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RESEARCH ARTICLE

Lures do not increase box-trapping success of an endangered felid in South Texas

Ashley M. Reeves[1] | Landon R. Schofield[1] | Alynn M. Martin[2] | Aidan B. Branney[3] | Lindsay A. Martinez[1] | Georgia Harris[1] | Meghan Murphy[1] | Jason E. Sawyer[1]

[1]East Foundation, 200 Concord Plaza Drive Suite 410, San Antonio, Texas 78216, USA

[2]Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, Howe Agricultural Building No. 205, Kingsville, Texas 78363, USA

[3]Warnell School of Forestry and Natural Resources, University of Georgia-Athens, 180 E Green St, Athens, Georgia 30602, USA

Correspondence
Ashley M. Reeves, East Foundation, 200 Concord Plaza Drive Suite 410, San Antonio, Texas, 78216 USA.
Email: areeves@eastfoundation.net

Funding information
East Foundation

Abstract

Live capturing of wildlife is important for research and conservation, but is rife with challenges including animal welfare concerns, resource commitments (e.g., time and effort), and low capture success rates. Such challenges may be especially apparent for species listed under the Endangered Species Act and species whose ecology impacts capture success. Thus, it is important to investigate and implement strategies that can improve the capture success of endangered carnivores while reducing human effort and risk to animals. In the United States, ocelots (*Leopardus pardalis*) are a federally endangered species. To minimize risk to ocelots, capture efforts for research in Texas are limited to box trapping, but capture success is generally low. We tested whether visual and scent lures can increase capture success of ocelots and other co-occurring mesocarnivores with box traps baited with a live bird on a private ranch in the Texas-Tamaulipan thornscrub ecosystem. From December 2023 through April 2024, we used a randomized design and placed visual (hanging compact disc [CD] or shiny ribbon) and scent (civet musk or ocelot urine) lures at a total of 20 box traps and established 5 control traps across 3 temporally and geographically discrete trapping sessions for 75 trapping locations. We used linear regression to assess 2,900 trap nights and found that none of the lures (scent nor visual) impacted capture success of ocelots, bobcats (*Lynx rufus*), or coyotes (*Canis latrans*). Further, lures did not increase or decrease capture of non-target animals. Based on our findings, we cannot recommend the use of CDs, ribbon, civet musk, or ocelot urine as lures to increase ocelot box trapping success, as they did not increase capture success of ocelots or other target carnivores nor decrease captures of non-target species. We suggest that researchers prioritize other strategies to increase capture success (e.g., setting additional traps) rather than the addition of lures we tested.

KEYWORDS

bobcat, box trapping, carnivore capture, coyote, endangered species, ocelot, scent lure, visual lure

Live capture of wildlife is important for research and conservation; however, challenges such as animal welfare concerns, resource commitments (e.g., time and effort), low capture success, and regulatory provisions may exacerbate capture challenges for threatened or endangered species. Direct capture methods aim to live capture individuals for hands-on processing and include the use of hounds and aerial dart immobilization (in felids and larger carnivores; McDonald 2003, McBride 2007, Elbroch et al. 2013, McBride et al. 2016), or box trap, footholds, and neck snares (for the capture of felids and canids; Pruss et al. 2002, Kamler et al. 2008, Webster et al. 2022, Reeves et al. 2024). Indirect methods aim to capture a photo or biological specimen(s) without the physical capture of the individual and include techniques such as camera trapping (Read et al. 2015, Suárez-Tangil and Rodríguez 2017, Ferreras et al. 2018), hair snares (Rounsville et al. 2022, Freund and Bump 2025), or scat transects (Ruell et al. 2009).

Visual, scent, and auditory lures are commonly added to both direct and indirect trapping sets to improve capture success and detection, respectively. The use of lures is well documented for improving detection probabilities of carnivores in camera trapping research (Jordan and Lobb-Rabe 2015, Read et al. 2015, Suárez-Tangil and Rodríguez 2017, Ferreras et al. 2018), but few studies report on the use of lures for live trapping or their associated effects on successful capture (Molsher 2001, Michalski et al. 2007, Monterroso et al. 2022). Visual lures are beneficial for catching the attention of felids and improving the detectability of traps (Kitchener 1991, Tanner and Zimmerman 2012, Cove et al. 2014). Auditory lures, which include playing the calls of a struggling prey animal or sympatric carnivore, are used less (Read et al. 2015). Scent lures, either food or urine based, are commonly used to improve detection probability at camera locations for carnivores across taxa (Guil et al. 2010, Braczkowski et al. 2016, Ferreras et al. 2018, Webster and Beasley 2019, Holinda et al. 2020).

Research projects that require the hands-on collection of biological samples (e.g., tissue biopsy and blood) and fine-scale movement data from mesocarnivores using geospatial positioning system (GPS) or very high frequency (VHF) collars require the use of direct capture methods. However, direct capture methods may be limited for endangered species to minimize health risks for the animal, which can consequently decrease trapping success (Widmer et al. 2017, Palomares Fernández 2018, Caravaggi et al. 2021). As the use of hounds, footholds, and snares can increase risk of severe injury and mortality (Pruss et al. 2002, Way et al. 2002, Iossa et al. 2007, Elbroch et al. 2013, Caravaggi et al. 2021), such methods are often limited in areas where species of conservation concern occur. Using capture techniques that can potentially stress or injure endangered species is often reserved only for when box trapping is not an efficient or viable option (Sahr and Knowlton 2000, McBride 2007). Direct capture utilizing live box traps in combination with bait is widely used across mesocarnivores and large carnivores (Molsher 2001, Ruette et al. 2003, McCarthy et al. 2013, Widmer et al. 2017).

