list, conserving the biodiversity of Ecuador's cloud forests.

INTRODUCTION

The Pinocchio lizard (*Anolis proboscis*) was last described in 1966, known only by six male specimens until 2005 when it was rediscovered by ecotourists in Mindo, Ecuador (Almendáriz and Vogt 2007). Currently, the Pinocchio lizard is listed as endangered for its limited extant range of only 33 ha (Yánez-Muñoz et al. 2010, Mayer and Poe 2013). However, it's estimated that the species extends some 20,000 ha from its known occupancy (Yánez-Muñoz et al. 2010, Mayer and Poe 2013). The population exists in a biodiversity hotspot, and the lack of enforcement combined with lenient timber harvesting, agriculture, and infrastructure laws threaten this population (Mayer and Poe 2013). Since it's rediscovery, we are beginning to develop an understanding of the life history, ecology, and behavior of this group of anoles, and *A. proboscis* in particular (Losos et al. 2012, Poe et al. 2012). *Anolis* have a complex and interesting evolutionary history of which the Pinocchio lizard could provide new insights (Losos et al. 2012, Poe et al. 2012, Prates et al. 2015). Recently, it has gained much attention in the media and public eye, attracting researchers and ecotourists.

NATURAL HISTORY

Morphology

The Pinocchio lizard is a small cryptic anole (*Dactyloidae*) of the *Anolis laevis* species group, characterized by their unique elongated snout appendage, or horn as it's referred to (Losos et al. 2012). This species expresses strong sexual dimorphism with the male's obvious horn and white-blotched sides. Females lack the species' characteristic horn and are often one shad of green. Adult sexes also differ in size with males (80-86 mm SVL) being larger than the female (70-75 mm SVL) (Losos et al. 2012, Poe et al. 2012). The Pinocchio lizard is a slender bodied anole, with

short limbs, and a narrow head, which corresponds significantly with the morphological measurements of West Indian twig anoles (Losos et al. 2012).

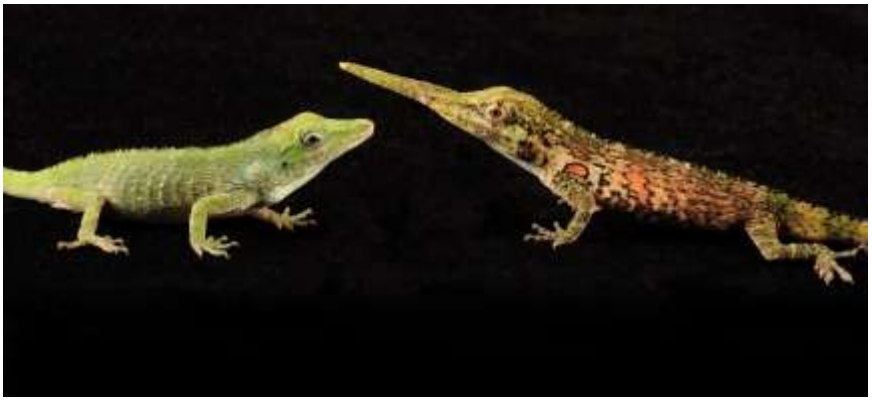

Fig 1. Pinocchio lizard female (left) with male (right). Photo by Santiago R. Ron.

Reproduction

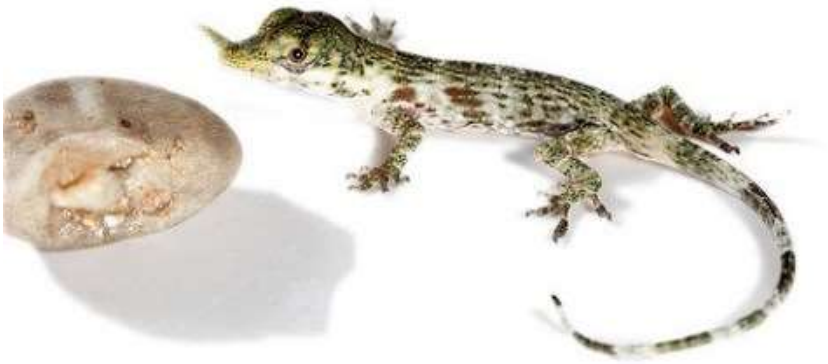

Fig 2. Baby Pinocchio lizard (Photo by Santiago R. Ron).

Most of what has is known of the Pinocchio lizard's reproduction refers to courtship behavior. Quirola et al. (2017) documented the various courtship displays including male-female and male-male interactions of the species in detail. Pinocchio lizards preform head bobs, and pushups like other anoles, however the horn is erect and a saying from side-to-side display is unique to this species (Quirola et al. 2017). Successful copulation was monitored in semi-captive enclosures resulting in a one fertile egg, confirming that the Pinocchio lizard lays a one

egg clutch, a trait shared among all *anolis* species (Andrews and Rand 1974, Bock et al. 2010). Eggs are often buried under soft soil or in deep crevasses (Andrews and Rand 1974). The average gestation period for anoles at optimal incubation temperature is 30-40 days, however the captive breed Pinocchio lizard underwent incubation for 165 days (Ruibal and Philibosian 1974, Quirola et al. 2017). This long gestation period was only recorded once and suggests a decreased rate of reproductive output which is uncharacteristic among *Anolis* (Andrews and Rand 1974). The evolution of a single egg clutch is a response to a year-round growing season (Cox and Celsbeek 2010). For this reason, the 30-40 day period was used in calculating adult fecundity (F(a)= 1.47) for the species (Fig 2). Pinocchio lizard survival rates and reproductive outputs still remain unstudied. To create a population model to show a general trend of what is expected for the Pinocchio lizard vital rates from surrogate anole species were used. Egg survival (S(e)= 0.255) was derived from *A. limifrons*, hatchling survival (S(h)= 0.04) from *A. sagrie*, and juvenile survival (S(j)= 0.17) and adult survival (S(a)= 0.245) from *A. acutus* (Rubial and Philibosian 1974, Andrews and Nichols 1990, Johnson et al. 2006).

