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PREDATOR COMMUNITY AND RESEARCHER-INDUCED IMPACTS ON NEST SUCCESS OF RIO GRANDE WILD TURKEYS IN TEXAS

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Abstract: Rio Grande wild turkey (*Meleagris gallopavo intermedia*) populations in Texas appear to be declining, and poor nest success could be contributing to the decline. Techniques to monitor nest success and predator impacts are necessary to make sound conservation decisions. We evaluated nest predator community structure and researcher-induced impacts on success of Rio Grande wild turkey nests and artificial nests at study sites located on the Edwards Plateau and South Texas Plains ecological regions of Texas. During the 2007 nesting season in the Edwards Plateau, we monitored 22 wild turkey nests with digital cameras and 20 without cameras. The presence of the digital camera did not result in higher nest failure rates. To simulate researcher impacts on nests, we compared predation rates of handled and unhandled artificial nests in 2007 and 2008. Predation rates were higher on handled nests in both years. Cameras placed at random, non-baited points captured photos of potential nest predators. Nest predator communities differed between study areas; avian predators were more frequent in the South Texas plains, whereas mammalian predators were more prevalent in the Edwards Plateau. Our results indicate that the presence of cameras alone did not impact wild turkey nests, but active human activities associated with nest surveillance may influence artificial nest failure. Moreover, nest predation could be, to some degree, a random occurrence depending on the nest predator's search image and the predator community present.

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Nest survival (proportion of nests hatching ≥1 young) underlies recruitment for many bird species (Martin 1987, Miller and Leopold 1992, Dinsmore et al. 2002) and therefore is of considerable importance to conservationists and land managers. Predation is the leading cause of nest loss for avian species (Ricklefs 1969) and rates of nest predation typically are high for ground-nesting birds (Ransom et al. 1987, Trevor et al. 1991, Rollins and Carroll 2001). To estimate predation rates of nests without disturbing active nests, researchers have employed artificial nests with mixed results (George 1987, Major and Kendal 1996). Artificial nests may provide accurate surrogates for estimating predation rates of real nests (Gottfried and Thompson 1978, Major 1990, Hernandez et al. 2001), but also can provide biased estimates of nest success (Butler and Rotella 1998, Wilson et al. 1998, King et al. 1999). Typically, artificial nests overestimate predation rates for real nests (Major and Kendal 1996). Increased predation rates on artificial nests often are attributed to human scent associated with researchers checking nests (Whelan et al. 1994) and lack of parental protection of the nest (King et al. 1999). Artificial nests can attract a community of predators that normally would not locate wild nests (Willebrand and Marcstrom 1988), although predators such as snakes typically do not find artificial nests due to lack of heat and the scent of a hen tending to her eggs (Wilson et al. 1998).

A wide variety of studies have used automatically triggered cameras to identify nest predators (e.g., Leimgruber et al. 1994, Picman and Schriml 1994, Dreibelbis et al. 2008). Presence of cameras at the nest may bias results (Hernandez et al. 1997); however, few studies have addressed this bias using real nests for comparison. In a study using live and artificial nests, Herranz et al. (2002) found predators avoided nests monitored with non-camouflaged cameras, but predated nests with camouflaged cameras at the same rate as those without cameras. Both Pharris and Goetz (1980) and Leimgruber et al. (1994) observed no difference in nest predation rates between artificial nests with and without cameras. Use of cameras requires human visitation near nests for maintenance (e.g., changing batteries and video cards), but few studies explicitly have evaluated the effects of human observers on nest survival and those completed yielded conflicting results (Gottfried and Thompson 1978, Major 1990, Ortega et al. 1997).