One endangered species in the United States that has received extensive research attention to inform conservation activities is the ocelot (*Leopardus pardalis*; Lombardi et al. 2020, Blackburn et al. 2021, Veals et al. 2022, Sergeyev et al. 2023, Reeves et al. 2024). Ocelots can be captured with a variety of methods, including padded foothold traps, treeing with the use of hounds, and box traps (Crawshaw and Quigley 1989, Widmer et al. 2017, Sergeyev et al. 2023). However, due to ocelots' endangered species status in the United States, federal Endangered Species Act permits prohibit the use of snares or footholds due to risk of injury or other harm to ocelots, and box traps are the only permitted capture technique. Additionally, permitted activities limit the use of foothold traps, snares, or other capture methods for other species in areas where ocelots or their habitats are known to occur, limiting their use for other mesocarnivores in the same system.

Two other mesocarnivores exist in our south Texas study system: bobcats (*Lynx rufus*) and coyotes (*Canis latrans*). Each of the 3 species are comparable in size and utilize similar space and resources with limited, if any, mortality due to predation in this region. Along with monitoring ocelot movements, health, and genetics, assessing partitioning of space and resources between these 3 carnivores is a topic of interest for ocelot recovery (Leonard et al. 2020, Lombardi et al. 2020, Sergeyev et al. 2023), considering current plans to reintroduce ocelots into sites where bobcats and coyotes exist and ocelots do not (Swanson et al. 2025). The only way to effectively evaluate co-occurrence questions is through collar deployment and biological sample acquisition requiring handling. However, due to the limitations on capture methods where ocelots exist, capture methods often used for bobcats and coyotes (e.g., footholds, snares) are prohibited, and it is necessary to use live box traps—which yield lower capture success for each species (Kamler et al. 2002, White et al. 2021).

Ocelot and co-occurring carnivore capture efforts began in southern Texas in the 1980s (Tewes 1986) and are ongoing. Trapping methods have been consistent over the last 4 decades, using live-catch box traps with bait boxes attached that contained a live chicken or pigeon. Capture efforts span 4–6 months (December to May), 7 days per week, with 20–50 box traps equating to ~2,400 to 5,800 trap nights per season. South Texas ocelot research has utilized data collected over decades of capture efforts (Sergeyev et al. 2023, Veals et al. 2022, 2023), due to limited capture success and the elusive nature of the species. In the past 5 years, for example, approximately 4–10 ocelots were captured annually for the 4- to 6-month intensive season (A. Reeves, unpublished data) necessitating the use of long-term data sets. A variety of factors may contribute to low capture rates, including the low number of free-ranging ocelots at study sites in Texas, limitations on trapping methods, frequent by-catch or trap disruption by non-target species, and logistical limitations (manpower, finances, etc.) to conducting trapping.

Despite the substantial efforts to study southern Texas ocelots and co-occurring mesocarnivores through live captures over the last 40 years, there has been no published empirical evaluation of strategies that can improve capture success. One study conducted in the Brazilian Amazon where ocelots were plentiful, utilized box traps and food baits (e.g., bacon) or live bait (e.g., birds), but did not increase capture success with the use of food baits (Widmer et al. 2017). Our aim was to assess whether 2 types of visual lures (compact discs [CDs] and silver shiny plastic ribbons) and 2 types of scent lures (ocelot urine and civet musk [*Civettictis civetta*]) at baited box traps improved the capture rates of free-ranging ocelots (where they are listed as endangered), and co-occurring bobcats and coyotes, in southern Texas (the latter a species notoriously difficult to catch without footholds).

Our hypothesis was that both scent and visual lures would increase capture success. Scent lures would attract more target animals to the area around a trap and thus increase the chance of the animal going into the trap. Shiny visual lures (Cove et al. 2014) placed at a trap opening would attract more animals already in the area of the trap to the trap opening, and therefore into the trap. The purpose of our assessment of lures was to inform future capture efforts of ocelots and co-occurring mesocarnivores by identifying strategies that could increase capture rates of target species and/or reduce capture of non-target species.

STUDY AREA

Our study area was the East Foundation's El Sauz Ranch (113 km^2) in Willacy and Kenedy counties, Texas, USA (Figure 1). The El Sauz Ranch is a private cattle (*Bos taurus indicus*) ranch supporting both ranching operations and wildlife conservation objectives. Located in the Gulf Prairies and Marshes ecoregion (Gould et al. 1960), El Sauz contains estuaries, marshes, tallgrass prairies, coastal live oak forest, and Tamaulipan thornscrub. To bolster native vegetation and remove invasive plant species in prairie habitats, a patch-burn grazing system is used on the property in an experimental context (Fulbright et al. 2023, Zerlin et al. 2024). Outside of anthropogenic treatments of the vegetation community, the landscape is also influenced by hurricanes as a disturbance regime (Zerlin et al. 2024). Hunter effort on the El Sauz Ranch includes removal of non-native invasive wildlife including nilgai antelope (*Boselaphus tragocamelus*) and wild pigs (*Sus scrofa*), with no other wildlife hunting occurring. Most wild ocelots persisting in the United States occur on El Sauz and proximate private lands (Lombardi et al. 2022). Camera (Lombardi et al. 2020, 2022) and live trapping (Leonard et al. 2020, Sergeyev et al. 2023, Reeves et al. 2024) research studies on ocelots began at El Sauz in 2011 and continue today. The climate is described as subtropical to semi-arid, with annual temperatures ranging from 10°C to 36°C (Norwine and Kuruvilla 2007). Rainfall in the region is highly variable; annual rainfall averages 68 cm but in recent years episodic drought has become more frequent (Norwine and Kuruvilla 2007).