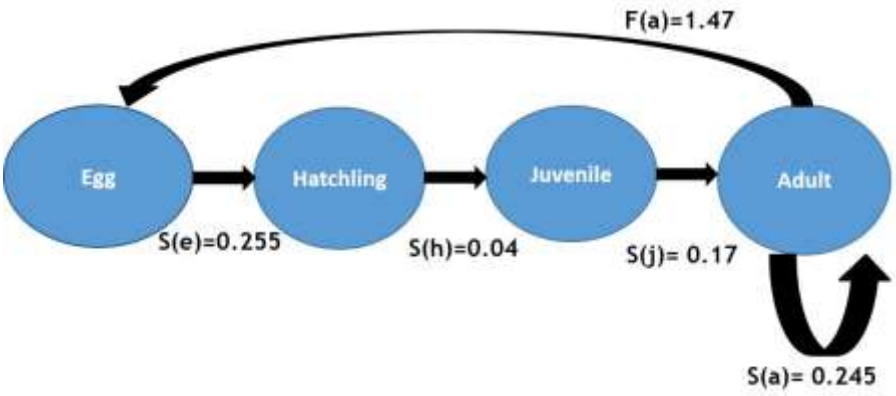

Fig 3. Pinocchio Lizard life table. Vital rates derived from surrogate anole species with available data (*A. limifrons*, *A. sagrie*, and *A. acutus*).

Diet

The diet has been examined through stomach flushing (Appendix 1), and an energy allocation budget has not yet been determined for the Pinocchio lizard. However, Losos et al. (2012) provides

a time budget demonstrating the percent of movement, foraging, and displaying (Appendix 2). Losos et al. (2012) examined the stomach contents of 19 individuals and found that caterpillars, Hemiptera, Coleoptera, Hymenoptera, and diptera were the most common prey items. Like most anoles, the Pinocchio lizard is insectivorous, however the food requirements can be assumed to vary across ages and seasons (Andrews 1971). Hatchlings and juveniles of seasonal breeding anoles have 3-4 months of high food availability which is needed to reach sexual maturity (Andrews 1974, Andrews 1971, Ruibal 1974). During juvenile and hatchling stages anoles feed on smaller insects (prey no greater then the width between eyes) (Andrews 1971). Prey that is high in protein and calcium is a must not only for developing anoles, but also to sustain the reproductive output of adults (Lovern et al. 2004, Johnson et al. 2006). Hatchlings and juveniles are not sexually mature and allocate all of their time to feeding and predator avoidance, where as adults divide their time between feeding and social interactions (i.e. courtship) (Bock et al. 2010, Losos et al. 2012).

Habitat

The full extent of the Pinocchio lizard's habitat requirements remains unknown. The full extant population resides in a 3300 ha area near Mindo, Ecuador at ~1300m elevation. Individuals have been collected mostly in disturbed areas, along road sides, and secondary forests (Losos et al. 2012, Poe et al. 2012). However, observations in the field and on the lizard's morphology (i.e. slight prehensile tail, short limbs, slender body) conclude it is an arboreal specialist found on the out ward limbs of branches as high as eight meters above the ground (Losos et al. 2012, Poe et al. 2012, Quirola et al. 2017). During visual encounter surveys, it has been found to prefer primary forest canopy.

Home range and Reproduction

It has been found to require slightly open areas in the canopy to display courtship rituals (Quirola et al. 2017). It is common amongst most anole species to require suitable perch diameter, angle, and visibility (Appendix 2) (Johnson et al. 2006). The territory it defends during a breeding season, yet other anoles have been observed to travel within a 3m range (Calsbeek 2009). To lay eggs, the Pinocchio lizard moves to the ground and requires leaf litter and loose soil to burry eggs (Quirola et al. 2017, Lovern et al. 2004).

Thermal

Due to the consistent tropical climate where the Pinocchio lizard inhabits, thermoregulation is mostly passive (Losos et al. 2012). However, several individuals' body temperatures were recorded to be slightly above the ambient temperature (23.3^{o}C vs. 22.2^{o}C and 24.4^{o}C vs. 22.7^{o}C) after observed basking in the sun (Losos et al. 2012).

Disease

The diseases and their effects on the Pinocchio lizard are not understood. Assumptions on the physiological and morphological effects can be made from the diseases found in other members of the *Anolis* genus. Anoles of the Lesser Antilles, Brazil, and Ecuador host blood parasites, the most common being malaria (*plasmodium spp.*) (Goldberg et al. 2006, Schall et al. 2000). 27% of *Anolis gundlachi* showed infection by *Plasmodium sp.*, however infection had little effect on overall health in the species (Schall 1992). In a competitive anole, *A. gingivinus* the same *Plasmodium sp.* altered blood cell chemistry and composition, decreasing individual across the population (Schall 1992). Anoles are also often infected by nematodes, most of which cause little harm (Goldberg et al. 2006). *Cyrtosomum penneri* infects the small and large intestines a sexually transmitted nematode and *Falcaustra belemensis* could be contracted by *A.*

proboscis. (Langford et al. 2013, Goldberg et al. 2006). In the neotropics, *F. belemensis* has been found to be the only species to harm arboreal mainland anoles (*A. punctatus*) (Goldberg et al. 2006). *C. penneri* persists in brown anoles (*A. sagrei*) and is less of a threat due to it being transmitted by copulating hosts (Langford et al. 2013).

Ranavirus

The most devastating disease that the Pinocchio lizard is at risk of is ranavirus. Although most prevalent in amphibians, ranavirus has spread through tortoise species and in a number of lizard species, including the green (*A. carolinensis*) and brown anole (*A. sagrei*) (Stöhr et al. 2013). Ranavirus persists on every continent except Antarctica and is spreading (Duffus et al. 2015). However, not documented in Ecuador (2015), the ability to cause massive die-offs and extinction is well document, and poses the greatest threat to rare, isolated species (Duffus et al. 2015).

Ranavirus is a viral pathogen of several species that can cause variable symptoms of variable severity (Duffus et al. 2015, Ranavirus Fact Sheet). Ranavirus affects ectothermic organisms (i.e. fish, amphibians, reptiles) and has a 90%-100% mortality rate (Duffus et al. 2015, Stöhr et al. 2013). Infected organisms display appropriate symptoms to how the virus affects the species. Anoles showed black lesions and necrosis of vital organs (Stöhr et al. 2013).

Individuals can become infected from direct contact with the virus, consuming an infected organism, ingestion of virus, or contact with virus within substrate (Duffus et al. 2015). Anoles are most likely contracting the disease from other infected anoles, during social interactions (i.e. territoriality, courtship). There is high rate of mortality by ranavirus through the pet trade, which suggests that humans are indirectly spreading the disease not only to wild populations by also captive individuals (Duffus et al. 2015, Stöhr et al. 2013).

There is currently no treatment for an infected organism. Suggested course of action to maintain and control outbreaks. Infected organisms should be quarantined and removed immediately upon encounter (Duffus et al. 2015, Stöhr et al. 2013). Sterilizing equipment that could have been in contact with ranavirus is crucial to eliminating the spread of the disease (Duffus et al. 2015). Ranavirus outbreaks would provide reason for concern to the Pinocchio lizard as the restricted population is at greater risk than an open population (Duffus et al. 2015). An extreme die-off of herpetofauna can have negative consequences that effect the entire trophic system, disrupting ecosystem productivity that offers potential to negatively effect humans. Anoles control pest insect populations in agriculture areas and a decrease int their population from Ranavirus could devastate crops (Johnson et al. 2006).

