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Efficacy of increased visual and olfactory cues for luring and trapping invasive tegu lizards

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Controlling invasive wildlife species relies on the ability to efficiently remove individuals from the invaded environment. Thus, maximizing capture potential is of high interest, particularly for species that are difficult to capture. For invasive species such as the Argentine black and white tegu lizard (*Salvator merianae*), increasing attraction to traps could increase the probability of removal. While it has been established that *S. merianae* can be lured with a single chicken egg, the efficacy of increasing olfactory or visual cues to increase tegu captures has not been rigorously tested. To test this, we leveraged an ongoing National Park Service trapping effort near Everglades National Park. In 2023 and 2024, we randomly assigned traps to a control treatment (single real egg), increased olfactory and visual treatment (three real eggs), an increased visual plus standard olfactory treatment (one real egg and one decoy egg, or one real egg and two decoy eggs), or visual treatment only (three decoy eggs). We fitted Bayesian binomial models for tegu lizards and non-target species to the trapping data to assess how bait treatment, trap style, and trap location affected the daily probability of capture at a trap. Additionally, we fitted Bayesian linear models to test the effect of bait treatment on the size of tegus captured. We found that increasing the olfactory cue to three real eggs increased the probability of tegu capture, but not the probability of non-target species capture. Conversely, traps with one real egg and two decoy eggs increased the probability of non-target captures while reducing the probability of tegu captures. Trap style and trap location also had statistically significant effects. Bait treatment did not significantly influence the size of tegus captured; however, there was a weak effect suggesting juvenile and male tegus captured in traps with three real eggs were larger compared to traps with a single egg and two decoy eggs. Our results highlight potential improvements in tegu control methods that balance effective capture with minimizing non-target bycatch.

KEYWORDS

Argentine black and white tegu, Bayesian modeling, invasive reptiles, invasive species removal, trapping efficiency

Introduction

Once established, controlling a population of invasive species to minimize ecological and economic damage is difficult. Suppressing or eradicating the population(s) usually requires sustained, long-term investment. While [Fantle-Lepczyk et al. \(2022\)](#) estimate that only 4% of costs for invasive species go to control efforts, the absolute cost for agencies or land managers controlling invasive species can be burdensome ([Larson et al., 2011](#)). Despite the investment, suppression and/or eradication continue to be the primary goal of many invasive species management programs ([Green and Grosholz, 2021](#)). Thus, optimizing control efforts can be a high priority for invasive species managers. Optimization depends on control and removal methods (e.g., physical removal, chemical control, biological control) as well as a species' life history traits. For example, in some cases, removing individuals of a certain life stage or age class from an invasive population can actually result in an increase in the population growth rate as a result of density-dependent release ([Govindarajulu et al., 2005](#); [Zipkin et al., 2009](#)).

Optimizing captures often focuses on understanding the behavior of an invasive species ([King et al., 2009](#); [Bravener and McLaughlin, 2013](#)), which involves testing various chemical or pheromone attractants (e.g., for invasive insects), or identifying physiological cues that will lure individuals into traps such as auditory, olfactory, vomerolfactory, or gustatory lures ([Campbell et al., 2012](#); [Lavelle et al., 2017](#)). For example, in a study of invasive green crabs off the coast of Newfoundland, researchers found that using squid or cod increased green crab captures by 47% and 77% respectively, compared to the control bait of herring, which is typically used in removal efforts, and that these baits also led to captures of larger crabs ([Favaro et al., 2020](#)). For the invasive brown tree snakes on the island of Guam, extensive studies have been conducted to determine the optimal lure, and this research has led to using live or dead mice in the majority of control efforts ([Clark et al., 2017](#)). Ultimately, if removal of an invasive species is a primary goal for management, identifying attractants can increase the probability of reaching this goal.

Tegu lizards are an example of an invasive species that can be removed via trapping ([Haro et al., 2020](#); [Udell et al., 2022](#)). Three species of tegus that are common in the pet trade have, or are at risk of, establishing invasive populations in the United States (U.S.) and other countries ([Gaiotto et al., 2020](#)). The Argentine black and white tegu (*Salvator merianae*) has established populations in four Florida counties ([Engeman et al., 2011](#); [Harvey et al., 2021](#)) as well as one county in Georgia ([Haro et al., 2020](#)). Sightings continue to increase across the southern United States in particular, including new, ecologically sensitive areas of Florida ([Sandfoss et al., 2025](#)). The gold tegu (*Tupinambus teguixin*) has established a single population in southern Florida as well ([Edwards et al., 2017](#)), and while there are no established populations of the red tegu (*Salvator rufescens*) confirmed in the United States, there have been multiple sightings ([EDDMapS, 2025](#)). Recent projections suggest that much of the United States contains suitable habitat for all three species ([Jarnevich et al., 2018](#)), and that suitability will likely increase in the

future ([Kissel et al., 2025](#)). Similar to other invasive reptiles (e.g., brown treesnakes [[Savidge, 1987](#)], Burmese pythons [[Guzy et al., 2023](#)]), tegu lizards have the potential to cause substantial ecological and economic damage ([Klug et al., 2015](#)), given they are a generalist omnivore ([Figueroa et al., 2025](#); [Gaiotto et al., 2020](#); [Harman et al., 2025](#); [Offner and Johnson, 2021](#)) with broad physiological tolerances ([Currylow et al., 2021](#); [Goetz et al., 2021](#)). They have been sighted on poultry farms as well ([Haro et al., 2020](#)), and identified as an economic threat due to their attraction to eggs.