METHODS

Capture effort

We captured ocelots, bobcats, and coyotes using modified Tomahawk box traps (Special model 609.5- 42" (L) X 15" (W) X 20" (H) original series rigid trap with a trap door and solid metal trip pan with an overall powder coating; Tomahawk Live Trap Co., Tomahawk, WI, USA). All traps were equipped with a hardware cloth extension bait box, measuring 51 cm

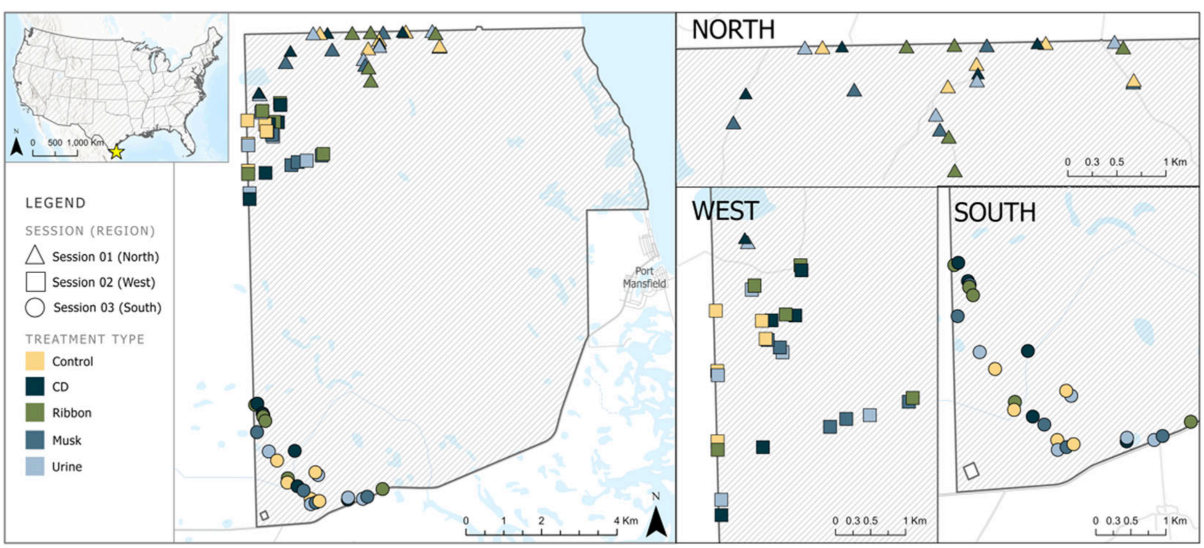

FIGURE 1 Map of East Foundation's El Sauz Ranch, Willacy County, Texas, USA (inset), and the location of traps with the 4 lure treatment types (compact disc [CD], ribbon, musk, and urine) and control across 3 trapping sessions from December 2023 to April 2024 that loosely fall into 3 regions of the ranch: north (1 December 2023–21 January 2024), west (24 January–11 March 2024), and south (18 March–28 April 2024), respectively (main map and zoomed inserts).

x 38 cm x 51 cm (external bait cage for model 109.5/609.5 with sliding door and powder coating; Tomahawk Live Trap Co., Tomahawk, WI, USA), on the distal end of each trap to hold live prey (i.e., a pigeon provided with water and feed *ad libitum*). All bait boxes contained a live pigeon, regardless of lure treatment. Trapping locations were selected within the study area based on ideal habitat for ocelots and bobcats, defined as large patches of woody vegetation with dense cover (Sergeyev et al. 2023), with traps typically placed along game trails. Each trap was covered on all sides, except for the entrance, using vegetation to encourage species to approach the opened trap door only.

A completely randomized design was used via a random number generator that assigned a lure treatment, either visual, scent, or control, to each trap. For scent lures, we used female ocelot urine (since ocelots are our primary target species) or civet musk. Civet musk was chosen due to anecdotal evidence that captively-managed felids are attracted to substances containing this compound during enrichment activities (WCSNewsroom 2010, Cove et al. 2014). The effect of civet musk on bobcats and coyotes in captivity or in the wild has not been studied. Female ocelot urine was chosen due to the potential to attract male ocelots and to not deter female ocelots. The 2 visual lures were chosen due to anecdotal evidence of felids and their attraction to shiny objects (Cove et al. 2014), as well as personal experience of past team members and their use of these items for capturing felids. For visual lures, we selected objects (CDs and silver plastic ribbons) that reflect moonlight and other ambient light and could pique the interest of our nocturnal targets' curiosity. Twenty-five traps were used for the study, with 5 traps per lure type and 5 controls.

We completed 3 geographically and temporally discrete trapping sessions. The trapping sessions loosely corresponded to 3 geographic areas of the ranch, starting on the north side, moving to the west, and concluding in the south (Figure 1). The delineation of trapping sessions (trap session area coverage: ~10.15 km^2 North; ~4.94 km^2 West; ~7.25 km^2 south; total coverage: ~22.34 km^2; Figure 1) was to cover as much of known ocelot home ranges as possible, and use geographically and temporally discrete trapping sessions to minimize daily travel and maintain compliance with permitting (males: 10.55 km^2; females: 3.92 km^2; Lombardi et al. 2022, Smith et al. 2025). Each trapping session comprised ~40 trap nights, and between each session traps were moved and lures reset over 3–5 days at new locations to attempt capture of unique individuals (Andelt 1985, Leonard 2016, Smith et al. 2025). There were 25 traps (5 traps per lure and 5 control traps) in fixed trapping locations for each of the 3 trapping sessions, with a season total of 75 trapping locations from December 2024 to April 2025. Control traps were at a minimum placed greater than 10 meters from lured traps; however, the distance between control traps and lure traps frequently reached 50–100 meters, if not more. Lures were re-randomized when switching trapping sessions. During the entirety of the trapping season, there were an additional 25 traps during each session that were not included in the experiment and analysis. Each of the traps were within 10 meters of an experimental trap, as our trapping efforts routinely used 2-trap stations for ocelot captures. The additional traps were excluded from formal analyses because of their proximity (within 10 meters) to scent-baited traps, as potential lure effects could not be ruled out even though the traps themselves were only baited with a live bird; thus, we could not include them as true controls. True control traps (those without any lure treatment and not paired with a lure treated trap) served as a direct comparison of lure-based traps to traditional box trapping with live bait and no additional lures. For each capture night, traps were opened between 3–7 PM and checked by 8:30 the following morning. The number of captured ocelots, bobcats, coyotes, and other animals in each trap was recorded daily.