Fig 4. Infected *A. carolinensis* (Ranavirus expressed as dark blotches).

CONSERVATION ISSUES

Ecological

Ecuador has a long history of environmental resource exploitation dating back to the 1500's (Mecham 2001). Today, Ecuador holds one of the worlds highest rates of deforestation at

over 300,000 ha (3%) annually (Mecham 2001, Mayer and Poe 2013). In the past 50 years logging, agriculture, and urbanization have increased exponentially, limiting habitat availability (Cuesta et al. 2017). Though all of Ecuador is affected by the loss of forests, the greatest rate of deforestation occurs in the coastal forests (Mecham 2001). Roughly 30% of the coastal forests remain, 60% of cloud forests, and 80% of the amazon forest (Cuesta et al. 2017). Deforestation has lasing affects such as soil erosion, watershed degradation, and loss of biodiversity (Mecham 2001, Mayer and Poe 2013, Broadbent et al. 2008).

Reforestation efforts are seldom and typically result in non-native monocultures that can not support the original level diversity, losing entire communities (Mecham 2001, Broadbent et al. 2008). Forest fragmentation results in loss of canopy cover and formation of edge habitat which alters communities creating competition pressures previously absent (Broadbent et al. 2008, Johnson et al. 2006).

Agriculture practices using agro-chemicals and pesticides are degrading the fertility of the soil and upsetting ecosystem productivity (Mecham 2001, Sherwood et al. 2005). These chemicals are known to have harmful affects on wildlife and humans (Sherwood et al. 2005). Due to the over grazing and the unsustainable practice of clear cutting, soil loss is 20 times the acceptable maximum defined by the U.S. Soil Conservation Service (Mecham 2001, Sherwood et al. 2005).

The oil industry is the leading cause of deforestation, and poses the greatest threat to biodiversity by opening seismic lines, highways, and pipelines, it allows urban development to expand with ease (Mecham 200).

Directly responsible for a third of the annual deforestation, the timber industry is the second leading cause of forest loss (Mecham 2001). Promoters of clearcutting, road building, and

other government-sponsored highway projects, the local communities rely on this industry for employment (Mecham 2001).

34.5% (9.8 million ha) of the overall forest cover remains (Global Forest Atlas 2019). Pinocchio lizards are dependent upon the preservation of forested, canopy covered habitat at mid-elevations, between 1000-2000 m (Losos et al. 2012, Poe et al. 2012, Yánez-Muñoz et al. 2010). The known population of the Pinocchio lizard persists within the Mindo-Nambillo Reserve where these threats are less likely to cause concern. Though, no data exists on the how *A. proboscis* is affected by deforestation, change in forest structure, or pesticides, because of its restricted range any disturbance to habitat would have a significant effect on the population (Mayer and Poe 2013).

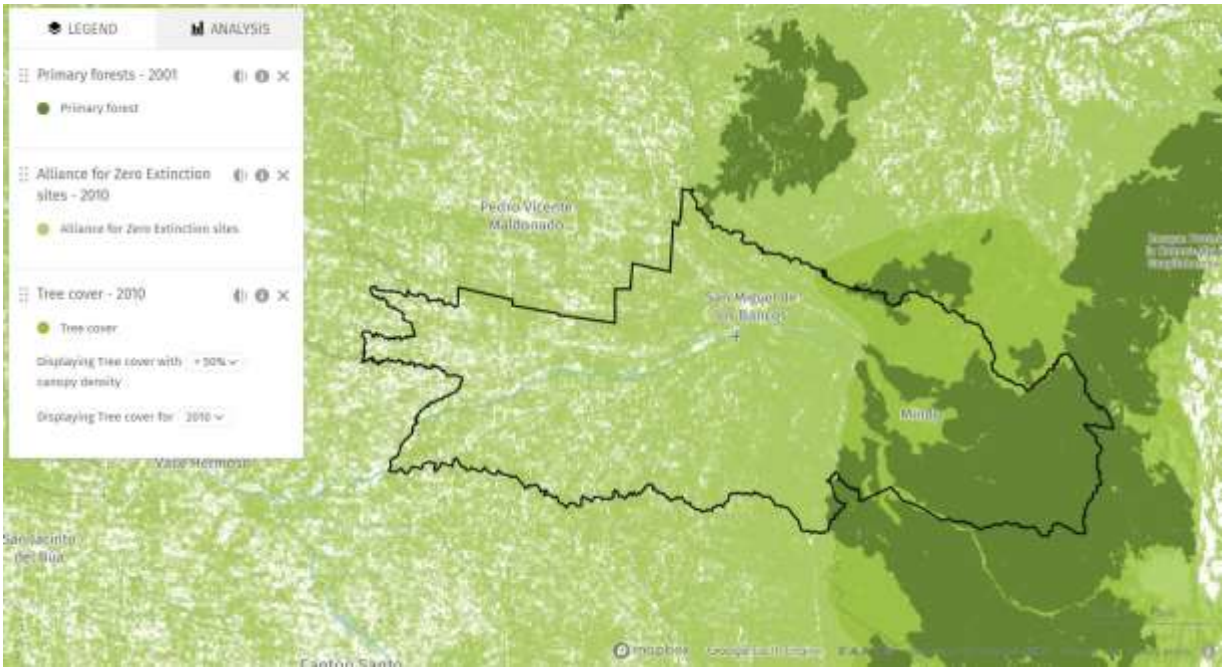

Fig 5. Shows area within Pichincha (Mindo) that is preserved habitat (primary), remaining canopy cover (> 50%), and critical habitat for endemic species (alliance for zero extinction). Information provided by Global Forest Watch.