Typically, a single chicken egg is used as a lure in trapping and removal efforts for tegus ([Avery et al., 2016](#); [Haro et al., 2020](#); [Udell et al., 2022](#)). Chicken eggs, along with squid, and chicken meat have been used as bait to trap other invasive carnivorous lizards in Florida as well ([Cambell, 2005](#)). However, it is unknown as to whether tegus are attracted via olfactory or visual senses, or both. [Avery et al. \(2016\)](#) tested melon-scented oil and mouse paste as alternative lures, but these were no more effective than chicken eggs. A recent y-maze experiment tested vomerolfactory, olfactory, and visual sensory cues in *S. merianae*, and a field study tested different scent lures (blueberry oil or mouse oil), but no clear patterns emerged ([Xiong, 2025](#)). Experiments to test olfactory cues of other invasive reptiles, such as the Burmese python, have found that pythons are not attracted to rabbit feces, urine or hair, suggesting that olfactory cues are not the primary lure for this species ([Miller et al., 2025](#)). In general, there have been few experiments to manipulate the visual or olfactory cue of lures to determine the mechanisms behind attractants for invasive reptiles.

Currently, there are extensive trapping efforts led by the National Park Service (NPS) and Florida Fish and Wildlife Conservation Commission (FWC) to prevent tegus from establishing in Everglades National Park (ENP). Trapping within ENP and along the park's boundary commenced in 2019, has continued annually, and has largely kept the population from spreading deeper into ENP, despite a dense population just to the east of the park boundary ([Sandfoss et al., 2025](#)). Managers deploy traps with a single chicken egg as a lure, and while generally successful at capturing tegus, non-target species are also caught in the traps, which can reduce availability of the traps for tegus.

To test whether using different combinations of real and decoy eggs affected tegu or non-target species captures, we used two years of data in which traps were randomly deployed by NPS staff with either a single real chicken egg (control), three real chicken eggs (representing an increase in olfactory and visual cues), a single real chicken egg and either a single decoy egg or two decoy eggs (increase in visual cue with the standard olfactory cue), or three decoy eggs (representing only a visual cue). We did not have a treatment that increased olfactory cues without a corresponding increase in visual cue because this was not possible with the bait we used for our study (i.e., eggs). Our objectives were to understand whether different combinations of real and decoy eggs could increase tegu capture probability while minimizing non-target captures and provide a more cost-effective alternative to chicken eggs (i.e., reusable decoy eggs). This was of particular concern to managers given rising costs and reduced availability of chicken eggs in 2023, due in part to an outbreak of avian influenza.

Methods

Study site

The study was conducted along water management canals and levees, within the Southern Glades and Frog Pond Wildlife Management areas, adjacent to the eastern boundary of Everglades National Park, Miami-Dade, Florida (Figure 1). The study area is dominated by freshwater marsh and marl prairie interspersed with cypress domes, tropical hardwood hammocks, and mixed non-native forests. Common vegetation includes Jamaica swamp sawgrass (*Cladium jamaicense*), Hairawn muhly grass (*Muhlenbergia capillaris*), poisonwood (*Metopium toxiferum*), strangler fig (*Ficus* spp.), willow (*Salix* spp.), saltbush or eastern baccharis (*Baccharis halimifolia*), Brazilian peppertree (*Schinus terabinthifolia*), white leadtree (*Leucaena leucocephala*), and various species of cane grass.

Trapping

We conducted annual tegu live-trapping between February and October 2023–2024 across 4 trap lines, with temporary trap closures during severe weather events and on weekends. Each trap line had between 15 and 39 traps, depending on the length of the canal levee (Figure 1). Traps were placed within vegetation along levee roads anywhere from a meter to 20-meters (m) from the roadbed and distance between individual traps ranged from five to 500-m, depending on habitat quality and the availability of cover. The open trap door faced out from the vegetation, towards the roadbed, to target tegus foraging on the habitat edge. In the case of trap types equipped with two doors, only one door was opened. All traps were placed on the ground in a shaded location and checked daily and primarily on

weekdays. If adequate shade was not present, traps were manually covered with palmetto fronds (*Sabal* spp.) to provide shelter for captured wildlife and conceal the trap from curious members of the public.