Lure setup

Visual lures included a CD hung with clear fishing line, or 1.0–1.5 feet of shiny silver ribbon tied to brush (Figure 2). Visual lures were displayed near the trap entrance at mesocarnivore eye level for optimal visualization and were replaced as needed due to wear from wildlife or the elements. For scent lures, 2–3 mL of Civet Musk-100% Pure Civet Perfume Oil purchased online (Sultan Fragrances, Australia) or female ocelot urine (collected from ocelots in U.S. zoos) diluted with 2–3 mL of distilled water were deposited in 6 mL perforate tube containing 1 cotton ball that

FIGURE 2 Visual and olfactory lure placement in live traps set from December 2023 to April 2024 on El Sauz Ranch, Texas, USA. Compact disc (A) and shiny, silver ribbon (B) placed at eye-level for a medium-sized felid and adjacent to the front of the trap entrance. Civet-musk or female ocelot urine-soaked cotton balls (C) placed in a perforated container and attached to the trap within the pigeon bait box with zip-ties.

helped absorb the fluid and prolong the efficacy of the appropriate scent lure. The tubes were secured via zip tie to the inside of the pigeon bait box, and were refilled every 2–3 weeks, depending on the remaining levels of liquid within the tube (Figure 2). Scent lures were also refilled as needed if the traps were disturbed and the tubes knocked free or emptied. This ensured the scent lure was always actively refreshed and present.

Statistical analysis

We used beta regression models with a logit link to examine the effect of lure type and trapping session on trap success for 4 species groups of interest: ocelots, bobcats, coyotes, and non-target species (Ferrari and Cribari-Neto 2004, Cribari-Neto and Zeileis 2010). Beta regression is appropriate for modeling proportional data bounded between 0 and 1, particularly when the response is continuous, right-skewed, and constrained—as is the case with trap success (captures per trap night; Ferrari and Cribari-Neto 2004, Cribari-Neto and Zeileis 2010). To accommodate exact 0 or 1 values, we adjusted them by ±0.0001. All β values reported are regression coefficients from beta regression models with a logit link, representing changes in the log-odds of trap success relative to the reference category (reported as log-odds estimates in the tables). The β values are often referred to as log-odds estimates and exponentiating them yields odds ratios. For all models, trap success was the dependent variable, defined as the number of animals captured from the target species group divided by the total number of trap nights. Lure type (control, CD, ribbon, musk, urine) and trapping session (session 01 = north, session 02 = west, session 03 = south) were included as fixed effects. We ran 4 separate models—one for each species group (ocelot, bobcat, coyote, non-target species). We fit a fifth model focusing on the most common by-catch species (raccoon, *Procyon lotor*) to assess if lures decreased capture of non-target animals.

Models were implemented in R (R Core Team 2025; R version 4.5.0) using the betareg package (Cribari-Neto and Zeileis 2010). Model fit was assessed using McFadden's pseudo R^2 (McFadden 1974), a likelihood-based measure of explained variance for generalized linear models. We also evaluated model dispersion by examining the precision parameter (φ), with larger values indicating less residual variance in trap success. Model adequacy was assessed via quantile residuals, and we flagged potential outliers as observations with residuals exceeding $|2|$. To evaluate their influence, we conducted sensitivity checks by rerunning models with and without flagged points; outliers were retained in final models if their removal impaired convergence or did not meaningfully change inference.

We calculated log-odds estimates and odds ratios, with 95% confidence intervals for each regression model predicting trap success as a function of lure type and trapping session. We used control traps in session 01 (north region) as the intercept. Odds ratios >1 indicate higher success relative to the intercept, and <1 indicate lower success. Effects were considered statistically significant if the 95% confidence interval of the log-odds estimate did not include 0, or if the odds ratio confidence interval did not include 1.

For descriptive comparison, we referred to previous ocelot trapping efforts repeated annually at this study site from December or January to April. Our previous and subsequent (January–April 2023 and January–April 2025) capture seasons consisted of 50 traps on the same property and in the same general regions with 2 to 3 temporally-spaced sessions. During the 2023 and 2025 seasons, no additional lures other than live pigeons or doves were utilized during our capture effort. Further, we reported activity at traps using camera observations. Both of these data streams were utilized to increase our understanding of lure influence and trap activity but did not provide enough data for a formal analysis.

RESULTS

Capture effort and success

From 1 December 2023, to 28 April 2024, 2,934 trap nights were completed for ocelots, bobcats, and coyotes. Total trap nights per session and captures of target carnivores and nontarget species were recorded (Table 1, Appendix A, Figure 3). Across sessions, 4 ocelots, 9 bobcats, and 11 coyotes, and 184 nontarget animals were caught. In each session, raccoons comprised most non-target captures, ranging from 38.1% to 72.4% of all non-target species captures (Figure 4). A total of 6 ocelots, 15 bobcats, 11 coyotes, and 242 nontarget animals were captured in the 25 traps that were located on the ranch but were not part of the study. A total of 2,524 trap nights in 2023 and 3,779 trap nights in 2025 produced 12 ocelots, 10 bobcats, 5 coyotes, and 216 nontarget animals in 2023, and 14 ocelots, 8 bobcats, 2 coyotes, and 227 nontarget animals in 2025 (A. Reeves, unpublished data). We note these data were not included in the formal statistical analyses but provide a relevant course-scale comparison.