Sociocultural and Economic

Ecuador's economy is ranked eighth in productivity for Latin America, 69th in the world. It is a third world country and poor (Chepkemoi 2017). It is dependent on agricultural and oil goods to export, the methods of which, negatively impacting forested habitat and biodiversity (Mecham 2001, Mosandl et al. 2008). Ecuador's economy depends on exploiting their natural resources, and more so oil (Mecham 2001). However, ecotourism is the main source of revenue for Mindo village and the Mindo. Some 350 bird species birds attract birdwatchers from around the world. Hikers looking to experience the Andean cloud forests will stay in cottages in the town site. Now with the rediscovery of the Pinocchio lizard it attracts researchers and herpetofauna enthusiasts, slowly becoming an iconic species of the area. Ecuador brought in 1.44 billion US dollars in 2016 from ecotourism alone, as opposed to the timber industry in 2015 that brought in only 242.9 million US dollars. The Pinocchio lizard is apart of that ecosystem and by protecting the population, ensuring the financial stability of the people who work in ecotourism. The legislation however, is not heavily enforced and it is mainly the revenue from tourism that incentivizes the habitat protection (Swig 2011, Lisocka-Jaegermann et al. 1998)

Due to the unique nature of the Pinocchio lizard it is appealing to pet traders and collectors. Less than 8% of reptile species are regulated under the Convention on International Trade in Endanger Species of Flora and Fauna (CITES) (Auliya et al. 2016). Endangered reptiles are usually taken illegally, against the legislation of the country's laws.

Legality and Policy

Under the Constitution of the Republic of Ecuador nature has the right to exists and to protection (Appendix 4). This includes the Pinocchio lizard. However, Ecuador's legal system is

full of contradictions (Lisocka-Jaegermann et al. 1998). The Ministry of Environment was established in 1996 and is underfunded (Mecham 2001). The Constitution of the Republic of Ecuador states in Title II: Fundamental Rights, 7th Chapter: Rights of Nature, Art. 73. "The State will apply precaution and restriction measures in all the activities that can lead to the extinction of species, the destruction of the ecosystems or the permanent alteration of the natural cycles. The introduction of organisms and organic and inorganic material that can alter in a definitive way the national genetic patrimony is prohibited." Yet, the government allowed all oil pipelines to cross through all parks and reserves, and indigenous lands (Mecham 2001). The government is ecologically minded on paper but when it comes to enforce it the resources aren't there (Swing 2011). One proposed oil pipeline would run through the Mindo-Nambillo Ecological reserve exposing the Pinocchio lizard to habitat alterations and oil pollution (Mecham 2001). This is just one example of the contradiction of laws practiced by the Ecuadorian government. Underfunding is having the greatest effect on the protection of the lizard's limited habitat.

MANAGEMENT NEEDS

If management needs are met, extinction can be avoided. Assuming the Pinocchio lizard is similar to its surrogate species, modeling shows that with an increase in egg survival by 54%, hatchling survival by 72%, juvenile survival by 63%, and adult survival by 21%, then with within ten years the population can reach 2,500 (Figure 3). Furthermore, a stable population can be maintained by increasing egg, hatchling, and juvenile survival to 80%, while increasing adult survival by 0.3% (Figure 4). However, the data needs to be collected on the Pinocchio lizard to develop an accurate assessment of the population dynamics. The most important need is protection of habitat with dense primary forest canopy to increase survival rates.

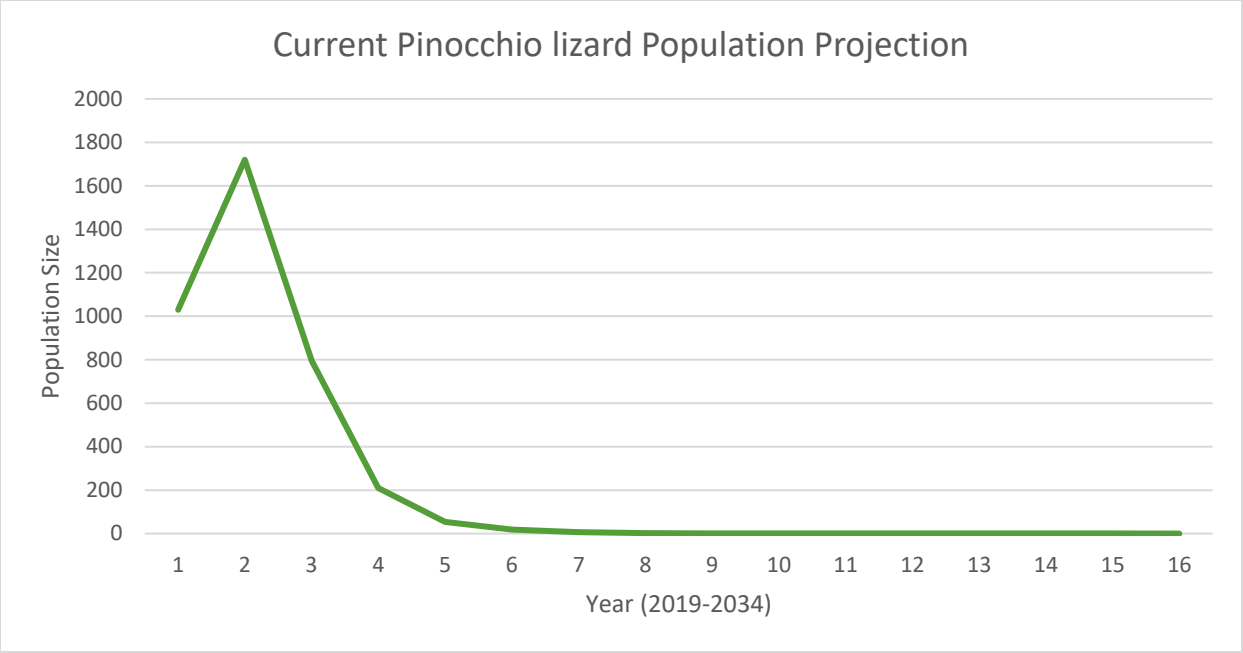

Fig 6. Population trend determined from surrogate *Anolis spp.* vital rates. Extinction in seven years without management.