Transects were labeled using the numerical section of the canal and a cardinal direction to indicate whether transects were on the east or west side of the canal or north or south of a landmark (AERO, C-111SW, L-31WN, L-31WS, Figure 1). Multiple trap types were deployed to capture a range of sizes of tegus. We deployed three standard Havahart traps: large single-door traps (SL), medium single-door traps (SM), and small two-door traps (XS2D) (Supplementary Table S1). Additionally, we modified the standard small two-door and medium two-door traps in four ways to capture juvenile tegus: increased sensitivity of the trip plate to ≤ 10 g, closed one of the two doors, installed wooden dowels to block gaps between doors, and attached 0.6-cm hardware cloth to trap exterior to reduce gap size. We refer to the modified small two-door traps as XS2DM2 and the modified medium two-door traps as M2DM2 (Supplementary Table S1). The trap naming convention refers to the size (e.g., XS=small, M=medium), number of doors (2D for two doors), and modified second generation (M2). Large traps (SL) and modified medium traps (M2DM2) were deployed in February at the beginning of the trapping season, when larger tegus are available. Small (XS2D) and modified small traps (XS2DM2) were added in May, when smaller tegus become available for trapping (i.e., smaller tegus emerge from overwintering later, and young of the year start hatching in May). All invasive lizards (teguas, green iguanas, brown anoles) caught were removed and euthanized. Invasive cane toads were euthanized as well. All other non-target species were released from the traps unharmed. Approval was not required by the NPS Institutional Animal Care and Use Committee because invasive species are euthanized as part of ongoing mitigation management. However, euthanasia methods were developed in consultation with the NPS

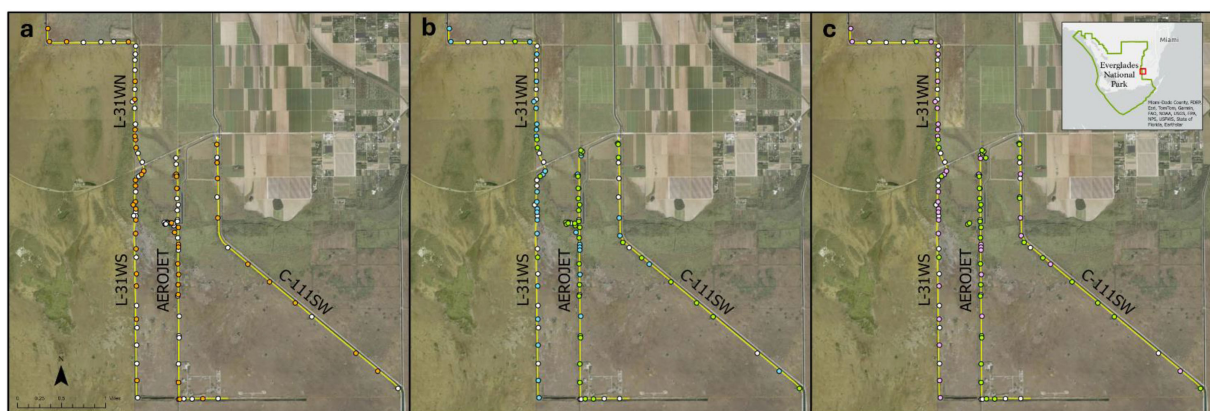


FIGURE 1

Map of study area and placement of traps and treatments. Panel (a) Trap deployment and treatments in 2023. White points represent the 'one real egg' treatment and orange represent the 'one real, one decoy egg' treatment, all of which were replaced by the 'three real egg' treatment on March 10, 2023. Panel (b) Trap deployment between February 13, 2024 and June 12, 2024. White points represent the 'one real egg' treatment, blue points represent the 'three decoy eggs' treatment, and green points represent the 'three real egg' treatment. Panel (c) Trap deployment and treatments between June 12, 2024 and October 4, 2024. White points represent the 'one real egg' treatment, pink points represent the 'one real egg, two decoy eggs' treatment and green points represent the 'three real egg' treatment. Note that on June 21, 2024 all 'one real egg' treatments were replaced with the 'one real egg, two decoy egg' treatment. Map credits: Miami-Dade County, FDEP, Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, NPS, USFWS, State of Florida, Earthstar.

Wildlife Health Team to ensure safe and humane practices. For invasive reptiles, euthanasia consisted of rendering the individual unconscious via blunt force trauma to the head achieved by a penetrating captive bolt stunner (CASH Special Captive Bolt Stunner Gun, 0.22 caliber) for large reptiles (i.e., tegus and green iguanas) and a hammer for brown anoles, which are too small for the captive bolt gun. This was followed by pithing to destroy all remaining brain tissue. For cane toads we used an application of Benzocaine hydrochloride (e.g. ANBESOL™; 20% concentration). All field work was conducted under permit #EXOT-23-17 and #EXOT-24-33 issued to NPS by the Florida Fish and Wildlife Conservation Commission.

Bait treatments

Treatments consisted of ‘one real egg,’ ‘three real eggs,’ ‘one real egg, one decoy egg,’ ‘one real egg, two decoy eggs,’ or ‘three decoy eggs.’ Decoy eggs were made of balsa wood and painted white, and real eggs consisted of grade A, large chicken eggs. Both bait types were placed behind the trip plate in their respective trap. The chicken eggs were loose, and available to the captured animals. In 2023, the decoy eggs were loose as well. However, in 2024 decoy eggs were secured to the trap with wire (galvanized steel, 18-gauge) threaded through a 2.5-millimeter hole, drilled through the middle of the egg, across the transverse plan, and wrapped around the bottom trap mesh. Attachment to the trap was necessary to avoid ingestion by native non-target captures.