Effect of lure and session

Mean capture rates for carnivore species were low, with <0.5% mean success for each species of interest across the entire season (Sessions 01–03), with 0.17% capture success for ocelots (S.E. = 0.001%), 0.32% for bobcats (S.E. = 0.001%), and 0.39% for coyotes (S.E. = 0.001%; Figure 3). Nontarget trap success was higher overall (6.15% $\bar{x}$ success, S.E. = 0.007%) compared with target species.

For all 3 carnivore species, neither lure type nor trapping session significantly influenced trap success (all $P \geq 0.25$; Table 2). Lure type also did not impact by-catch captures, which showed significant differences only by

TABLE 1 Summary of capture effort and results from the 3 trapping sessions for all lure types and controls from December 2023 to April 2024 on El Sauz Ranch, Texas, USA.

Trapping Session	Trap Nights	Ocelot Captures	Bobcat Captures	Coyote Captures	By-catch Captures
1 (north)	1,016	0	3	7	65
2 (west)	1,020	1	4	0	98
3 (south)	898	3	2	4	21

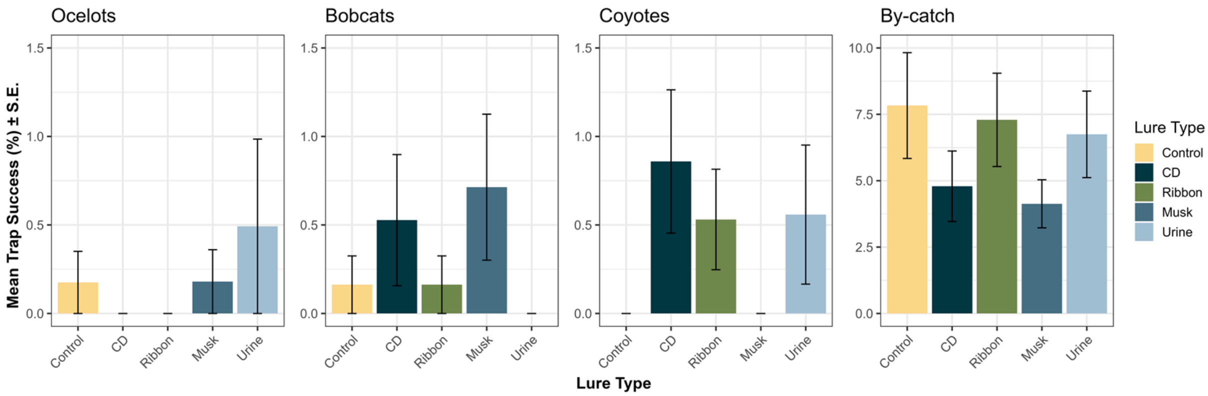

FIGURE 3 Capture success by lure type for target (ocelot [*Leopardus pardalis*], bobcat *[Lynx rufus]*, and coyote *[Canis latrans])* and nontarget species from December 2023 to April 2024 on El Sauz Ranch, Texas, USA. Mean trap success is the total number of captures per number of trap nights as a percentage (with standard error bars). Lure types were control, visual (compact disc [CD] and ribbon), and olfactory (musk and ocelot urine). Nontarget species are presented on a different y-axis limit than the carnivore species.

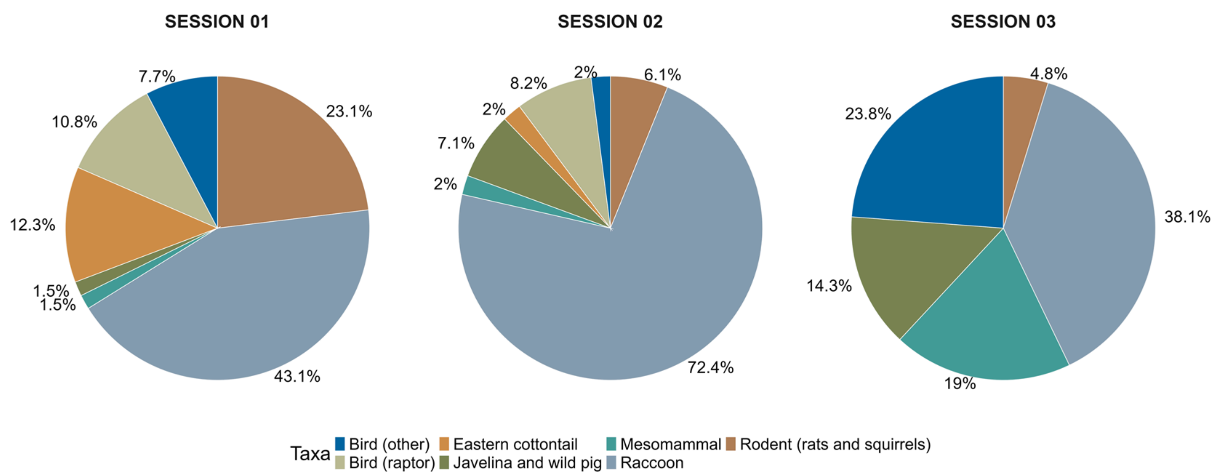

FIGURE 4 Proportion of nontarget species type per trapping session. The 3 trapping sessions (01, 02, and 03) occurred consecutively, with each spanning ~40 nights from December 2023 to April 2024 on El Sauz Ranch, Texas, USA. Sessions also corresponded to different regions of the ranch: north, west, and south, respectively. Not all nontarget species groupings were detected in all sessions. Note: nontarget species (i) bird (other), non-raptor species (green jay [*Cyanocorax luxuosus*], dove and pigeon [family Columbidae]; and thrasher [family Mimidae]); (ii) bird (raptor), hawks (*Buteo* spp.) and falcons (*Falco* spp.), (iii) javelina and wild pig (*Cyanocorax luxuosus* and *Sus scrofa*, respectively); (iv) mesomammals, armadillo (*Dasypus novemcinctus*), striped skunk (*Mephitis mephitis*), American badger (*Taxidea taxus*), and Virginia opossum (*Didelphis virginiana*); (v) raccoon (*Procyon lotor*); (vi) eastern cottontail (*Sylvilagus floridanus*), and (vii) rodent, rats and squirrels.