Ground-nesting species, such as wild turkeys (*Meleagris gallopavo*), are influenced by nest predation given the host of potential predators and vulnerability of their nests. Predation is the primary cause of nest failure for wild turkeys across their range (e.g., Cook 1972, Speake 1980, Vangilder et al. 1987, Randel et al. 2005, Dreibelbis et al. 2008), and nest loss can influence population growth (Davis 1959, Baker 1978, Roberts and Porter 1996). Rio Grande wild turkey populations in Texas appear to be declining (Collier et al. 2007a, b, Dreibelbis et al. 2008, Collier et al. 2009) and documented nest success has been low (<30%; Melton 2007, Dreibelbis et al. 2008). Therefore, techniques to estimate nest predation rates are necessary to make sound conservation decisions. Because nest predation influences population trajectories of wild turkeys in Texas, and because of conflicting results regarding camera effects, artificial nest reliability, and observer effects on nest survival, we evaluated the effects of cameras and human activity on Rio Grande wild turkey (*Meleagris gallopavo intermedia*) nests and artificial wild turkey nests in 2 regions of Texas: the Edwards Plateau and South Texas Plains (Gould 1975).

STUDY AREAS

We conducted research in the Edwards Plateau (2007) and South Texas Plains (2008) regions of Texas (Gould 1975) from January through July of 2007 and 2008 on study sites in Kerr and Bandera counties (Edwards Plateau) and Jim Wells and Duval counties (South Texas Plains) of Texas. Sites in Kerr and Bandera counties were characteristic of Edwards Plateau topography—rolling divides with limestone bedrock and outcrops with rocky soils (Gould 1975). This region previously was a fire-evolved grassland savannah interspersed with live oaks (*Quercus virginiana*) and mesquite (*Prosopis glandulosa*), with Ashe juniper (*Juniperus ashei*) along sheltered outcroppings (Taylor and Smeins 1994). Fire suppression and grazing concomitant with settlement gradually converted the area to brush land and open woodland consisting primarily of live oak mottes and Ashe juniper thickets. Our study sites included a corporate-owned cattle ranch (8,858 ha) along the Medina River and the Kerr Wildlife Management Area (Texas Parks and Wildlife Department; 2,627 ha) near Hunt, Texas. Both sites were managed for cattle production and hunting of both native and exotic species; rotational cattle grazing occurred on both sites.

Our South Texas Plains region study sites included La Copita Research Ranch in Jim Wells County and a private ranch in Duval County. La Copita Research Ranch (1,103 ha) is owned by the Texas A&M University System and was managed as an experimental rangeland. The private ranch (5,261 ha) is located ~20 km NW of San Diego, Texas, and was managed intensively for hunting of native species with limited seasonal cattle grazing. Vegetation communities consisted of upland savanna parklands and closed canopy woodlands in lowland drainages. Woody plant species in both study areas included blackbrush acacia (*Acacia rigidula*), honey mesquite (*Prosopis glandulosa*), live oak, hackberry (*Celtis* spp.), and Texas persimmon (*Diospyros texana*). Herbaceous species on the study sites included thin paspalum (*Paspalum setaceum*), fringed signal grass (*Brachiaria ciliatissima*), red grama (*Bouteloua trifida*), and coastal sandbur (*Cenchrus incertus*; Archer 1990).

METHODS

We trapped wild turkeys on the Edwards Plateau site from January through March 2007 and on the South Texas Plains site from January through March of 2008 using drop-nets and modified walk-in traps baited with milo (Glazener et al. 1964, Peterson et al. 2003). Each captured individual was fitted with a mortality-sensitive, backpack-style radio-transmitter (69.0–95.0 g; Advanced Telemetry Systems, Isanti, Minnesota, USA) and a uniquely numbered Texas Parks and Wildlife Department aluminum leg band. We located hens ≥3 times weekly during the breeding season until behavioral shifts suggested nest site selection and incubation had begun. We flushed each hen once from the nest so we could collect nest-specific data (e.g., clutch size, nest location). Because wild turkeys lay approximately 1 egg per day, we estimated date of nest initiation by subtracting the number of eggs in the nest from the approximate date when incubation began (Badyaev 1995).