Bait treatments and trap styles were evenly and randomly distributed across all sites during deployment. In 2023, the ‘one real egg, one decoy egg’ treatment was removed on March 10, due to concerns regarding native species consuming the wooden decoy egg (the traps were modified in 2024 to prevent this, see above) and replaced with the ‘three real egg’ treatment (Table 1). In 2024, the ‘three decoy eggs’ treatment was removed on June 12, because the low rate of tegu capture for this treatment was counter to tegu removal goals, and replaced with the ‘one real egg, two decoy eggs’

treatment (Table 1). On June 21, we switched all ‘one real egg’ traps to ‘one real egg, two decoy egg’ traps (Table 1). We did this because there were a few traps in the ‘one real egg’ treatment that were catching a disproportionate number of tegus, and we wanted to discern whether this was due to spatial variability or treatment type.

Data analysis

To explore the effects of bait treatments on the daily probability of capture of tegus or non-target wildlife in a trap, we fitted Bayesian binomial linear models. We developed separate models for tegus and non-target captures. We included bait category (with ‘one real egg’ as the reference level), trap style, and week as fixed effects and a random intercept of trap identification (ID) nested within site to account for potential spatial effects. In preliminary analyses we explored including a spatial autocorrelation structure, but this did not improve the model, so we did not include it in the final modeling effort. We included week as a covariate in the tegu model to capture the observed seasonal patterns in tegu captures, in which larger tegus tend to be caught earlier in the season and smaller tegus later in the season. We also included week in the non-target model to account for seasonality of different non-target species. Additionally, not all bait treatments were deployed throughout the trapping season, thus including week as a covariate allowed us to separate the effects of the bait treatment from the effect of seasonality. We combined data from 2023 and 2024 because of the absence of a strong hypothesis regarding year-to-year variation in tegu or non-target capture probability and because some treatments were confounded with year (Table 1). To test the hypothesis regarding year-to-year variation, we calculated catch per unit effort (CPUE) for each trap in 2023 and 2024. We subsetted the data to the ‘single egg treatment’ because it was the only treatment consistently deployed throughout both years and fitted a linear model to test the effect of year and site on CPUE. We found that year was not significant (p -value > 0.05), and thus felt it was appropriate to combine the two years of data for further analyses. Finally, we did not remove non-target captures from the dataset for analysis because

TABLE 1 Summary of bait treatment deployments and the total number of tegus and non-captures caught, as well as the total number of traps rendered non-functional by non-target species near Everglades National Park, Florida.

Year	Bait treatment	Treatment start date	Treatment end date	Number of days traps deployed	Number of traps deployed	Number of tegus captured	Number of non-target captured	Number of non-functional traps
2023	1 real egg	2/13/2023	10/20/2023	133	105	126	96	23
2023	3 real eggs	3/13/2023	10/20/2023	119	66	216	53	28
2023	1 real egg, 1 decoy egg	2/27/2023	3/10/2023	8	55	5	6	0
2024	1 real egg	2/13/2024	6/21/2024	70	41	47	27	6
2024	1 real egg, 2 decoy eggs	6/11/2024	10/4/2024	58	86	55	103	109
2024	3 real eggs	2/13/2024	10/4/2024	121	46	101	44	36
2024	3 decoy eggs	2/13/2024	6/12/2024	64	42	12	22	4

Data source: <https://doi.org/10.5066/P13TTGMN>

for management purposes, understanding how non-targets affect the probability of capture of a tegu is important (i.e., there is unlikely to be a real-world scenario in which non-targets do not affect tegu capture probability).

In our non-target species model, any instance where a non-target animal rendered a trap non-functional—such as flipping or triggering it—was classified as a non-target “capture”. This approach reflects the functional impact: if a non-target species flips the trap, it is unavailable to a tegu until it is reset. Additionally, bait types may influence non-target interactions with traps. For instance, in 2024, wooden decoy eggs were wired to the cage to prevent removal and consumption, which may have prompted some species (e.g., raccoon) to flip the traps in an attempt to access and remove the decoy eggs.

Finally, we ran a Bayesian linear model with a lognormal distribution to look at the effects of bait treatment type on the size (snout-vent-length [SVL]) of the tegu captured. We divided the data into ‘early season’ (March–April) and ‘primary season’ (May–October) because larger individuals tend to be more available for capture during the early season and thus only large traps are deployed, skewing the size distribution of the data. For the primary season, we also limited the data to 2024, because not all treatments were deployed during the primary season for both years, and 2024 had the most consistent data (i.e., treatment types deployed at the same time). However, this limited our comparison to two treatments for the primary season: ‘one real egg, two decoy eggs’ and ‘three real eggs’. We included bait category as a fixed effect and a random effect of trap ID within site in the early season model but did not include sex because the small sample size limited our ability to make inference regarding sex effects. For the primary season model, we used the same model structure but added sex and an interaction term between sex and bait category.