trapping session; trap success was higher in session 02 (west region; β = 0.73, $P = 0.005$) and lower in session 03 (southern region; β = −0.62, $P = 0.025$) relative to session 01 (Table 2). In the raccoon beta regression model, lure type also did not significantly influence capture rates. While traps baited with musk lure deterring raccoons showed the largest impact of any lure type on a species (β = −0.54, $P = 0.10$), this negative trend was not statistically significant. Trapping session exerted a stronger influence on by-catch, and on raccoons specifically, than any lure treatment. For raccoons, trap success was significantly higher in session 02 (west; β = 1.19, $P < 0.001$), with odds of capture 3.28 times higher than in session 01 (north). Session 03 (south) showed a weak negative trend (β = −0.52, $P = 0.062$).

TABLE 2 Summary of beta regression model results examining the effect of lure type and region on trap success for each species group from December 2023 to April 2024 on El Sauz Ranch, Texas, USA. The reference category for all models was the control trap and Session 01 (north region). Shown are parameter estimates (log-odds scale), 95% confidence intervals, odds ratios, odds ratio 95% confidence intervals, and associated *P*-values. All models were fitted using the betareg package in R.

Species Group	Predictor	Log-odds Estimate (β)	Log-odds 95% CI	Odds Ratio	Odds ratio 95% CI	P-value
Ocelot	Intercept (Lure: Control & Session 01)	−6.358	−7.050, −5.665	0.002	0.001, 0.003	<0.001
	Lure: CD	−0.098	−0.787, 0.591	0.907	0.455, 1.806	0.781
	Lure: Musk	−0.007	−0.694, 0.680	0.993	0.499, 1.973	0.983
	Lure: Ribbon	−0.098	−0.787, 0.591	0.907	0.455, 1.806	0.781
	Lure: Urine	0.033	−0.665, 0.732	1.034	0.514, 2.079	0.926
	Session 02 (west)	0.055	−0.479, 0.590	1.057	0.619, 1.804	0.839
	Session 03 (south)	0.136	−0.403, 0.675	1.145	0.668, 1.963	0.622
Bobcat	Intercept (Lure: Control & Session 01)	−5.771	−6.483, −5.060	0.003	0.002, 0.006	<0.001
	Lure: CD	0.093	−0.600, 0.786	1.097	0.549, 2.195	0.793
	Lure: Musk	0.188	−0.503, 0.880	1.207	0.605, 2.411	0.593
	Lure: Ribbon	0	−0.695, 0.695	1	0.499, 2.004	1*
	Lure: Urine	−0.082	−0.791, 0.628	0.922	0.454, 1.873	0.822
	Session 02 (west)	0.046	−0.491, 0.582	1.047	0.612, 1.79	0.868
	Session 03 (south)	−0.004	−0.547, 0.540	0.996	0.579, 1.715	0.989
Coyote	Intercept (Lure: Control & Session 01)	−5.586	−6.294, −4.878	0.004	0.002, 0.008	<0.001
	Lure: CD	0.399	−0.294, 1.091	1.49	0.746, 2.976	0.259
	Lure: Musk	0	−0.699, 0.699	1	0.497, 2.012	1*
	Lure: Ribbon	0.267	−0.428, 0.962	1.306	0.652, 2.616	0.451
	Lure: Urine	0.204	−0.504, 0.912	1.226	0.604, 2.49	0.572
	Session 02 (west)	−0.305	−0.843, 0.233	0.737	0.43, 1.262	0.266
	Session 03 (south)	−0.076	−0.615, 0.464	0.927	0.54, 1.59	0.783
Nontarget species	Intercept (Lure: Control & Session 01)	−2.819	−3.412, −2.226	0.06	0.033, 0.108	<0.001
	Lure: CD	−0.333	−0.994, 0.327	0.716	0.37, 1.387	0.323
	Lure: Musk	−0.299	−0.959, 0.360	0.741	0.383, 1.434	0.374
	Lure: Ribbon	0.097	−0.546, 0.740	1.102	0.579, 2.096	0.767
	Lure: Urine	−0.090	−0.751, 0.571	0.914	0.472, 1.77	0.79

(Continues)

TABLE 2 (Continued)

Species Group	Predictor	Log-odds Estimate (β)	Log-odds 95% CI	Odds Ratio	Odds ratio 95% CI	P-value
	Session 02 (west)	0.725	0.223, 1.227	2.065	1.25, 3.412	0.005
	Session 03 (south)	−0.619	−1.162, −0.077	0.538	0.313, 0.926	0.025
Raccoon	Intercept (Lure: Control & Session 01)	−3.580	−4.186, −2.974	0.028	0.015, 0.051	<0.001
	Lure: CD	−0.462	−1.108, 0.184	0.63	0.33, 1.203	0.161
	Lure: Musk	−0.542	−1.192, 0.108	0.582	0.304, 1.114	0.102
	Lure: Ribbon	−0.106	−0.736, 0.524	0.899	0.479, 1.689	0.741
	Lure: Urine	−0.016	−0.651, 0.619	0.984	0.521, 1.856	0.96
	Session 02 (west)	1.187	0.681, 1.694	3.278	1.975, 5.439	<0.001
	Session 03 (south)	−0.519	−1.065, 0.026	0.595	0.345, 1.027	0.062

*Estimate unstable due to low sample size ($n \leq 1$).