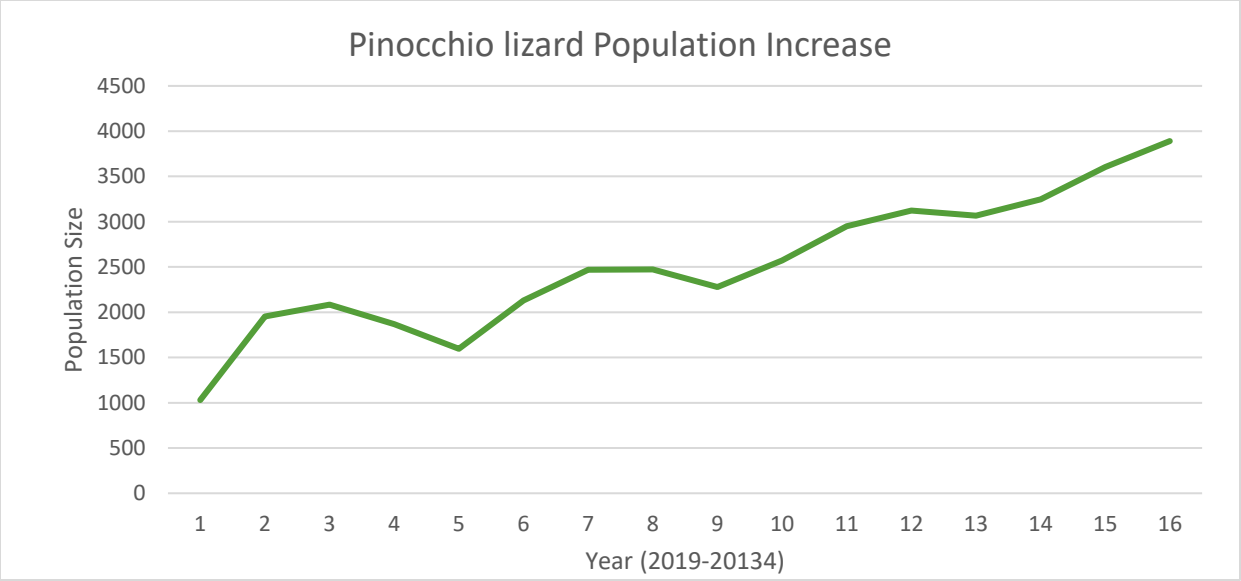

Fig 7. Population increase when survival equals 80% for all life stages. Not a sustainable increase as the population will reach carrying capacity.

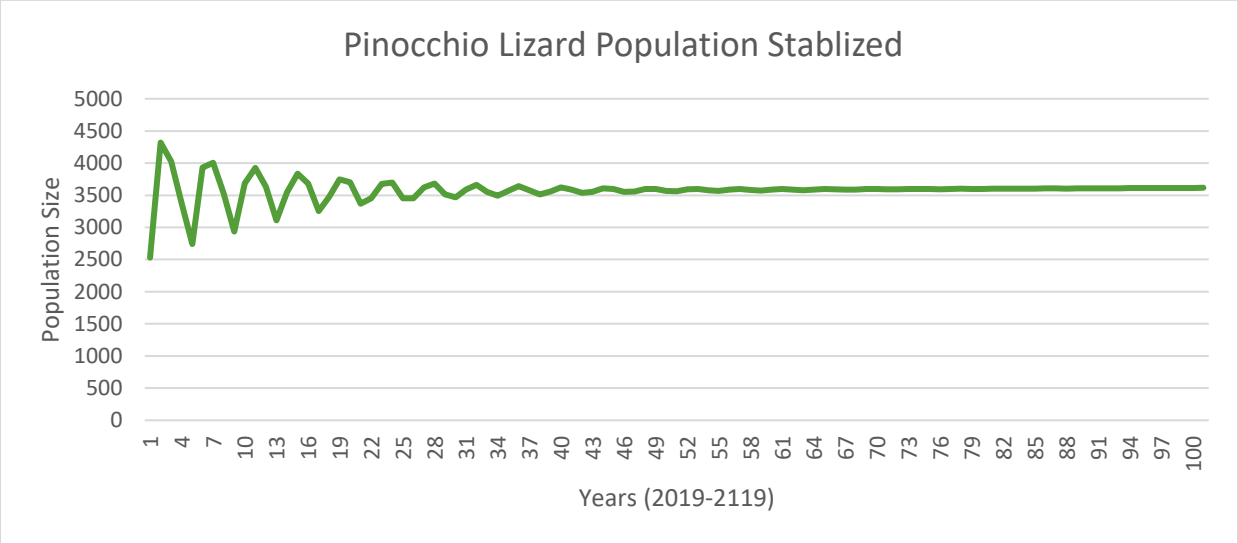

Fig 8. Long-term self-sustaining population.

GOALS AND OBJECTIVES

Goal: Recover and Increase the populations of Pinocchio lizards

Objective 1: Determine population size estimates and detailed suitable habitat requirements of the Pinocchio lizard within 2-3 years.

Objective 2: Implement an education and awareness campaign in Mindo within 1 year.

Objective 3: Establish the lizard's extant range as a National Park within the next 5 years

Objective 4: Increase survivorship of all life stages to 80% within 3 years.

COURSE OF ACTIONS

Goal: Recover and increase the populations of the Pinocchio lizard.

Objective 1: Determine population size estimates and detailed suitable habitat requirements of the Pinocchio lizard within 2-3 years.

***Course of Action 1.1*:** Conduct short-term mark-recapture study to estimate population densities near Mindo (Appendix 3). Visual encounter and spotlight surveys will be conducted at random along roads and successional, and undisturbed forest. Anoles will be caught with noose poles or hand capture. Once a specimen is safely captured, the coordinates will be recorded using hand held GPS. will be Once safely captured, various morphological measurements will be recorded (i.e. SVL, sex, horn length, limb length, etc.). To identify individuals, Bee-tags (Johnson 2005) of a unique color and number combination will be applied with epoxy in an area of optimal viewing on anoles that are less than 40 mm SVL. Anoles as long as 40 mm SVL or grater will be marked by surgically attaching color bead combinations through the methods described by Galdino et al. (2014). Each individual will be released after processing, in the area of capture. Surveys will be repeated for one month until the majority of the population has been accounted for. Monitoring of the population size will continue for 2-3 years.

***Course of Action 1.2*:** Vegetation surveys will be conducted in conjunction with population surveys. At the time of capture, forest type, height off ground, part of tree/plant (i.e. twig, branch, trunk, etc.), species, visual obscurity (i.e. cover), and percent canopy cover will be recorded to create a habitat suitability index for the Pinocchio lizard within one year.

***Course of Action 1.3*:** Individual anoles will be fitted with radio transmitters to determine home range and territory size estimates. Holohil BD-2N transmitter will be attached to both male and female anoles greater than 70 mm SVL in length (Losos et al. 1990). Tagged individuals will then be monitored daily during the dry and wet season for one month (transmitter battery lasts 3-4 weeks) using a Yagi and ATS R410 Scanning Receiver (Losos et al. 1990).

***Course of Action 1.4*:** Data collected from transmitter will be plotted in Arc GIS. Home range and territory models will be made by creating a minimum convex polygon (MCP) and the Kernel method to crate 90% and 100% buffer range (Laver and Kelly 2008) within one year.

Final Course of Action: 1.1, 1.2

No Action: No action would result in the inadequate management of an endangered species. Without proper understanding the habitat requirements and population dynamics of Pinocchio lizard's management decisions and courses of action rely on surrogate species of anoline lizards, which do not adequately represent the uniqueness of the Pinocchio lizard.