We fitted all models using the package ‘brms’ (Bürkner, 2017) in the statistical programming language R (R Core Team, 2024) using default priors (student’s *t*-distribution with 3 degrees of freedom and a scale parameter of 2.5 centered at 0 on the intercept and flat priors on the regression coefficients). For each model, we ran three chains with a warmup of 1,000 iterations and an additional 3,000 iterations per chain. We assessed convergence by inspecting the chains for sufficient mixing and assessing whether all \hat{R} values were < 1.1 (Gelman and Rubin, 1992). Data used in the analysis are available via a USGS data release (Kissel et al., 2026).

Results

Trap deployment

Over the course of 2023 and 2024, traps were deployed for a total of 254 days. Trapping commenced on February 13th in both 2023 and 2024 and ended on October 20th in 2023 and October 4th in 2024. The timing and deployment of different egg combinations varied depending on management goals (Table 1). A total of 562 tegus were captured and removed, and a total of 351 non-target individuals (consisting of 35 species, Supplementary Table S2) were captured and released during trapping efforts (with the exception of

other invasive species, which were euthanized). Nearly 70% of all non-target captures were made up of just three species: Hispid cotton rats (*Sigmodon hispidus*) accounted for the majority, representing 54% of non-targets; followed by Virginia Opossums (*Didelphis virginiana*) at 7.4%; and Florida box turtles (*Terrapene carolina bauri*) at 5.9%. An additional 206 traps were rendered non-functional by non-target species, until observers could reset the trap the following day (Table 1).

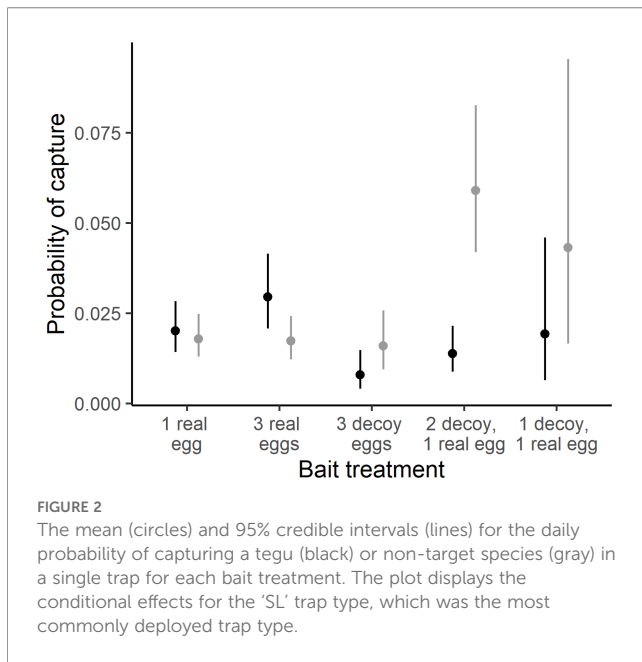
Tegu probability of capture

Daily capture probability increased significantly, by approximately 33%, under the ‘three real eggs’ treatment compared to the ‘one real egg’ treatment (Table 2, Figure 2). The mean daily probability of capture for the ‘three real eggs’ treatment was 0.030 (95% credible interval [CI]: 0.020 – 0.040) while the mean daily probability of capture for the ‘one real egg’ treatment was = 0.020 (95% CI = 0.010 – 0.030), holding all other covariates constant and using an ‘M2DM2’ style trap (Figure 2). The bait treatments consisting of ‘one real egg, two decoy eggs’ and ‘three decoy eggs’ both had significantly negative effects on tegu capture probability compared to the reference treatment of ‘one real egg’, and the bait treatment consisting of ‘one real egg, one decoy egg’ had a weak negative effect on daily tegu capture probability but not significant (i.e., 95% CI overlapped 0, Table 2, Figure 2). Week had a non-significant positive effect on daily tegu capture probability (Table 2). Medium single-door traps (SM) had significantly lower daily capture probability compared to the M2DM2, XS2D, and XS2DM2 traps.

TABLE 2 Coefficient estimates for the effects of trap style, bait treatment, week, and the standard deviation (sd) of the random effect of trap identification (ID) nested within site on the daily probability of tegu capture at a single trap.

Parameter	Mean coefficient estimate	LCI	UCI
trap M2DM2	-3.933	-4.409	-3.46
trap SL	-4.739	-5.082	-4.392
trap SM	-5.9	-6.907	-5.053
trap XS2D	-4.24	-4.756	-3.718
trap XS2DM2	-4.142	-4.604	-3.676
1 real egg, 2 decoy eggs	-0.384	-0.749	-0.037
3 real eggs	0.392	0.131	0.651
3 decoy eggs	-0.954	-1.607	-0.366
1 real egg, 1 decoy egg	-0.045	-1.153	0.812
week	0.002	-0.01	0.013
sd intercept site:trap ID	1	0.832	1.202

Values represent the mean, lower 95% credible interval (LCI), and upper 95% credible interval (UCI). For trap style, SL, single-door large; SM, single-door medium; M2DM2, single door medium with modifications; XS2D, two-door small; XS2DM2, single-door small with modifications.