Model diagnostics indicated varying levels of dispersion across species, as reflected by the precision parameter (φ). All models were estimated via maximum likelihood with 8 degrees of freedom (7 mean model coefficients + 1 precision parameter). Ocelot models showed high precision ($\varphi \approx 150$), suggesting extremely consistent, low trap success across trap sessions and lure types, while bycatch and raccoon models showed lower precision ($\varphi \approx 10$–16), consistent with more variable capture patterns. We evaluated model fit for each species group using McFadden's pseudo-R^2 and identified potential outliers based on quantile residuals. Pseudo R^2 values indicated little explanatory power for the felid models (ocelot and bobcat, $R^2 = 0.06$), low explanatory power for the coyote and by-catch models ($R^2 \approx 0.18$), and relatively strong explanatory power for the raccoon model ($R^2 = 0.35$), particularly given the rarity of capture events. Outliers, defined as quantile residuals > |2| , were rare but plausible. The ocelot, coyote, and bycatch models each had 3 such points, the bobcat model had 6, and the raccoon model had 3. All outliers were retained in final models after confirming that their removal impaired convergence and did not meaningfully alter inference.

DISCUSSION

Free-ranging carnivore capture efforts can present unique challenges associated with difficult terrain, large home range sizes, widespread low-density populations, limited time for capture efforts (e.g., constrained by daily temperature maximums), elusive nature of the species, and nocturnal or crepuscular behavior, all of which can reduce the efficacy of even the most well-designed capture methods (Leonard 2016, Smith et al. 2025). Challenges may be exacerbated in endangered species, which are already rare and for which additional difficulties arise such as smaller capture periods and limitations on the use of capture methods.

The ocelot population on El Sauz was small, with an estimated 36 free-ranging endangered ocelots (17.6 ocelots per 100 km^2; Lombardi et al. 2022) across a 200-km^2 space. Indeed, our efforts to capture free-ranging endangered ocelots in southern Texas over nearly 2,900 trap nights and 120 days resulted in a capture efficiency of 1.4 ocelots/1,000 trap nights. Compared to another study that attempted to capture ocelots in the Brazilian Atlantic Forest Reserve (estimated density of 45.84 ± 5.45 ocelots per 100 km^2; Wolff et al. 2019) with box-traps in which only live bait was successful in their capture had a capture success of 18.5 ocelots/1,000 trap nights (Widmer et al. 2017). The higher density of ocelots in the Brazilian location (within the core of their distribution) compared to in Texas increased the likelihood of ocelot presence and subsequent capture. In our other capture seasons in Texas where live bait was the only lure, we achieved a capture efficiency of 4.75 ocelots/1,000 trap nights in 2023 and 3.7 ocelots/1,000 trap nights in 2025, suggesting the addition of the lures we tested were ineffective at increasing capture success of ocelots or even deterring it. Our findings are not surprising considering others' lack of success in capturing ocelots with anything but live prey (Widmer et al. 2017).

Other co-occurring target mesocarnivores were also difficult to capture; we captured only 9 bobcats and 11 coyotes which correlates to 3.1 bobcats/1,000 trap nights and 3.7 coyotes/1,000 trap nights. Our capture efficiency was 4.0 bobcats/1,000 trap nights during the 2023 season and 2.1 bobcats/1,000 trap nights in 2025, suggesting lures have minimal effect in attracting or deterring bobcats into traps. Bobcats in our study region are estimated to have a density of 25–35 bobcats/100 km^2 (Watts 2015), showing our capture efficiency, which was around 1.5 to 2 times that of ocelots, to be proportional to their higher population density in the region. Compared to previous seasons for coyotes, our capture efficiency was 1.98 coyotes/1,000 trap nights during the 2023 season and 0.5 coyotes/1,000 trap nights in 2025, suggesting lures may increase capture success, though this was not statistically significant in the formal study season. Other studies in Massachusetts using box trapping have achieved a capture rate of 20.1 coyotes/1,000 trap nights utilizing various dead baits (Way et al. 2002), showing our box trapping success rate (with or without lures) is very low relative to other efforts.

Identifying techniques that increase capture efficiency of target animals, reduce nontarget animal capture, and minimize trapping effort would increase the productivity of research and conservation efforts and optimize the use of financial and personnel resources. Conversely, and equally as important, formally identifying ineffective techniques can prevent wasted time, effort, and financial resources by allowing researchers to focus solely on methods that are more likely to succeed.

While other studies have documented the use of lures for capturing carnivores (Boitani and Powell 2012, McCarthy et al. 2013), our study investigates their potential use for the capture of endangered ocelots in southern Texas. We assessed the efficacy of 2 visual lures and 2 scent lures for capturing ocelots and co-occurring mesocarnivore species, bobcats and coyotes in South Texas. First, while we observed target animals visiting the entrance of traps with visual lures, our capture success was not increased as a result of either a CD or shiny ribbon visual lure, despite our hypothesis that visual lures near the entrance of a box trap would entice more target animals into the trap. Additionally, the capture of nontarget species limits the chances of capturing target species; however, visual lures did not impact the capture of nontarget species. Although a previous study concluded that compact discs were effective at attracting ocelots to camera traps (Cove et al. 2014), our results did not support the use of CDs or ribbon as lures for improving box trapping capture rates of ocelots, bobcats, or coyotes, as the lures did not increase capture success of carnivores nor deter by-catch.

For scent lures, our hypothesis was that carnivore scents could attract some target mesocarnivore species to trap areas to investigate the scents while deterring some nontarget species. We predicted both scent lures (ocelot urine and civet musk) would attract felids to the trapping areas, thus increasing the probability of successful capture. However, there was no significant effect of either scent on capture success of any target species. One concern was that scent lures may attract nontarget species, leading to more bycatch and less possibility of target species captures, but the scents had no significant effect on capture of nontarget animals. While not statistically significant, the civet musk lure shows a modest negative trend with capture of raccoons, our most common nontarget species captured, and could be further investigated as a potential raccoon deterrent. One study (Yocom-Russell 2021) found that raccoons were deterred from food sources due to placement of coyote urine; however, neither scent lure utilized in this study had a significant effect on the successful capture of target or nontarget species. Other studies in which olfactory lures were utilized have had mixed results. In some cases, olfactory lures did not influence camera capture success of various mesocarnivores (Jacques et al. 2016), though others have found that scent lures in combination increased detectability (Ferreras et al. 2018), suggesting that combining different scent lures could be useful, but results may be species specific (Holinda et al. 2020).

