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## The Relationship between People and the Tegu: A Review of the Literature

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Murray State University Honors College

HONORS THESIS

Certificate of Approval

The Relationship between People and the Tegu: A Review of the Literature

Jordan Haley  
05/2022

Approved to fulfill the  
requirements of HON 437 or 438

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Dr. Laura Hoffman, Professor  
Pre-Veterinary Medicine

Approved to fulfill the  
Honors Thesis requirement  
of the Murray State Honors  
Diploma

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The Relationship between People and the Tegu: A Review of the Literature

Submitted in partial fulfillment  
of the requirements  
for the Murray State University Honors Diploma

Jordan Haley

05/2022

## Abstract

This thesis will explore the relationship humans have had with tegu lizards and how it has evolved over time. Tegus (*Salvator spp.*) are large, prolific, hardy, omnivorous, intelligent, and docile lizards. These traits have shaped the evolution of their relationship with humans. Historically, these animals have been used as a source of leather and bushmeat in their native range in South America, where their size and fecundity made them a sustainable resource for local peoples. In recent decades, tegus have become popular in the exotic pet trade due to their hardiness, intelligence, and calm demeanor. By purposeful and accidental release, these creatures have established populations through the pet trade in nonnative regions such as the southeastern United States. Several characteristics make tegus a particularly threatening invader. They are quick to adapt and reproduce, and they will prey upon nearly anything, especially nests of eggs. They are also the only known lizards to be capable of endothermy, if only partially so, further contributing to their adaptability. Florida, South Carolina, and Alabama have implemented legislation in response to this threat that prohibits buying, selling, or breeding tegus. Wildlife harvesting, captive breeding, and removal efforts continue to this day.

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## Introduction

The purpose of this literature review is to synthesize a brief history of the relationship between people and the tegu. With hundreds of species across two families of lizards, *Teiidae* and *Gymnophthalmidae* can be classified as “tegu.” This review will focus on just two of these, the Argentine black and white tegu (*Salvator merianae*) and the red tegu (*Salvator rufescens*). Formerly classified in the genus *Tupinambis*, these lizards were reclassified in the genus *Salvator* when the *Teiidae* family was restructured in 2012 based upon the study of 137 morphological characteristics (Harvey et al., 2012). These two species have several characteristics that have shaped their history and interactions with humans. They are large, highly adaptable, hardy, prolific, intelligent, docile, and omnivorous creatures. Tegus have historically been used as sources of animal protein and leather for indigenous peoples. The exotic skin trade was and still is an important source of income for rural populations. The tegu’s size and patterns make desirable products, and their docility makes them relatively easy targets. Their ability to adapt and procreate ensure that they will remain a sustainable resource for local people. These lizards eventually caught the attention of pet owners in the United States, where they have gained substantial popularity in recent years. Their colors, size, gentle nature, intelligence, and ease of husbandry make them what many would argue to be the best pet lizard available today. The pet trade popularized the tegu, but it also introduced it to new, nonnative environments where it has since established itself. Starting in Florida, the Argentine black and white tegu has been threatening the balance of local ecosystems and contributing to the destruction of endangered species. Populations have been established as far north as Georgia with sightings of individuals as far as South Carolina. Studies indicate that their capacity to adapt, reproduce, and eat almost anything will make them widespread and destructive invaders. As their threat grows, tegus have

become increasingly relevant to scientific research. Studies expand our data on these lizards as researchers look for a way to exploit their behavior and physiology to control their proliferation and subsequent impact on the environment.

## **Description**

Both species are similar in size, although individual differences vary greatly depending on the level of care received. Some individuals may weigh up to 17.6 pounds, and lifespan ranges from about 12 to 20 years (Enge, 2006). They are highly sexually dimorphic. Males are significantly larger than females, reaching lengths of four to four and a half feet, while females can typically attain about three to three and a half feet. They have a generally streamlined body shape with narrow heads and thick necks. Males also possess large jowls that contain well developed lateral pterygoideus muscles, which provide increased biting strength (Tattersall, 2016). Their ventral surface has large rectangular scales that form distinct transverse rows, and their dorsal surface has more granular, beaded scales. They possess forked tongues, which are flicked to detect and discriminate between food and nonfood odors, and heterodont teeth as adults (Enge, 2006). In the adult, the anterior teeth are more conical and pointed with a cutting edge, used for grasping and puncturing prey, and the posterior teeth are robust and blunt, used for crushing hard food items (Berkovitz and Shellis, 2017). As hatchlings, Argentine black and white tegus have emerald green heads and browner bodies that transition into black and white as they grow. Hatchling red tegus are a dull reddish brown with broken white and black stripes. Adults will develop an intense red hue, although females aren't typically as bright as males.

## Behavior

Tegus play similar ecological roles as monitors, although they are only distantly related. Monitors are large and inhabit burrows, but they are entirely carnivorous and exhibit more arboreal and aquatic behaviors than the more terrestrial tegu. Tegus are opportunistic omnivores and will consume a wide variety of invertebrates, vertebrates, and plant matter, and they will tolerate consuming widely varied ratios of each. However, they tend to become picky eaters in captivity, preferring a primarily carnivorous diet. Tegus are diurnal, and they are known to be unusually active and more intelligent than most lizard species. Captive specimens can be trained to perform basic tasks using clickers, targets, and positive reinforcement. They are largely terrestrial lizards, but their streamlined shape and long tail also make them excellent swimmers. Researchers have observed other wild tegu species to remain submerged for up to twenty-two minutes to escape threats (Olmos, 1995). Another researcher immersed a young tegu in a 50% alcohol solution, where it stayed for one and a half hours before emerging unharmed (Beebe, 1945, as cited in Hall, 1978).