In the Edwards Plateau region, we allocated nests to experimental groups where every other nest was either a treatment (monitored by a motion-sensor digital trail camera; Moultrie Outfitter Cam, Moultrie Feeders, Alabaster, Alabama, USA) that was not revisited until hatching, predation, or abandonment of the treatment wild turkey nest or a control (left without a camera) group. Within the treatment group, after a treatment nest was equipped with a camera (treatment = camera), we placed 3 additional cameras in the same pasture at randomly generated points. To prevent monitoring activities from attracting predators to experimental nest sites, we established a 150-m buffer around each treatment wild turkey nest to ensure independence (i.e., so activities associated with monitoring actively nesting hens at one nest site would not influence fate of experimental nest sites). At 2 of the 3 random points, we constructed artificial nests within 5 m of randomly selected points in habitat we subjectively classified as nesting substrate (based on our monitoring of 162 live nests in this study region between 2005 and 2007; Collier et al. 2007b, Dreibelbis et al. 2008, Collier et al. 2009). Artificial nests were constructed using 4 unwashed chicken eggs. The first artificial nest site was treated exactly as the treatment wild turkey nest and not revisited. The second artificial nest site was equipped with a camera; however, we approached this nest as if we were conducting a nest check each time the study site was visited (once every 2 days). At the final random point, a camera was placed without an artificial nest and was not revisited until hatching, predation, or abandonment of the associated treatment wild turkey nest. Upon a treatment nest hatching or failure, all cameras within that experimental group were collected and events up to that point determined.

Due to a low number of attempted nests ($n = 5$) in the South Texas Plains region during the drought of 2008, we modified the artificial nest study design. We selected 7 pastures containing nesting habitat on the private ranch as our study area. We constructed 5 artificial nests (using 4 unwashed chicken eggs/nest) within 5 m of randomly selected points in habitat we classified as nesting substrate within each pasture. We placed trail cameras on the first 2 treatment nests; the first nest was approached and handled every 2 days, whereas the second was not revisited following the 2008 protocols. In addition, we also placed 2 artificial nests without cameras in the same fashion where one was checked every 2 days and the other was not. Finally, we placed a digital video camera on the final artificial nest and only walked within 45 m to change batteries and memory cards every 3rd day. We replicated the above design 4 times over the 2008 breeding season. We approached and constructed all artificial nests in both study years wearing leather boots and without gloves, making no attempt to disguise human scent.

Table 1. Candidate models[a] used to examine the difference in daily nest survival between nest types during the 2007 Edwards Plateau nesting season (DSR = daily survival rate, T1 = wild turkey nest without camera, T2 = wild turkey nest with camera, A1 = artificial nest not handled, A2 = artificial nest handled regularly, R = Camera overlooking random point without eggs).

Model	No. of parameters	Deviance	ΔAIC_c	w_i
$DSR_{T1=A1\neq T2=A2\neq R}$	3	352.62	0.00	0.521
$DSR_{T1=T2=A1=A2\neq R}$	2	356.40	1.77	0.215
$DSR_{T1\neq T2\neq A1\neq A2\neq R}$	5	352.07	3.51	0.090
$DSR_{T1=T2\neq A1=A2\neq R}$	3	356.30	3.68	0.083
$DSR_{T2\neq A2\neq T1=A1=R}$	3	357.15	4.53	0.054
$DSR_{T2\neq A1\neq T1=A2=R}$	3	360.27	7.65	0.011
$DSR_{T1\neq T2\neq A1=A2=R}$	3	360.27	7.65	0.011
$DSR_{\text{days on nest}}$	2	364.38	9.74	<0.01
$DSR_{T1=T2=A1=A2=R}$	1	366.46	9.81	<0.01
$DSR_{A1=A2\neq T1=T2=R}$	2	365.89	11.25	<0.01
$DSR_{T1\neq T2=A1=A2=R}$	2	366.31	11.67	<0.01
$DSR_{T1\neq A2\neq T2=A1=R}$	3	365.13	12.51	<0.01
$DSR_{A1\neq A2\neq T1=T2=R}$	3	365.13	12.51	<0.01
$DSR_{T1\neq A1\neq T2=A2=R}$	3	366.20	13.58	<0.01

[a] Minimum -2lnL = 352.6185.