Assessment Protocol: These actions will be considered successful when the studies are conducted and repeated resulting in an accurate population estimate and HSI for the Pinocchio lizard is in place. Assessing these actions will require analyzing data collected in the field and publishing the findings within a peer-reviewed scientific journal.

Objective 2: Implement an education and awareness campaign in Mindo within 1 year.

***Course of Action 2.1*:** A survey will be conducted that tests the pre-existing knowledge of the existence of the Pinocchio lizard around Mindo and neighboring towns (Appendix). Poe et al. (2012) documented their encounters with the local community and provided evidence for a lack of knowledge from the people from Mindo. A short survey asking basic, quantifiable questions can reach a large mass of people. This survey will reach locals and tourists alike to understand the entire populations awareness of the Pinocchio lizard and the conservation needs surrounding them, before a campaign is initiated. This will be conducted during the summer months when western tourism is at its highest to maximize effectiveness and sample size.

***Course of Action 2.2*:** A pamphlet will be created to provide information about the Pinocchio lizard and its conservation needs (Appendix 5). The pamphlet will be brochure style and include images along as information that convers: The story of rediscovery, unique morphology, behavior, the enigma of the horn, human impact, and a "what you can do" section to end it. The purpose of the pamphlet is to provide a brief introduction to the anole and raise awareness and support for the success of its conservation. With owner's permission pamphlets will be stocked in local hotels, restaurants, and companies that participate in ecotourism.

***Course of Action 2.3*:** Schedule and implement outreach programs over the course of a year that involve tourists and locals within all age groups. Program topics will include, ethical hiking (i.e. carry in-carry out and LNT) to ensure people practice sustainable use of the forest where anoles are present. Natural history and ecology lessons led by trained personnel to ensure people are educated on their effect on endemic wildlife and ecosystems, and have an ethical conscience when in nature. Conservation talks will be held to communicate the large-scale issues facing anoles and the surrounding cloud forests, providing incentive for people to make conscientious decisions requiring palm oil and unsustainable agriculture. Interactive photography workshops

will be held for middle and high schoolers to educate future generations on the importance of biodiversity and conservation.

***Course of Action 2.4*:** Fundraising will be implemented with action 2.3 and will aim to include other non-profit and governmental financial aid to conserve land around Mindo utilized by the Pinocchio lizard. In-depth proposals on the conservation goals of this project and the need importance of the Pinocchio lizard will be written and sent to local and international organizations such as the World Wildlife Fund, Cloud Forest Foundation, and Tropical Herping.

Final Actions: 2.1, 2.2, 2.3, 2.4

No Action: If no action is taken to educate the public on the existence and importance of the Pinocchio lizard conservation efforts will not have the support and resources needed to properly protect the species. Public support is often a determining factor in the successful conservation of a species (i.e. Bald eagle, Panda, game species). The public must be informed in order to make proper decisions to sewed government implications.

Assessment Protocol: The objective will be considered complete when at least 50% of the Mindo population, local and tourist included, is informed on the presence, importance, and conservation issues of the Pinocchio lizard. This will be measured with an assessment survey one year after the proper actions have taken place.

Objective 3: Establish the Mindo-Nambillo Ecological Reserve as a National Park within the next 5 years

***Course of Action 3.1*:** Ecuador's The Ministry of Environment will be contacted by email and telephone to initiate discussion on designating the Mindo and the area around it a National Park. Ideally the park will protect the 200,000 ha area the lizard is estimated to exist (Mayer et al.

20013). However, it would require protecting at minimum 3,300 ha of the established range. The park will provide legal protection from habitat destruction, poaching, and trade. It will also increase tourism and create jobs that will benefit the conservation of the Pinocchio lizard and Mindo's economy.

Fig 9. Extant range at of Pinocchio lizards (pink). Data from iNaturalist.org

***Course of Action 3.2*:** Write a comprehensive proposal that clearly articulates the biological and cultural significance of Mindo and the surrounding cloud forest's biodiversity and present it to The Ministry of Environment as an eligible site for a national park. The proposal would recommend a community-based approach for the management of land and resources within the park as Mindo's ecotourism industry would benefit form a pristine ecosystem the most. Although national parks are not as well protected and regulated as in the U.S. places such as Yasuni National Park have benefited. The proposal would recommend that it seek partnership with land

owners and ecotourism companies to enforce and mitigate the laws within an established national park.

***Course of Action 3.3*:** Provide economic incentive for locals to protect the area designated as a national park. Hiring people in low-income areas to protect and monitor wildlife has added benefits of alleviating poverty in the area (Clements et al. 2013). In areas where federal governments overlook conservation needs or do not allocate the necessary funding to appropriately protect endangered species, local communities are met with more success (Clements et al. 2013, Schweitzer 1992). Involving the local community of Mindo is cheaper than hiring government protection, offering a solution to the poor governmental protection Ecuador is notorious for when it comes to their protected lands (Cuesta et al. 2017, Mecham 2001). In preparation for lack of funding from the Ministry of Environment, foreign aid from the USAID Biodiversity program will be contacted in hopes of achieving the funding to hire local people of Mindo to enforce protection of the species.

Final Actions: 3.1, 3.2, 3.3

No Action: If no action is taken to establish Mindo and the Pinocchio lizard's extant range as a National Park with in five years then the species and its habitat will remain legally unprotected. Mindo's economy will not receive the possible increase from increase in jobs and tourism. Protection is the right of nature and the right of nature is the right of the people of Ecuador (Article 73,74). Taking no action to designate Mindo as a national park, the Government is in direct violation of the constitutional rights of nature.

Assessment Protocol: Objective 3 will be considered successfully complete once at a minimum of 3,300 ha covering cloud forest habitat is designated a National Park within the next five years.

This will protect the known range of the Pinocchio lizard and once an area is protected the entire range is more likely to be protected in the future.

Objective 4: Increase survivorship of all life stages to 80% within 10 years.

***Course of Action 4.1*:** As a last resort measure, a captive breeding program will be implemented. A lizard room will be installed in a yet to be determined location. Following the protocols instructed in Anolis Newsletter VII, page 37. (Stroud et al. 2019) and modified to meet the Pinocchio lizard's requirements as in Quirola et al. (2017) (. Individuals will be incubated, hatched, and raised until sexual maturity (4-5 months, ~75mm SVL). Anoles will be fed as natural a diet as possible, strictly insectivorous. Then individuals will be released into the most suitable areas near Mindo.

***Course of Action 4.2*:** Through this captive breed program, internships will be available to provide education to conservation students who seek hands on experience. It will also be used as public outreach by running tours through the "lizard room".

Final Actions: 4.1, 4.2

No Action: Breeding programs are often a last-resort effort and should only be put into effect after a population estimate of the species is established. Breeding programs are timely and expensive and are usually unsuccessful (Snyder et al. 1996).