Although tegus are relatively docile, aggression is an important facet of behavior in many animals. Size and bite force show significant positive correlation with aggressive behavior and negative correlation with evasive behavior, which suggests a fight versus flight trade-off (Herrel et al., 2009). This trait may be driven by the fact that having a larger head means more bite force, but less maneuverability. Individuals were also less likely to display either aggressive or evasive behavior when they were in familiar territory. One study found that as body temperature increased, escape behavior increased as well (Cury de Barros et al., 2010). However, smaller tegus still tend to run away even at low body temperatures. Aside from biting, tegus may use their long tails to swipe at a perceived threat. Their limbs are highly developed, and they are

capable of bipedal running over short distances. When attempting an escape, they may drop a section of their tail as a distraction, a characteristic trait of many lizard species.

Seasonal changes determine the tegu's reproductive behavior. They stay active through the spring and summer, but tegus will hide in their burrows during the colder months. They will remain dormant for about five to six months in a process called brumation, which is an ectothermic equivalent of hibernation. Toward the end of this brumation period, testosterone in males will increase 20 to 30-fold, encouraging engagement in territorial, aggressive, and mate searching behaviors (Winck and Cechin, 2008, as cited in Tattersall, 2016). Tegus exhibit scent-marking and trailing behaviors with females exhibiting stronger trailing behavior than males. Females will maintain their nests within their burrows, lay eggs in the spring, and may stay with them until they hatch. Additionally, tegus have a unique ability to use their metabolism to generate heat and sustain their body temperature up to 10°C above ambient temperature during the reproductive season (Tattersall, 2016).

### **Leather Industry**

Millions of people around the world depend on local wildlife for their income. This is particularly prevalent in developing countries, where the indigenous peoples collect wild animals to be sold for meat at local markets or sold for their skins or as pets to international markets. Their characteristic rectangular ventral scales made tegu skins a desirable product in the market of exotic leathers. An average of 1,900,000 tegu skins were traded in the 1980's, most of them going to the United States (Fitzgerald, 1994). Published in 1987, a survey conducted on 84 rural farmers in northeastern Paraguay revealed that tegus, specifically *Tupinambis teguixin* and *S. rufescens*, provided a significant source of income and food for the local peasantry (Norman, 1987). During the summer 1984–1985, 67 of the 84 farmers each earned an average wage equal

to that of 20 days of agricultural wages from approximately 850 tegus. This study also found that these harvests had a significant impact on wild tegu populations. These populations are not strictly monitored, but the demand from international markets incentivizes rural people to continue to harvest wild populations without taking their ability to withstand such exploitation into account. Management programs for the harvesting of the most exploited snakes and lizards are only recent advancements toward sustainability.

One long-term study gathered tegu harvest data from 1991-1998 in Paraguay. Researchers examined the trade practices and traits of caught skins such as size, number, and sex ratios to gather information on the local harvesting of the black and white tegu and the red tegu (Mieres and Fitzgerald, 2006). Trained dogs found tegus for their hunters, who caught and killed them. Their skins would pass through several middlemen in a trade chain before reaching tanneries to be processed into leather and exported to international markets. Middlemen often stretched the skins to make them more valuable. Legal trading lasts from October to May of each year. During this time, researchers would pay monthly visits to “check stations,” which were locations where commercial trade of tegu skins were known to occur. These stations consisted of nine trading stations and one to four tanneries, depending on which tanneries were operating that year. The number, size, sex, and species of a sample were recorded at each visit. In the tanneries, a total of 26,300 black and white tegu skins and 6,915 red tegu skins were measured. At trade stations, 7,335 black and white tegu skins and 6,157 red tegu skins were measured. This means that the whole sample of measured skins consisted of 72% black and white tegus and 28% red tegus. Black and white tegus have a significantly wider geographic distribution. Red tegu skins were slightly larger on average than black and white tegu skins. The skins of both species leaned

consistently on the male side, but the degree of bias varied from 56% to 88.3% depending on the year.

### **Wildlife Sustainability**

At the time of data collection, tegus were the only actively managed wildlife in Paraguay. The program consisted of three basic parts: 1) a policy to ban the harvest of small tegus, since preserving the younger stages of life is crucial to maintaining a healthy wild population, 2) an incentive to harvest adults since smaller skins were less valuable, and 3) an export quota of 300,000 skins (Mieres and Fitzgerald, 2006). Quotas for Argentina stand at 1,000,000 (CITES, 2007).