Data Analysis

We estimated daily nest survival for nests of each experimental group using the nest survival approach (Dinsmore et al. 2002) in program MARK (White and Burnham 1999). We used an information theoretic approach to model selection and assessed model strength based on AIC_c and Akaike weights (w_i; Burnham and Anderson 2002). When we found evidence of model selection uncertainty ($w_i < 0.8$; Mong and Sandercock 2007), we used multimodel inference and provided model-averaged estimates of survival (Burnham and Anderson 2002).We developed a set of candidate models specific to describing differences in nest loss for each experimental group in our camera study (Tables 1, 2). We only considered daily nest survival models with constant survival because our relatively small sample of experimental nests limited the complexity of the models we could evaluate. Our models were based on a priori hypotheses

Table 2. Candidate models[a] used to examine the difference in daily nest survival between nest types during the 2008 South Texas Plains nesting season (DSR = daily survival rate, T1 = wild turkey nest without camera, A1 = artificial nest not handled, A2 = artificial nest handled regularly, A3 = artificial nest with camera handled regularly, A4 = artificial nest with video camera).

Model	No. of parameters	Deviance	ΔAIC_c	w_i
$DSR_{T1\neq A1=A4\neq A2\neq A3}$	4	382.93	0.00	0.749
$DSR_{T1=A1=A4\neq A2=A3}$	3	387.63	2.68	0.262
$DSR_{T1\neq A1=A4\neq A2\neq A3}$	3	390.90	5.95	0.038
$DSR_{T1=A1=A4\neq A2=A3}$	2	395.60	8.63	0.009
$DSR_{T1=A1=A2=A3=A4}$	1	399.20	10.22	0.005
$DSR_{T1\neq A1=A2=A3=A4}$	2	398.65	11.68	0.002

[a] Minimum -2lnL = 382.9258.

Table 3. Predators photographed at different nest types during Edwards Plateau camera study (n = number of nests where predator species were identified from photographs).

Predator	Wild turkey nest with camera ($n = 7$ nests)	Artificial nest, not handled ($n = 6$ nests)	Artificial nest, handled ($n = 6$ nests)	Camera with no bait ($n = 6$ nests)
Collared peccary (*Pecari tajacu*)	0	0	0	2
Common raven (*Corvus corax*)	3	2	4	0
Coyote (*Canis latrans*)	0	0	0	2
Feral hog (*Sus scrofa*)	1	0	1	3
Gray fox (*Urocyon cinereoargenteus*)	1	0	0	1
Nine-banded armadillo (*Dasypus novemcinctus*)	1	0	0	0
Porcupine (*Erethizon dorsatum*)	0	0	1	0
Raccoon (*Procyon lotor*)	3	0	2	0
Western scrub jay (*Aphelocoma californica*)	0	1	1	0
Western spotted skunk (*Spilogale gracilis*)	0	1	0	0

regarding nest loss, differences between handled and unhandled nests, and differences between live and dummy nests, as well as models that accounted for the amount of time a hen spent on the nest before the nest was included in the study (e.g., before it had a camera put into place; Table 1). Note that our model set for our 2008 South Texas experiment was smaller because we had fewer live nests ($n = 5$) and were unable to use the exact design used during the 2007 Edwards Plateau study.

RESULTS

We found that 19 of 22 (86%) wild turkey nests with cameras failed as compared to 17 of 20 (85%) wild turkey nests without cameras in the Edwards Plateau study area and 4 of 5 (80%) wild turkey nests in the South Texas Plains. After removing abandoned nests from the Edwards Plateau data (with camera = 5; without camera = 3), nest failure due to predation was identical (14/17). Artificial nests handled regularly failed more frequently than artificial nests that were not handled in both study areas (68% and 50%, respectively, for the Edwards Plateau; 71% and 46%, respectively, for South Texas Plains). Moreover, 27% of cameras at random points without eggs captured images of potential nest predators, which we considered an analogue to nest failure.