Assessment Protocol: The objective would have succeeded once survival reached 80%. Individuals released will be tagged with radio transmitters and monitored for a month after release to monitor survival and reproductive output.

CONCLUSION

The Pinocchio lizard is a unique representative in the evolutionary and life history of *Anolis* lizards. Preserving diversity is crucial for preserving ecosystem functions and ecotourism value. Loss of habitat from agriculture, oil, and human development threatens the species already limited range. Population estimates are needed to implement successful management actions. Public support is the strongest method to obtaining the resources needed to complete objectives. Protecting the remaining cloud forest near Mindo is essential to the sustaining populations at this point. If habitat degradation continues, captive breeding will be a last resort to increase populations. If management objectives are met, the existence of a unique species will be preserved through future generations. A biodiversity hotspot will be protected, benefiting Ecuador's economy and natural resources. We have already lost this species once, now we have a second chance to do right by it.

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Appendix 1 -

Stomach contents of 19 *A. proboscis* specimens from Losos et al. (2012).

TABLE 5. DIET OF *ANOLIS PROBOSCIS*.

Phylum	Class	Order	Family*	Number Items (%)	Number Lizards (%)
Gastropoda				1 (0.7)	1 (5.3)
Arthropoda					
	Arachnida				5 (26.3)
		Araneae		7 (4.6)	5 (26.3)
		Pseudoscorpionida		1 (0.7)	1 (5.3)
	Diplopoda			2 (1.3)	2 (10.5)
	Insecta				
		Hemiptera			11 (57.9)
			Cicadellidae	17 (11.2)	7 (36.8)
			Largidae	2 (1.3)	1 (5.3)
			Lygaeidae	1 (0.7)	1 (5.3)
			Reduviidae	1 (0.7)	1 (5.3)
			Tingidae	2 (1.3)	2 (10.5)
			Indeterminate	8 (5.3)	8 (42.1)
		Coleoptera			15 (78.9)
			Anobiidae	1 (0.7)	1 (5.3)
			Carabidae	4 (2.6)	3 (15.8)
			Cetonidae	1 (0.7)	1 (5.3)
			Cucjoidea	1 (0.7)	1 (5.3)
			Curculionidae	5 (3.3)	3 (15.8)
			Dytiscidae (larvae)	7 (4.6)	5 (26.3)
			Histeridae	1 (0.7)	1 (5.3)
			Lycidae	1 (0.7)	1 (5.3)
			Melyridae	1 (0.7)	1 (5.3)
			Scarabeidae	2 (1.3)	2 (10.5)
			Indeterminate	10 (6.6)	8 (42.1)
			Indeterminate larvae	2 (1.3)	2 (10.5)
		Hymenoptera			12 (63.2)
			Apoidea	10 (6.6)	3 (15.8)
			Chalcidoidea and other wasps	11 (7.2)	8 (42.1)
			Formicidae	11 (7.2)	6 (31.6)
		Lepidoptera			14 (73.7)
			Adult	5 (3.3)	4 (21.1)
			Larvae (caterpillar)	25 (16.4)	13 (68.4)
		Diptera			8 (42.1)
			Cecidomyidae	3 (2.0)	3 (15.8)
			Indeterminate	8 (5.3)	4 (21.1)
			Indeterminate larvae	1 (0.7)	1 (5.3)
Total				152	19

*Several prey items identified only to Superfamily.

Appendix 2-

Time budget and Perch requirements described by Losos et al. (2012).

	Mean ± 1 SD	Range
Crawl	15.5 ± 21.9	2.5–75.4
Walk	0.9 ± 1.5	0.0–4.8
Run	0.1 ± 0.3	0.0–0.8
Forage	1.0 ± 2.4	0.0–7.6
Display	0.7 ± 1.1	0.0–3.2

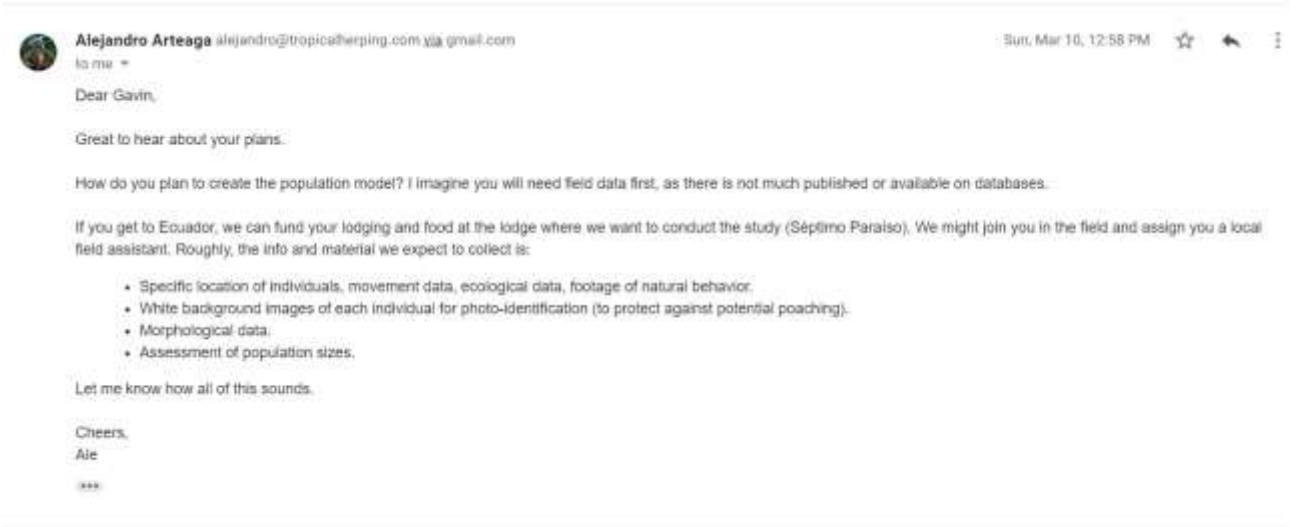
TABLE 3. PERCH USE OF *ANOLIS PROBOSCIS*.

	Height (m ± 1 SD)	Diameter (cm ± 1 SD)
Day		
Male (n = 8*)	4.6 ± 1.1	2.4 ± 3.2
Female (n = 1)	2.5	1.0
Night		
Male (n = 5)	5.9 ± 1.8	1.7 ± 1.9
Female (n = 11)	5.0 ± 1.2	1.9 ± 1.5

*One of these observations probably was of an animal for which data had previously been recorded, so the number of individual males is probably seven.