Lee Fitzgerald, a herpetologist at Texas A&M University, believes that the tegu skin trade could become a model for wildlife sustainability in other species across South America. The Convention on International Trade of Endangered Species (CITES) monitors the total trade of tegu skins, and tegus showed no signs of endangerment even throughout the peak of skin harvests in the 1980's. Their biology in part lends itself to being a sustainable species. They grow relatively large, they have long life spans, they reach maturity quickly at about four years of age, and they have large clutches of eggs ranging from about 20 to 35 depending on the species. According to Fitzgerald's research, he makes two overarching recommendations to provide a solid population monitoring base for management. First, he states that monitoring the size and sex of tegus passing through trade posts and tanneries must continue, just as was done in Paraguay in the 1980's. As a part of this, it is important to ensure that the skins passing through these facilities are from lizards that came from the local province. Sometimes lizards that are harvested in one province find their way across provinces through trades and the tanning process. One way this has been discouraged is through tax incentives. Taxes on transport permits for raw

skins in 1989 in Argentina were \$1 per skin, \$0.16 per semi-tanned skin, and only \$0.08 per finished skin (Fitzgerald et al., 1991). This would encourage industrial development by keeping tanneries near harvesting locations. The second recommendation proposes to implement a system that quantifies hunter effort. Harmful practices like stretching skins may alter readings from monitoring systems at trade posts and tanneries. Additionally, stretching skins out to sell them at a higher price has negative effects on management. First, it damages the resource when middlemen fool traders into buying smaller skins for a marked-up price. Second, the pressure of harvest will remain on the smaller and more critical stages of life as long as hunters are able to sell these smaller animals. Third, the process of stretching these skins weakens them, which often results in damage during the tanning process. These damaged skins are discarded and cannot be exported, yielding no value to their seller. The management program in Paraguay only monitors the skins that are exported, meaning that the number of harvested tegus is larger than the number of exports. Keeping records of hunter effort will help monitor what age groups are actually being pulled from the wild and help to enforce violations of management policy.

The countries of South America and their people, particularly Argentina and Paraguay, have much to gain from a sustainable use program. At the time of publishing, the export of tegu skins was worth at least \$20,000,000 USD annually to these countries, and it continues to offer jobs to rural people as hunters, traders, and tannery workers (Fitzgerald, 1994). Tegus have also provided important food and income for these indigenous people. In 1987-1988, hundreds of people in the rural vicinity of Joaquín V. González, Argentina were hunting tegus. About half of the people were eating tegu meat or feeding it to their dogs, and almost everyone used the fat for medicinal purposes. Some are occasional hunters, who hunt to supplement their income or only when the opportunity arises. Others are professional hunters, who rely on them entirely for their

livelihood. Precise numbers of people who benefit from tegu hunting are unknown, but it is clear it would take thousands of hunters to produce the annual harvest of 1,900,000 skins that was common in the 1980's, which brought in about \$7,500,000 USD to those hunters. Each skin sold in Argentina yielded about \$4 USD. A farmhand could work all day to earn about that much, or he could hunt and find just one large tegu. In 1992-1993, a large tegu skin sold in Paraguay would sell for more than double that price at about \$10 USD. In 1991, there were at least five operating captive rearing facilities in Argentina for the red tegu and another tegu species, the gold tegu (*T. Teguxin*). The objective is to transfer the technology to more rural peoples in hopes that they can create their own small-scale operations to provide families with meat and skins (Fitzgerald et al., 1991). The Argentine Wildlife Service launched an education campaign for hunters targeting tegus in 1990. The focal point of the campaign can be expressed in the following message: "Cuide su dinero, dejar las iguanas chicas para el futuro. Las iguanas chicas no tienen valor comercial." ("Take care of your money, leave the small tegus for the future, small tegus have no commercial value.").

## **Husbandry**

The Argentine black and white tegu and red tegu have seen a steady increase in popularity in the pet trade over the last 10 to 15 years. The same characteristics that make tegus a sustainable resource in the wild also make them good pets. They readily reproduce in captivity, they can tolerate wide ranges of temperature and humidity, they will eat a wide variety of foods, and their relatively docile attitude makes them quite handleable. Survey results in 2021 showed that 27.5% of participants thought that tegus would continue to increase in popularity over the next decade (Valdez, 2021).

Nearly all pet reptiles are kept in enclosures, which allows for more control over environmental parameters. It should be noted that while larger enclosures will provide more space for the animal, it will be more difficult to maintain consistent temperature and humidity. Generally, the size of a cage for a terrestrial lizard should be about 0.2 square meters for every 0.1 meters in length of the lizard to be housed (Divers, 1996). For the Argentine black and white and red tegus specifically, a 6 by 3 by 3 feet enclosure is widely recognized to be the bare minimum dimensions for one adult, although an enclosure measuring 8 by 4 by 4 feet is preferred. Melamine and plywood are often used for large indoor tegu enclosures. Ventilation should not be neglected to keep humidity and temperature higher. Tegus are largely terrestrial so ground space is more important, but tegus will make use of pools, foliage, and climbing features. However, they can be destructive, so care should be taken to prevent rocks and the like from crushing a burrowing tegu. Substrate should be able to keep moisture and retain shape well enough to support burrowing behavior. Coconut fiber, cypress mulch, or a sand and soil mix are common substrates for tegus. Mulch should be free of dyes, and cedar is toxic to reptiles and should never be used. Substrate depth should be at least 8 inches for adults. Although some have had success in keeping two tegus of the same size and sex in the same cage, adults should generally not be housed together. Competition for food, basking spots, and retreats may be harmful to their long-term health. Housing a male with a female may cause health issues. One such case occurred in 2017. A female tegu who was housed with two male tegus suffered several episodes over two years in which she strained to defecate, requiring three hospitalizations (Pereira, 2019). It is suspected that stress caused by the males' constant attempts to mate with her contributed to the issue. Solitary reptiles are usually the healthiest.