Large traps (SL) also had reduced daily capture probabilities relative to these trap types, but the differences were not statistically significant (Table 2; Supplementary Figure S1). Additionally, there was significant variation in the random intercept estimates for trap ID nested within site, indicating site-level heterogeneity in trap performance (Table 1; Supplementary Figure S2).

Non-target probability of capture

For non-target species, we found that the treatment 'one real egg, two decoy eggs' had a significantly positive effect on the daily probability of capture compared to the 'one real egg' treatment (Figure 2). The daily probability of capturing a non-target species with the 'one real egg, two decoy eggs' treatment was 0.060 (95% CI: 0.040 – 0.080), while the daily probability of capturing a non-target species for the single egg treatment was 0.018 (95% CI: 0.012 – 0.025). The 'three real eggs' and 'three decoy eggs' treatments had a weakly negative effect on daily non-target capture probability, while the 'one real, one decoy egg' treatment had a weakly positive effect (Table 3). The effect of week was not significant, but the random intercept of trap ID nested within site was statistically significant, indicating site-level variation in trap performance (Table 3). Large traps were associated with a significantly lower probability of non-target captures, whereas all other trap types did not significantly differ from each other (Table 3).

Effects of bait type on size of tegus captured

The effect of bait treatment on SVL was not significant during the early season. Tegus captured using the 'three real eggs' lure had a slightly lower predicted mean SVL of 33.99 centimeters (cm, 95%

TABLE 3 Coefficient estimates for the effects of trap style, bait treatment, week, and the standard deviation (sd) of the random effect of trap Identification (ID) nested within site on the daily probability of non-target capture and disturbance at a single trap.

Parameter	Mean coefficient estimate	LCI	UCI
trap M2DM2	-3.904	-4.351	-3.432
trap SL	-5.118	-5.48	-4.727
trap SM	-4.012	-4.554	-3.497
trap XS2D	-3.785	-4.243	-3.3
trap XS2DM2	-3.765	-4.186	-3.34
1 real egg, 2 decoy eggs	1.24	0.982	1.515
3 real eggs	-0.036	-0.289	0.231
3 decoy eggs	-0.118	-0.604	0.343
1 real egg, 1 decoy egg	0.918	-0.08	1.721
week	-0.005	-0.017	0.008
sd intercept site:trap ID	0.608	0.459	0.779

Values represent the mean, lower 95% credible interval (LCI), and upper 95% credible interval (UCI) estimates. For trap style, SL, single-door large; SM, single-door medium; M2DM2, single door medium with modifications; XS2D, two-door small; XS2DM2, single-door small with modifications.

CI: 31.25 – 37.15 cm, Figure 3), indicating a weak negative association. In contrast, the 'three decoy eggs' treatment was associated with the highest predicted mean SVL of 38.44 cm (95% CI: 32.93 – 45.01 cm), suggesting a weak positive effect. Tegus captured in the 'one real egg' treatment had a predicted mean SVL of 35.66 cm (95% CI: 33.47 – 38.02 cm), while the 'one real, one decoy egg' treatment had minimal influence on SVL (Table 4).

In the 'primary season' model, there was a significant effect of sex: males were significantly smaller than females, and juveniles were significantly smaller than both males and females (Table 4; Figure 3B). The bait type ('one real egg, two decoy eggs' versus 'three real eggs') did not significantly influence size of tegus captured, and interaction between bait treatment and sex did not have a significant effect on the size of tegus captured either. The interaction term was weakly positive for both males and juveniles, suggesting a slight increase in SVL in these groups for the 'three real egg' treatment, but weakly negative for females (Table 4, Figure 3B).

Discussion

Our Bayesian linear random-effects models accounted for multiple factors influencing capture probabilities and allowed for direct comparisons between tegu and non-target models using posterior distributions (Hobbs and Hooten, 2015). Despite variation in deployment duration across treatments, our sample sizes (e.g., number of traps deployed with each bait type) were sufficient for model convergence and provided informative estimates. Our results demonstrate that baiting traps with three

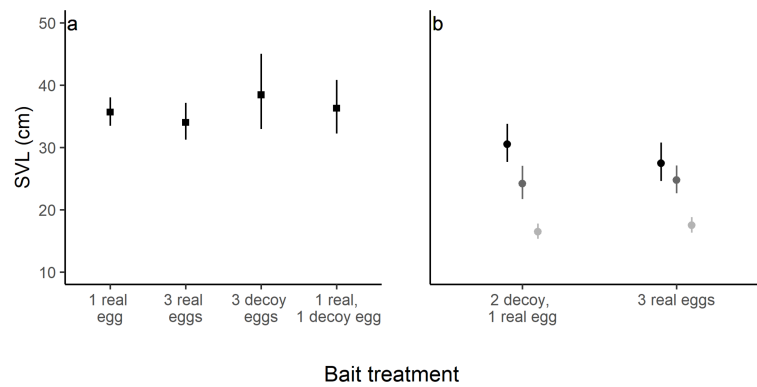


FIGURE 3 The effects of bait type on snout-vent-length (SVL) of captured tegus. Panel (a) mean estimates (squares) and 95% credible intervals (lines) of SVL during the early season (March and April). Note that this model did not include sex. Panel (b) mean estimates (circles) and 95% credible intervals of SVL during the primary season (May to October 2024) for each bait type. Black represents females, dark gray represents males, and light gray represents juveniles.