Appendix 3-

Email discussing the research needed by the founder of Tropical Herping Co., Alejandro Arteaga.



Alejandro Arteaga alejandro@tropicalherping.com via gmail.com Sun, Mar 10, 12:58 PM

to me

Dear Gavin,

Great to hear about your plans.

How do you plan to create the population model? I imagine you will need field data first, as there is not much published or available on databases.

If you get to Ecuador, we can fund your lodging and food at the lodge where we want to conduct the study (Séptimo Paraíso). We might join you in the field and assign you a local field assistant. Roughly, the info and material we expect to collect is:

- Specific location of individuals, movement data, ecological data, footage of natural behavior.
- White background images of each individual for photo-identification (to protect against potential poaching).
- Morphological data.
- Assessment of population sizes.

Let me know how all of this sounds.

Cheers,
Ale

Appendix 4-

Nature Rights of the Constitution of the Republic of Ecuador.

Rights of Nature Articles in Ecuador's Constitution

Title II
Fundamental Rights

Chapter 1
Entitlement, Application and Interpretation Principles of the Fundamental Rights

Art.10 Rights Entitlement.- Persons and people have the fundamental rights guaranteed in this Constitution and in the international human rights instruments.

Nature is subject to those rights given by this Constitution and Law.

Chapter 7th: Rights for Nature

Art. 71. Nature or Pachamama, where life is reproduced and exists, has the right to exist, persist, maintain and regenerate its vital cycles, structure, functions and its processes in evolution.

Every person, people, community or nationality, will be able to demand the recognitions of rights for nature before the public organisms. The application and interpretation of these rights will follow the related principles established in the Constitution.

The State will motivate natural and juridical persons as well as collectives to protect nature; it will promote respect towards all the elements that form an ecosystem.

Art. 72. Nature has the right to restoration. This integral restoration is independent of the obligation on natural and juridical persons or the State to indemnify the people and the collectives that depend on the natural systems.

In the cases of severe or permanent environmental impact, including the ones caused by the exploitation on non renewable natural resources, the State will establish the most efficient mechanisms for the restoration, and will adopt the adequate measures to eliminate or mitigate the harmful environmental consequences.

Art. 73. The State will apply precaution and restriction measures in all the activities that can lead to the extinction of species, the destruction of the ecosystems or the permanent alteration of the natural cycles.

The introduction of organisms and organic and inorganic material that can alter in a definitive way the national genetic patrimony is prohibited.

Art. 74. The persons, people, communities and nationalities will have the right to benefit from the environment and form natural wealth that will allow wellbeing.

The environmental services are cannot be appropriated; its production, provision, use and exploitation, will be regulated by the State.

Appendix 5-

Educational pamphlet to be distributed to local business and hotels in Mindo. Contains an overview of management plan.

Land cover type: Forest (green), forest loss (Gray), and biodiversity hotspot (blue)

Conservation Issues

The greatest threat to the Pinocchio lizard is habitat loss. Resources are limited and more susceptible to disturbance as a consequence of existing in a restricted range (3300 ha). Populations are at risk of genetic bottlenecking and the extinction vortex. Ecuador has suffered extensive deforestation and habitat degradation from Oil infrastructure and agriculture. 34.5% (9.8 million ha) of the land remains covered by forest. Species and natural lands are given the right to persist and exist by the Republic of Ecuador, however these rights are not effectively enforced due to deficient funding.

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PINOCCHIO LIZARD

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THE PINOCCHIO LIZARD (*ANOLIS PROBOSCIS*)

Conserving Mindo's Hidden Anole

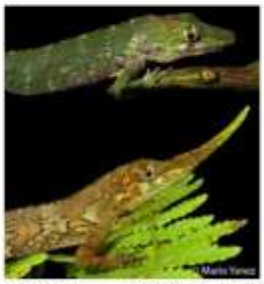
Background

The Pinocchio lizard was last described in 1966, known only by six male specimens until 2005 when it was rediscovered by ecotourists in Mindo, Ecuador. Currently, the Pinocchio lizard is listed as endangered for its limited extant range of only 3,300 ha However, it's estimated that the species extends some 200,000 ha from its known occupancy. The population exists in a biodiversity hotspot, and the lack of enforcement combined with lenient oil regulations, agriculture, and infrastructure laws threaten its existence. Since rediscovery, we are beginning to develop an understanding of the life history, ecology, and behavior of this this unique anole. Anoles have a complex and interesting evolutionary history of which *A. proboscis* could provide new insights to. Recently, conservationists like Tropical Herping are giving the species the attention it deserves.

Extant range (from iNaturalist.org)

Natural History

Morphology: Small (70-85 mm SVL), Twig ecomorph; long-slender body, short-limbed, slight prehensile tail.
Courtship: "Horn" used in display with head bobbing and pushups
Diet: Insectivorous; Lepidoptera (butterfly) larvae, Hemiptera (katydid) preferred
Habitat: Montane cloud forests (Thin branches in forest canopy); Found in disturbed, secondary forest but most likely abundant in undisturbed primary forest
Reproduction: Single egg clutch; 30-40 day gestation period; 3-4 months to sexual maturity; no parental care.



Female (Top) and Male (bottom) Pinocchio Lizards.

Management

Protecting the cloud forest from further deforestation and degradation is crucial for the survival of this species. Implementing community-based conservation practices such as hiring locals to enforce nature rights is the best option to protect land. Mindo is a popular ecotourist community that will benefit from protecting the surrounding forest ecologically and economically. Research is desperately needed to understand the population dynamics of the species. A long-term monitoring program is under way and with the new information we will be better equipped to save the Pinocchio lizard.

Baby Pinocchio Lizard

Appendix 6-

Survey created to assess the public's knowledge of the Pinocchio lizard and its conservation needs.

The following survey was created to gain local and tourist insight on the assess the awareness of the Pinocchio lizard and its conservation needs. Deforestation threatens this rare lizard that represents a unique part of anole evolution and the biodiversity of Ecuador. Please take the time to answer these questions honestly.

1. Is Mindo your primary residence or are you a tourist?

   Local ____
   Tourist ____

2. Were you aware of the Pinocchio lizard (*Anolis proboscis*) prior to this survey?
   YES ___
   NO ___

3. If you answered YES, what method had you learned about the lizard?

   Internet ____
   Visual Encounter ____
   Peer Reviewed Literature ____
   News Article ____
   Word of mouth ____

4. How is it important is it to you that the lizard and biodiversity is protected? Circle answer with 1 being not at all and 10 being the most important.
   1 2 3 4 5 6 7 8 9 10

Thank you for participating in this survey. Your contribution to conservation and the planet is invaluable.