All reptiles are ectothermic and will therefore need an artificial heat source. There are a variety of heating elements available such as heating pads, cables, tape, infrared bulbs, ceramic heaters, and spotlights. Additionally, all heaters should be controlled by an accurate thermostat. Pads, cables, and tape are not appropriate for burrowing animals and may result in burns and secondary bacterial infections. Spotlight bulbs are commonly used to provide an adequate basking spot of about 100 degrees Fahrenheit, and the cooler end of the enclosure should target about 75 degrees Fahrenheit (Mede, n.d.; Larocca, 2017). These are just rough estimates, and tegus can tolerate some variance. What's more important is that the tegu has access to a gradient of temperatures so that they can thermoregulate as they desire. The optimal quantity and quality of light varies by species and season. Tegus are diurnal, which makes light particularly important for them. Ultraviolet light (UVB 280 to 315 nm) is vital for their health. It is used to metabolize calcium and synthesize vitamin D3. Without it, lizards will develop a condition known as metabolic bone disease (MBD), which results in weakened, malformed bones and weak muscle contractions, including in the heart. Just like heaters, there are a variety of UV light products out there. UV bulbs tend to weaken significantly after six to nine months depending on the bulb, so frequent replacement is a must. Tegus, as a tropical species can be maintained on a 14-hour daylight period and 10-hour dark period indefinitely unless breeding is intended (Divers, 1996). Timers can be used to maintain consistent daylight periods. Breeders must shorten daylight hours to induce brumation followed by a lengthening of daylight hours to stimulate breeding. Food, temperature, humidity, and social interactions can also play a role in stimulating breeding activity (Divers, 1996).

Humidity is also important for tegus. Not only are they primarily a tropical species, but humidity also plays an important role in aiding the process of ecdysis (skin shedding). Tegus are

found in tropical forests, woodlands, savannahs, and semi-desert biomes (Enge, 2006). The Argentine black and white tegu is commonly found in the pampas (rolling grasslands) of Argentina, on the beaches of southeastern Brazil, in the cerrado (tropical savannah) of southwestern Amazonia, and in moist gallery forests of river drainages in eastern Paraguay. The red tegu inhabits drier to semi-arid biomes. Keepers agree that the optimal humidity range is around 80% for these lizards (Mede, n.d.; Larocca, 2017). This can be achieved using humidifiers, foggers, misting systems, water bowls, or spraying down the soil as needed. Smaller hideouts can be stuffed with dampened sphagnum moss or vermiculite to create a localized humid chamber, which may be used to aid lizards who are having difficulty shedding. An enclosure's ability to maintain humidity depends on its temperature, water surface area, and ventilation. This can be monitored using a simple hygrometer.

As opportunistic omnivores, tegus can be sustained on a variety of food items. A study conducted in Argentina found that the stomach contents of adult Argentine black and white tegus contained 66.6 % plant material, 13.4 % invertebrates, and 20.0 % vertebrates by volume (Mercolli and Yanosky, 1994). Another study in Brazil found that the stomach contents of the Argentine black and white tegu contained 29.0% plant material, 27.8% ants, 27.5% vertebrates, and 13.1% mollusks among other minor components by volume, and the stomach contents of the red tegu contained 96.6% plant material by volume (Colli et al. 1998). Tegus will generally become more herbivorous as they mature into adults. In captivity, however, they tend to become picky and prefer a primarily carnivorous diet. Insects, rodents, eggs, and fish will usually make up the bulk of an adult captive tegu's diet. Hatchlings and juveniles are commonly fed mostly insects with small amounts of fish, egg, and fruits. A variety of commercial diets are also available, and some keepers will even offer cat and dog food. Depending on the body condition

score of the individual, carnivorous lizards like tegus are fed every two or three days (Mede, n.d.).

### **Hybrids and Color Morphs**

Multiple hybrids and color morphs exist within the species *S. merianae* and *S. rufescens*. A morph is a term given to any individual that displays a phenotype not typically found in nature. These are not well defined, and there is much controversy over their taxonomy. Morphological and genetic data has not provided any clean resolutions thus far, so most information comes from the hobbyists and breeders themselves (Pyron et al., 2013). Morphs are usually sold at a higher price than standard or “wild type” morphs since they are rarer. Several kinds exist for purchase in the pet trade today, including albino, purple, Chacoan white-headed, and blue to name a few. Albino tegus lack pigmentation, resulting in a mostly white or gray animal. They are quite rare and can sell for several thousand dollars. Although they’re not actually purple, crossing the Argentine black and white tegu with the red tegu results in what has been called a purple tegu. These can be found naturally, but they are typically bred selectively. The Chacoan white-headed tegus get their name from their pure white heads they possess as adults. Blue tegus actually do have a slight blue tint to them, and their nose has a “singd” appearance as if it has been blackened by a flame. They are similar to the standard morph in every other way. These are just a few examples, and breeders are actively experimenting to find new marketable morphs and hybrids.