real chicken eggs significantly increased the probability of capturing tegus (by ~33%), without a corresponding increase in non-target capture probability (Figure 2). In contrast, treatments combining one real egg with one or two decoy eggs increased non-target capture probability but did not improve tegu capture probability (Figure 2). The three decoy egg treatment resulted in lowest capture probabilities for both tegus and non-targets (Figure 2). Overall, these findings indicate that an increase in visual cues alone while keeping the olfactory cue constant (i.e., a single chicken egg with one or more decoy eggs) did not increase tegu capture probabilities, nor did a larger visual cue without an olfactory cue (three decoy eggs). An increase in olfactory stimuli (i.e., three real eggs) appears to be most effective, supporting the hypothesis that tegus rely primarily on olfactory cues when locating bait. An alternative

hypothesis is that the painted decoy eggs may give off a scent that could mask the chicken egg scent (partially or wholly) or act as a deterrent (i.e., tegus are repelled by the scent of painted decoy eggs). This would align with our results suggesting that treatments without decoy eggs were generally more effective at capturing tegus than treatments with decoy eggs. This may indicate odor plays a key-role in long distance attraction, though further research can help to isolate specific chemical or sensory drivers.

We leveraged an on-going control effort to assess the effect of bait type on the probability of capture. This resulted in a tradeoff between study design and achieving management goals (i.e., maximizing removal and reducing effects to non-target species). For example, some treatments were confounded with year because the treatment had to be removed or modified based on real-time

TABLE 4 Mean, lower 95% credible interval (LCI), and upper 95% credible interval (UCI) coefficient estimates for the effects of bait treatment and the standard deviation (sd) of the random effect of trap Identification (ID) nested within site, on the snout-vent-length of tegus captured in traps.

Model	Parameter	Mean coefficient estimate	LCI	UCI
early season	1 real egg	3.567	3.503	3.631
early season	3 real eggs	3.519	3.434	3.606
early season	3 decoy eggs	3.642	3.485	3.799
early season	1 real egg, 1 decoy egg	3.584	3.464	3.701
early season	sd intercept site:trap ID	0.052	0.002	0.123
primary season	1 real egg, 2 decoy eggs	3.401	3.301	3.502
primary season	3 real eggs	3.296	3.184	3.409
primary season	Male	-0.233	-0.377	-0.083
primary season	Juvenile	-0.616	-0.74	-0.492
primary season	Male:3 real eggs	0.126	-0.079	0.325
primary season	Juvenile: 3 real eggs	0.164	-0.011	0.346
primary season	sd intercept site:trap ID	0.042	0.002	0.107

Early season represents captures in March and April, when mostly large tegus are available for capture, and primary season represents captures in May through October when smaller tegus are available for capture as well.

adaptive management decisions (refer to methods, Table 1). This confounding of treatments prevented us from directly assessing the effect of year on tegu capture probability. However, there was no statistical difference in tegu CPUE between years for individual traps in the 'one egg' treatment (the treatment with the most data for both years), indicating that our assumption that there was no difference in capture probability across years was likely reasonable. Additional, multi-year experiments with a balanced study design could further validate this assumption.

We found no difference in the size of tegus captured during the early season (when larger tegus are available for capture) as a function of bait type (Figure 3A). During the primary tegu season, there was a weakly positive association of longer SVLs for males and juveniles captured with the 'three real eggs' treatment compared to the 'one real egg, two decoy eggs' treatment. However, although females were larger in general, the relationship with bait type was the opposite; larger females were caught in the 'one real egg, two decoy eggs' as opposed to the 'three real egg' treatment (Figure 3B). These patterns suggest that smaller tegus are seeking 'high reward' meals ('three real eggs' treatment), consistent with foraging theory (Troyer, 1984; Wikelski et al., 1993), though the weak signal could benefit from additional targeted studies or experiments.

Trap type also influenced capture probability. Tegus were much less likely to be captured in medium single-door (SM) traps, which had relatively high non-target captures rates (Supplementary Figure S1). The M2DM2 trap style (medium single-door trap with modifications) had the highest tegu capture probability, while minimizing the capture probability of non-targets (Supplementary Figure S1). Although the probability of capturing non-targets was relatively high in the M2DM2 trap, it was lower than the probability of capturing non-target species in the XS2D and XS2DM2 trap styles, which also had lower probabilities of capturing tegus. These results suggest that pairing the M2DM2 trap type with three real eggs may maximize tegu capture efficiency while minimizing interference from non-target species.