There were an additional 25 traps located on the ranch, each containing a live bird but no scent or visual lures, during the study timeframe that were not included in the study but, based on anecdotal data, performed about the same as the lured traps. While they were not a formal part of the study, our descriptive comparison indicates little difference between lured (scent or visual) and non-lured traps, with traps capturing slightly more felid species overall over a trapping effort that was comparable (2,866 trap nights for the 25 traps not included in the experiment).

We identified some limitations with the way our scent lures were deployed. First, it is possible that the scents were not strong enough or did not disperse enough to be detected by animals, though the scents were monitored and detected by our field personnel twice daily as they approached each trap for setting and checking (unpublished/ancillary data). Therefore, we believed scents were strong enough for wildlife to smell from a distance. Also, potential marking behaviors of carnivores at scent lures may act as a mask to the lure or may provide a secondary scent that could act as an attractant or deterrent to other sympatric carnivores in the area, both of which could impact the efficacy of the lure. Next, we did not test combinations of lures, where the scent lure may draw the target species to the area and the visual lure may increase activity at the entrance of the trap. Though neither scent nor visual lures increased capture rates on their own, it is possible that a trap with both a scent and visual lure or a combination of scent lures could increase trapping success. Finally, we recognize that our study had a low sample size. Sample-size limitations occurred due to the number of traps we could deploy per capture season and the low densities of the target species, which created low capture rates. Given the results from our experiment, the comparison to other traps used concurrently but outside the experiment, and the extra time and effort required to set up the lures, we were not interested in testing lures for additional capture seasons to increase our sample size.

We also recognize that there are myriad factors leading to the successful capture of a carnivore using the methods we employ, including trap placement and target species ecology, animal hunger at the time of trap encounter, the activity level of the live prey when the carnivore is present, the visualization and curiosity of the animal to engage in chase behavior, and environmental factors (e.g., weather and light conditions). We did not include co-factors in our experiment with lures because of a lack of straightforward measurement methods (for animal hunger and prey behavior) or consistent impact across the experimental treatments (environmental factors on the same trap night). Our ongoing research is investigating environmental factors as predictors of capture success, as studies have shown capture success to be impacted by species-specific activity patterns, temperature, moon phase, and precipitation (Rockhill et al. 2013, Noonan et al. 2015, Widmer et al. 2017). While these factors were outside of the scope of our study, the ongoing investigation is the natural next step to elucidate factors that affect capture success of mesocarnivores in southern Texas.

We demonstrated that visual and scent lures did not increase box trapping capture success of elusive carnivores in southern Texas, and we believe that prioritizing resources and time for trap-area selection and setting more traps baited only with live prey would benefit capture efforts.

CONSERVATION IMPLICATIONS

To inform future ocelot capture efforts necessary for research and conservation activities, we used one season of annual ocelot capture efforts in South Texas as an experiment investigating the impact of visual and scent lures on catching ocelots with box traps. We found that using visual lures (shiny objects) and scent lures (ocelot urine and civet musk) did not increase successful capture rates of ocelots, nor co-occurring bobcats and coyotes. They also did not decrease capture rates of nontarget animals that can disrupt capture efforts targeting ocelots. For others using box trapping to capture ocelots, we do not recommend expending effort setting up any of the visual or scent lures we tested, assuming live bait is being used in the trap. We do recommend that practitioners conduct experiments similar to ours to evaluate if other types of lures or other capture methods can increase the success of capturing ocelots. We are particularly interested in learning if lures can increase ocelot capture rates using foothold traps, which do not require an animal to enter a trap. Wildlife researchers should share empirical evaluations of the efficacy of different lure and trap combinations for difficult-to-capture carnivore species to aid capture efforts in future studies.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ETHICS STATEMENT

All animal use was reviewed and approved by and in accordance with the Institutional Animal Care and Use Committee at Texas A&M University-Kingsville, and the Caesar Kleberg Wildlife Research Institute (Protocol #2023-10-20). The study protocol was also reviewed for permitting under the Endangered Species Act by the United States Fish and Wildlife Service (ESPER0024337-4) and Texas Parks and Wildlife (SPR-0920-122).

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APPENDIX A: SUMMARY OF TRAP SUCCESS BY LURE TYPE ACROSS THE THREE SESSIONS FROM DECEMBER 2023 TO APRIL 2024 ON EL SAUZ RANCH, TEXAS, USA.

Lure type	Species group	Total captured	Mean trap success (%)	S.D.	S.E.
Control	bobcat	1	0.2	0.006	0.002
Control	by-catch	48	7.8	0.077	0.020
Control	coyote	0	0.0	0.000	0.000
Control	ocelot	1	0.2	0.007	0.002
CD	bobcat	3	0.5	0.014	0.004
CD	by-catch	29	4.8	0.051	0.013
CD	coyote	5	0.9	0.016	0.004
CD	ocelot	0	0.0	0.000	0.000
Musk	bobcat	4	0.7	0.016	0.004
Musk	by-catch	25	4.1	0.035	0.009
Musk	coyote	0	0.0	0.000	0.000
Musk	ocelot	1	0.2	0.007	0.002
Ribbon	bobcat	1	0.2	0.006	0.002
Ribbon	by-catch	44	7.3	0.068	0.018
Ribbon	coyote	3	0.5	0.011	0.003
Ribbon	ocelot	0	0.0	0.000	0.000
Urine	bobcat	0	0.0	0.000	0.000
Urine	by-catch	38	6.7	0.061	0.016
Urine	coyote	3	0.6	0.015	0.004
Urine	ocelot	2	0.5	0.018	0.005