### **Intelligence**

Lizards are commonly believed to be limited in cognitive ability, but many studies have shown that lizards are intelligent enough to exhibit more complex types of learning than was

originally thought. For example, one study demonstrated the behavioral and learning flexibility of anoles by giving tests in which the anoles would have to recognize and solve various mechanisms that would then give access to a reward (Leal and Powell, 2011). In another study, juvenile black throat monitors were tasked with using hinged doors to obtain prey from a plastic tube apparatus, which each solved within ten minutes of the first trial (Manrod et al., 2007). Even among these, tegus are known to be very intelligent lizards. They have one of the highest encephalization quotients (a measure of relative brain size) among all squamates, which may be an indicator of intelligence (Platel, 1975). Food is a strong motivator for these lizards, and there are many examples of tegus being classically conditioned to perform certain tasks. Common things that owners train their tegus to do in this way include going to the bathroom in a specific area, walking towards a specific spot and staying there, wearing a harness to go for walks, and coming when called by name.

One discovery that demonstrates the tegu's exceptional cognitive ability is that they may be capable of REM sleep, which is closely associated with dreaming in mammals. One study planted tungsten electrodes in different regions of the brain in a bearded dragon and 6 Argentine black and white tegus to determine their capacity to exhibit REM sleep (Libourel et al., 2018). Researchers were able to confirm the presence of two types of sleep states in both species. The second state was characterized by rapid ocular movement and was inhibited with Fluoxetine treatments, which inhibits REM sleep in mammals. This suggests that this second state may be analogous to REM sleep in mammals.

### **Disease and Common Health Issues**

All captive reptiles are prone to several health issues, but one of the most common issues seen in reptile medicine is metabolic bone disease (MBD). MBD is a general term used for

several medical conditions that affect the bones. It is caused by an imbalance of phosphorous and calcium in the body, which is usually related to poor husbandry. The normal range for the calcium to phosphorous ratio is 1.5:1 to 2:1, with the 2:1 end being more ideal (Center for Avian & Exotic Medicine, n.d.). If calcium falls below this range, phosphate ions can be absorbed, which stimulate the parathyroid glands to secrete parathyroid hormone. This tells the body to pull calcium from the bones, resulting in soft and weak bones. The body may add fibrocollagenous connective tissue to bones to compensate for lost integrity, resulting in bumps on the bones. Other symptoms include muscle tremors, lethargy, weakness, anorexia, and, in severe cases, seizures and paralysis. MBD commonly occurs in reptiles due to a poor diet or lack of a UV light source. A diet with too much phosphorous or too little calcium can lead to MBD, but this is less common than the lack of UV light. Tegus, like all diurnal lizards, require quality UVA and UVB light in their enclosure. They use this light to synthesize vitamin D3, which is essential to calcium absorption and metabolism. Treatment of MBD requires correction of husbandry, including proper lighting, nutrition, and temperature. Calcium gluconate administered orally or injections of calcium gluconate may be used in severe cases to restore blood calcium levels. Calcitonin treatment may be administered to accelerate calcium deposition on the bone (Center for Avian & Exotic Medicine, n.d.).

Poor husbandry can lead to several other issues. One such condition is dysecdysis, which happens when the tegu can't shed its skin normally. This commonly occurs around the digits, which often leads to necrosis and loss of the digit. Causes involve problems with diet or humidity. Raising humidity or giving regular baths can help the issue correct itself. Incorrect humidity can also lead to respiratory infections such as pneumonia. Being kept too cold, too wet, or too stressed can facilitate a bacterial infection in the lungs. Symptoms include decreased

appetite, bloated body, gaping, open mouth breathing, wheezing, clicking noises, stringy mucous in the mouth, and breathing with a raised head. Treatment usually requires the use of antibiotics and keeping the animal in a well ventilated and well heated enclosure. Increased temperature helps to stimulate the reptile's immune system, mobilize respiratory secretions, and increase effectiveness of antibiotics (Divers, 2020). Excessive humidity and moisture can also cause ulcerative or necrotic dermatitis, which is also known as "scale rot." Although this can occur even in a well-maintained enclosure, moist conditions will facilitate bacterial and fungal growth. These pathogens can then enter through damaged skin and cause necrosis, ulcers, and lesions on the skin. Debridement, antibiotics, and topical ointment are typically used to treat this condition (Divers, 2020).

Gastrointestinal issues can be a common cause for a visit to the clinic. One frequent issue is gastrointestinal impaction. Impaction occurs when material blocks the GI tract, stopping regular gut movements. This material can be anything, but it is commonly caused by inappropriately large food items or accidental ingestion of particulate substrates like sand, gravel, or fiber. This may cause the tegu to become lethargic, anorexic, and unable to defecate. It is usually surgically corrected. If not done in a timely manner, the impaction may cut off blood supply to the intestinal walls, leading to necrosis and eventually death. The GI tract can also be infected with parasites. Captive tegus that stay inside all day are less likely to be exposed to them, but even these indoor lizards can catch parasites from contact with other infected individuals or by ingesting infected prey items. Pinworms, coccidia, and flagellated protozoa are among the most common culprits (Ness Exotic Wellness Center, n.d.). Ectoparasites like mites and ticks are uncommon, which may be due to the tegu's thick skin and beaded scales. Obesity poses another issue for captive reptiles, and this is particularly true for the tegu. Low

temperatures or lazy lifestyles can lead to a tegu that can't burn the energy it consumes. Additionally, diets that are too high in energy dense foods like meat and sugary fruits can cause obesity in an inactive captive tegu. In this case it can be difficult to get them to accept eating vegetables again. Some owners have had luck mixing vegetables with eggs or ground turkey to increase palatability. Tegus are voracious animals who will eat more than what they need if offered, so feeding even the appropriate foods too often can also lead to an overweight lizard. Juveniles can be fed every day, but as they mature into adults, feedings can be spaced out to every two or three days. This can be an issue for overzealous feeders. Some individuals are so overzealous that they can't be safely handled until they've eaten. For pet parents who like to handle their animals often, they must feed them often. Some owners have reportedly fixed this issue by training their tegu using a clicker or target to indicate when it's feeding time.