Capture probability varied across sites. The C-111SW and C-111SE canals, and some trap locations within the AERO canal (Figure 1) had higher tegu capture probabilities, as suggested by the random intercept estimates (Supplementary Figure S2). While the variation in the probability for non-target capture was lower (Supplementary Figure S3), the C-111SW and C-111SE canals tended to have higher probabilities of non-target species capture as well, and L-31WS and L-31WN canals tended to have higher relative probability of non-target captures and lower relative probability of tegu captures (Supplementary Figures S2, 3). These spatial patterns suggest that trap deployment strategies could be refined by removing traps in locations with generally low-tegu and high non-target capture probabilities or optimizing trap and bait combinations in high-activity locations to reduce non-target interference (e.g., C-111SW and C-111SE).

Among non-target species, the hispid cotton rat was by far the most frequently captured, accounting for > 50% of non-target captures (Supplementary Table S2). Hispid cotton rats are generally common in Florida and throughout their range and are

an International Union for Conservation of Nature species of least concern (The IUCN Red List of Threatened Species, 2026) and were released from the traps unharmed. The majority of non-target species, particularly the top two most common, are opportunistic generalist feeders that are likely to be captured with the use of any food bait. However, reducing the number of hispid cotton rat captures would likely significantly increase the amount of time that traps are available for tegus (i.e., not occupied). Eight of the non-target species captured were also non-native or invasive to Florida which were humanely euthanized. These made up 10% of captures ($n = 34$), suggesting that tegu trapping may offer secondary benefits by removing other invasive fauna. Four non-target species of special concern in Florida were captured (Florida box turtle [*Terrapene carolina bauri*], King rail [*Rallus elegans*], Peninsula cooter [*Pseudemys peninsularis*] and Eastern diamondback rattlesnake [*Crotalus adamanteus*]) (Sunquist-Blunden and Montero-McAllister, 2022) comprising 7.04% of non-target captures ($n = 24$). Most were Florida box turtles ($n = 21$); all were safely released without visible harm.

In addition to actual physical captures, we classified traps rendered non-functional by non-target disturbance as a non-target "capture". These accounted for 37% of the 557 total non-target capture events. The 'one real egg, two decoy eggs' treatment had the highest number of both non-target captures and non-target trap disturbances, with trap disturbance rates more than ten times higher than any other treatment (Table 1). We hypothesize that the combination of olfactory cue given by the real egg and visual cue of the two decoy eggs may have attracted species such as raccoons, which attempted to extract the wired wooden eggs, resulting in flipped or triggered traps (Matlack et al., 2006; Piorkowska et al., 2024).

These findings have direct implications for both ongoing tegu control efforts and future early detection rapid response strategies. In rapid response scenarios, deploying medium, single door traps with modifications to decrease escape by smaller individuals, and baiting with three real eggs may maximize tegu capture probability. For long-term management, further research into methods for excluding frequent non-target species, particularly hispid cotton rats, could improve trap availability and efficiency. Although previous studies have found capsaicin treated baits ineffective at deterring non-targets (McBrayer et al., 2023), alternative scents or chemicals or trap modifications may be more effective. Additionally, identifying species with learned behavior that frequently disturb traps (e.g., raccoons) and developing mitigating strategies could enhance tegu trapping success (Rodén-Reynolds et al., 2018). However, non-target captures might also be the result of behaviors and physiological needs unrelated to bait type (Spence-Bailey et al., 2010).

Overall, our study indicates that wooden decoy eggs in traps do not increase tegu capture probability and likely increase the probability of non-target capture or interference. While decoy eggs were tested as a cost-saving alternative to real eggs, the tradeoff in reduced tegu captures and increase in non-target activity may outweigh any financial benefit. By leveraging

ongoing control efforts, we were able to evaluate bait types and trap styles in a real-world context. Our inferences can inform tegu management in other regions where tegu sightings are becoming more frequent (e.g., Georgia, South Carolina; Kissel et al., 2025) and contribute to broader efforts to refine trapping strategies (McBrayer et al., 2023) and understand the sensory mechanisms (e.g., olfactory vs. visual) that drive attraction in tegus (Avery et al., 2016).

Data availability statement

The raw data supporting the conclusions of this article are publicly available at the following DOI: <https://doi.org/10.5066/P13TTGMN>.

Ethics statement

The requirement of ethical approval was waived by National Park Service Institutional Animal Care and Use Committee for the studies involving animals because NPS policies do not require an approved IACUC review for resource management activities like invasive species control. The studies were conducted in accordance with the local legislation and institutional requirements.

Author contributions

AK: Visualization, Formal analysis, Methodology, Data curation, Funding acquisition, Writing – review & editing, Writing – original draft, Conceptualization, Investigation. KD: Funding acquisition, Resources, Writing – original draft, Visualization, Project administration, Conceptualization, Supervision, Data curation, Investigation, Writing – review & editing, Methodology. MS: Funding acquisition, Writing – review & editing, Conceptualization. JH: Resources, Funding acquisition, Writing – review & editing, Supervision, Investigation. CR: Writing – review & editing, Supervision, Resources, Funding acquisition. AY: Supervision, Funding acquisition, Writing – review & editing, Resources, Methodology, Conceptualization, Investigation.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/famrs.2026.1758585/full#supplementary-material>

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