Tegus, like any other pet reptile, can transmit zoonotic diseases to their owners. It is well known that reptiles are major carriers of salmonella. One study tested 30 captive-born tegus, and 100% tested positive for *Salmonella enterica* (Maciel et al., 2010). It is frequently found in clinically healthy reptiles and should be considered part of the GI system's normal flora (Divers, 2020). Attempts to remove them have been unsuccessful and treatment is not recommended. Although they don't cause any illness in their lizard hosts, these bacteria can cause diarrhea, headache, and fever and can lead to sepsis in humans. Zoonosis occurs through contact with contaminated reptile feces. Botulism is another common reptile vector-borne disease. Toxins released by the bacterium *Clostridium botulinum* can cause paralysis and death in people and pet reptiles. Leptospirosis poses another health concern. A study carried out in Brazil found that 9 out of 12 wild Argentine black and white tegus caught were positive for *Leptospira* spp.

(Fernandes et al., 2020). Those with leptospirosis often experience flu-like symptoms and severe headache. Infection is caused through contact with contaminated urine.

### **Personal Experience**

The author has owned one female Argentine black and white tegu. She was purchased at a reptile convention as a hatchling in 2017. Since, she has attained a length of three and a half feet and displayed no signs of illness. She is comfortable around dogs and cats, displaying neither aggression nor defensive behavior. She is picky about her diet, rejecting most fruits and vegetables in favor of meat, eggs, mice, and insects. The author has had success in mixing vegetables with ground turkey and eggs to entice the tegu to eat more plant matter. Feedings occur once every three days. She is docile enough to be handled safely when she is hungry, so target training has not been necessary. However, she has been successfully potty trained. She will defecate in the same spot every day and immediately receive food as positive reinforcement for desired behavior. She is also comfortable in a harness, but walking outside can be stressful. Lizards can see ultraviolet light, which makes things appear differently outside. When a tegu that has spent most of its life indoors steps outside, they may not recognize their owners and exhibit defensive or evasive behavior.

### **Invasive Threat**

Nonnative species invasion can be a serious threat to local conservation and biodiversity. Unfortunately, the same characteristics that make tegus a sustainable resource and a desirable pet also make them exemplary models for invasion. Such is the case for much of the southeastern United States. The Florida Fish and Wildlife Conservation Commission (FWC) reports that there are 46 established and potentially established nonnative lizard species in Florida, which is more

than three times greater the total number of native lizards at 15 species (Nonnative Reptiles, 2022). About 90% of Florida's nonnative reptile and amphibian species were introduced through the pet trade (Krysko, 2011, as cited in Barraco, 2015). Among these species are the Argentine black and white tegu and the red tegu, although the former has a more established population and is therefore of greater concern.

First observed in 2002, the Argentine black and white tegu was likely introduced through captive release. Tegus breeders in Florida will often utilize outdoor enclosures. Damage from burrowing habits and severe weather could be the cause of multiple escapes (Enge, 2006). Paraguay allowed the annual export of 1500–1732 live Argentine black and white tegus from 2000 to 2002 (CITES 2006, as cited in Enge, 2006). The most likely source of Florida's established population is the purposeful release by a dealer, whose tegus had imperfections like broken tails or missing digits that made them less valuable for trade. The large number of importations from Paraguay had dropped the price of hatchlings from about \$250 to \$35, meaning the lizards may not have been worth keeping. They may have been released with the intention to establish a population to exploit in the future or to avoid killing unwanted animals.

Florida's particular problem with invasive reptiles has much to do with its climate. In South America, tegus inhabit tropical forests, woodlands, savannahs, semi-deserts, beaches, and even agricultural areas. Wetter biomes like stream gallery forests and seasonally flooded savannahs are also suitable habitats (Enge, 2006). Florida's wet and dry prairies and agricultural and suburban areas are similar enough to allow these lizards to propagate.

One team of researchers made species distribution models (SDMs) using five model algorithms (logistic regression, multivariate adaptive regression splines, boosted regression trees, random forest, and maximum entropy) to predict potential distributions for invasive tegus in the

United States and Mexico (Jarnevich et al., 2018). They determined that a habitat's mean annual precipitation and mean temperature of the coldest quarter were the most important variables in determining habitat suitability. For the Argentine black and white tegu, maximum habitat suitability was achieved in areas with mean temperature of the coldest quarter being approximately 5–15 °C and the mean annual precipitation being greater than 1 meter. Their predicted suitable habitat occupied much of the southeastern United States, stretching from Texas to South Carolina down to the coastal regions and up to the southeastern plains and Piedmont. These regions align with their native distributions in the subtropical and humid ecoregions of southeastern South America. For the red tegu, maximum habitat suitability was achieved in areas with mean temperature of the coldest quarter being approximately 5–20 °C and the mean annual precipitation being less than 1.5 meters. Their predicted suitable habitat occupied the semiarid southwestern regions of the United States, northwestern Mexico, and the Baja California peninsula. This aligns with their native distribution in the characteristically arid Chacoan regions of South America. Not all environmental variables could be included in these calculations. For example, presence of predators, competitors, and food availability were not evaluated although they do play a role in habitat suitability. The tegus' ability to acclimate to new habitats was also not evaluated, meaning that potential distributions could be wider than predicted.

Another study took 12 wild-caught Argentine black and white tegus from southern Florida and housed them in outdoor enclosures for more than a year in Auburn, Alabama (Goetz et al., 2021). Then researchers evaluated survival, body temperature, duration and timing of winter dormancy, and health of each tegu during each of four biologically relevant time periods: late active, dormancy, early active, active. Nine of the twelve survived winter dormancy to

emerge the following spring, but decomposition of the three deceased tegus was too advanced to perform conclusive necropsies. Two of these were found in their artificial refugia boxes with standing water and a thick layer of silt, unlike any other box. Two more tegus passed after emerging in the spring at two and six weeks respectively. Necropsies on these two revealed heterophilic and granulomatous pneumonia with heavy lung growth of the bacteria *Serratia marcescens*, or moderate growth of the bacteria *Aeromonas hydrophilia* and heavy growth of the bacteria *Aeromonas veronii*, respectively. The average body temperature during the late active period was 27.1°C. The average body temperature during the dormancy period was 14.4°C. Average body temperature during dormancy in their native range is reported to be about 17–21°C. The females had a longer average duration of dormancy at 200 days than the males at 164 days. The average body temperature during the early active period was 17.7°C. Physical exams performed by a veterinarian revealed no signs of disease or injury in any of the remaining seven tegus. The average body temperature during the active period was 27.2°C, which was greater than ambient air temperature due to their ability to actively thermoregulate. Presence of sperm in the male testes and previtellogenic follicles in the female ovaries indicated that all lizards were sexually mature by the end of the active period. Reproductive behavior usually occurs shortly following the dormancy period, but the lizards used in this experiment were still rapidly growing and may have been too small to breed at the start of the early active period. Researchers believe that reproduction would have been possible the following spring. These findings demonstrate the Argentine black and white tegu's reproductive plasticity and strong thermal adaptation, which suggest that they are capable of surviving and reproducing in much colder climates than are found in currently established habitats like Florida.

The impact that the Argentine black and white tegu has had on Florida's wildlife is not yet fully understood. One study attempted to evaluate the potential impacts on Florida's native species by examining the stomach contents of a sample of tegus (Barraco, 2015.) A total of 169 tegus captured from 2011 to 2012 were used in the analysis. Every food item identified was placed into one of six categories: crustaceans, gastropods, insects, fruits, vertebrates, and eggs. Species were identified where possible. 76% of tegu stomachs contained insects, 50% contained fruits, 46% contained gastropods, and 37% contained vertebrates. The most commonly found insects were *Scarabidae* and *Carabidae* ground beetles and *Acrididae* and *Romaleidae* grasshoppers, which were already abundant in the environment. Only 10% of the samples contained eggs, and 5% contained crustaceans. The low occurrence of eggs in the samples could be influenced by the way tegus eat eggs. Many will break larger eggs open and lap out the insides, leaving the shell behind. This would leave little to no evidence of consumption of eggs. Smaller eggs are typically swallowed whole, which could be identified as mostly reptilian. Tegus in disturbed and agricultural areas had higher body condition scores and contained relatively more insects and gastropods than those obtained in natural areas, which contained more seeds and had lower body condition scores. Tegus with greater body condition have greater potential to reproduce. Since disturbed and agricultural areas make up most of Florida's northwestern portion, this suggests that tegus may find success in moving north out of their current established habitat. This potential to expand threatens a variety of endangered species, especially those that lay eggs in ground level nests. Notable examples include the American alligator (*Alligator mississippiensis*), the Florida red-bellied cooter (*Pseudemys nelson*), the Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*), the burrowing owl (*Athene cunicularia*), the loggerhead sea turtle (*Caretta caretta*), the green sea turtle (*Chelonia mydas*), the leatherback sea

turtle (*Dermochelys coriacea*), the gopher tortoise (*Gopherus polyphemus*), the short-tailed snake (*Stilosoma extenuatum*), the diamondback terrapin (*Malaclemys terrapin*), and the sand skink (*Neoseps reynoldsi*). Other non-endangered species of note that could face impact include the Florida mouse (*Podomys floridanus*), the Florida gopher frog (*Rana capito aesopus*), the Florida pine snake (*Pituophis melanoleucus mugitus*), the eastern indigo snake (*Drymarchon couperi*), and the bluetail mole skink (*Eumeces egregius lividus*). Out of the four stages of invasion (entry, establishment, spread, and impact), the Argentine black and white tegu is currently at the third stage, spread, in southern Florida. With this information, the author suggests focusing on removing tegus from disturbed and agricultural areas due to their increased reproductive potential. Without containment efforts, tegus will pose a substantial threat to native wildlife and enter the costly invasive stage of impact.

Effective April 29<sup>th</sup>, 2021, the FWC added the Argentine black and white tegu to their prohibited species list due to its being high-risk and nonnative (FWC, 2021). This means that tegus can no longer be purchased, and in-state breeders will have to end commercial breeding by June 30<sup>th</sup>, 2024. Tegu owners who were already in possession of their pet before April 29<sup>th</sup>, 2021, are required to have their animals registered and microchipped. The tegu industry across Florida was valued at about \$500,000 in 2019, according to the FWC.

As studies have predicted, the invasion has shown signs of progressing beyond Florida. From 2019 to 2020, a team of researchers set out to determine whether tegus had established a population in southeastern Georgia (Haro et al., 2020). Land managers in Georgia received more than 20 reports of Argentine black and white tegu in the wild in 2018. These reports were concentrated in Toombs and Tattnall counties, possibly due to a captive release of multiple tegus from a Toombs County resident when they moved in 2016. From 29 July to 14 October 2019,

researchers set 75 live traps baited with chicken eggs across 3 sites. A total of eight tegus were caught during this time. 7 additional tegus were obtained from March to September of 2020. Their capacity to reproduce was assessed through necropsy, revealing the potential to propagate. Frequent reports of sightings also suggest that these lizards were successfully reproducing. Eradication of invasive reptiles requires early detection and rapid response. This study suggests that public outreach may increase much needed reports before these invaders can establish themselves.

Despite the evidence of an established population, Georgia has made no restrictions or bans on owning or breeding tegus. Other states, namely South Carolina and Alabama, have already begun to take legal action, much to the dismay of exotic pet owners and breeders. Out of concern for the native ecosystem, the South Carolina Department of Natural Resources (SCDNR) has enacted legislation similar to that enacted by the FWC. As of September 2021, 13 tegu sightings have been documented in Berkeley, Lexington, Richland, Greenville, Pickens, Darlington, and Orangeburg counties (Underwood, 2021). On May 28<sup>th</sup>, 2021, buying, selling, transferring, or breeding the Argentine black and white tegu was effectively prohibited (SCDNR, 2021). The only legal owners are those who have microchipped and registered their pet with the SCDNR. Violations of these regulations are punishable by fine of \$2,500 or one year in jail (Cheatam, 2021). Effective October 15<sup>th</sup>, 2020, the Alabama Department of Conservation and Natural Resources (ADCNR) made an amendment to Alabama Wildlife and Freshwater Fisheries Regulation 220-2-.26, which banned the sale and importation of all tegus in the genus *Salvator* alongside several other species of nonnative wildlife (ADCNR, 2020). Current owners must also have their tegus registered and microchipped with the ADCNR. Like South Carolina,

this regulation change was made due to ecological concerns. The exact economic impact on the exotic pet business in these states has not been evaluated.

Tegus have historically invaded other regions outside of the United States. One such place is Fernando de Noronha, the largest island in an oceanic archipelago of the same name that is approximately 360 km off the northeastern coast of Brazil (Londe, 2020). Home to about 3,100 inhabitants, the island houses several endemic species, including the Noronha skink (*Trachylepis atlantica*), Ridley's worm lizard (*Amphisbaena ridleyi*), and birds like the Noronha elaenia (*Elaenia ridleyana*) and the Noronha vireo (*Vireo gracilirostris*). It is also an important breeding site for several regionally threatened marine bird species, including Audubon's shearwater (*Puffinus lherminieri*), the red-footed booby (*Sula sula*), the red-billed tropicbird (*Phaethon aethereus*), and the white-tailed tropicbird (*Phaethon lepturus*). Despite being native to continental Brazil, the Argentine black and white tegu was not native to Fernando de Noronha. It was introduced sometime between 1888 and 1950. Some believe people purposefully introduced it to control the invasion of rats or to provide another source of food for locals. A recent study suggests that the 18 km<sup>2</sup> island is home to between 7,000 and 12,000 individuals (Londe, 2020). This is up from the range of 2,000 to 8,000 individuals that was estimated in a 2003 study (Péres Jr., 2003 as cited in Bovendorp et al., 2008). Population information and control methods are currently being explored.

## **Conclusion**

The tegu is a remarkable animal with an increasingly involved relationship with human beings. Their meat and skins have sustained rural people in South America up to the present day. They had such a profound impact on the leather industry that several species became actively managed in multiple South American countries. It spawned a network of hunters, middlemen,

and tanners to produce exportable products. People even introduced the tegu to regions like the island of Fernando de Noronha to provide food for its inhabitants due to its reliability as a resource. The pet trade shifted the tegu's role in business and made these relationships more personal. In captivity, the tegu has been able to distinguish itself as a model pet reptile. It's a hardy animal that can tolerate a wide range of parameters. Previously thought as mindless or instinctual, their capacity to learn redefines our understanding of lizard intelligence. Above all, their docile nature makes them a relatively easy and approachable pet for reptile hobbyists. As the pet trade introduces these creatures to nonnative territory, the perspective shifts. Their exceptional durability and reproductive capacity make them strong invasive competitors. Legislators in South Carolina and Alabama have preemptively banned these lizards out of environmental concerns. The severe impact they've had on the ecosystems and vulnerable species of places like Florida and Fernando de Noronha encourages research. More studies are needed to aid mitigation efforts. This information can be used to further the understanding of other reptile species in the effort to control and sustain the world's resources.

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