The most common nest predators photographed in the Edwards Plateau study were common ravens (*Corvus corax*), raccoons (*Procyon lotor*), and feral hogs (*Sus scrofa*), in that order, and each predator species had a different preference for particular nest types (Table 3). The most common nest predators photographed in the South Texas Plains study were green jays (*Cyanocorax yncas*), crested caracaras (*Caracara cheriway*), and nine-banded armadillos (*Dasypus novemcinctus*; Table 4).

Model-averaged nest daily survival estimates from our Edwards Plateau study area based on the best approximating model ($DSR_{T1=A1\neq T2=A2\neq R}$, where DSR = daily survival rate, T1 = wild turkey nest without camera, T2 = wild turkey nest with camera, A1 = artificial nest not handled, A2 = artificial nest handled regularly, R = Camera overlooking random point without eggs; Table 1) for daily nest survival partitioned nests into 3 groups: (1) control (no camera) and artificial nests that were unhandled (0.9066; unconditional SE = 0.0205), (2) treatment and artificial nests that were handled (0.8659; unconditional SE = 0.0285), and (3) random points with cameras (0.9629; unconditional SE = 0.0188). Model averaged estimates from our South Texas study based the best approximating model ($DSR_{T1\neq A1=A4\neq A2\neq A3}$, where DSR = daily survival rate, T1 = wild turkey nest without camera, A1 = artificial nest not handled, A2 = artificial nest handled regularly, A3 = artificial nest with camera handled regularly, A4 = artificial nest with video camera; Table 2) on nests partitioned into 4 groups: (1) control nests (no camera; 0.9238; unconditional SE = 0.0177), (2) artificial nests that

Table 4. Predators photographed at different nest types during South Texas Plains camera study (n = number of nests where predator species were identified from photographs).

Predator	Artificial nest, not handled ($n = 5$)	Artificial nest, handled ($n = 15$)	Video camera ($n = 9$)
American badger (*Taxidea taxus*)	0	1	0
Bobcat (*Lynx rufus*)	0	1	0
Common raven (*Corvus corax*)	1	1	1
Coyote (*Canis latrans*)	0	1	0
Crested caracara (*Caracara cheriway*)	1	4	1
Green jay (*Cyanocorax yncas*)	1	6	3
Nine-banded armadillo (*Dasypus novemcinctus*)	1	3	1
Opossum (*Didelphis virginiana*)	1	0	0
Raccoon (*Procyon lotor*)	0	1	1
Spotted ground squirrel (*Spermophilus spilosoma*)	0	1	0
Western indigo snake (*Drymarchon corais*)	0	1	1

Table 5. Percentage of nest failures for each treatment ($n = 7$/replication) during 4 replications of the 2008 South Texas artificial nest project. Seven pastures were used for each replication and each pasture contained 5 artificial nests with each treatment.

Treatment	% nest failures			
	Replication 1	Replication 2	Replication 3	Replication 4
No camera	57.1	42.9	42.9	57.1
No camera, visited	71.4	100.0	57.1	100.0
Camera	28.6	42.9	42.9	57.1
Camera, visited	42.9	71.4	42.9	85.7
Video camera	71.4	57.1	42.9	42.9

were unhandled (0.9665; unconditional SE = 0.0103), (3) treatment nests with cameras that were handled (0.8686; unconditional SE = 0.0267), and (4) treatment nests without cameras that were handled (0.9494; unconditional SE = 0.0142).

DISCUSSION

Artificial nests were less likely to fail than live nests in our study regardless of whether a camera was used. Our results contrast with those in most published studies, which found artificial nests failing at greater rates than live nests (Major and Kendal 1996). Our estimates of daily survival for the Edwards Plateau experimental groups, however, indicated little support for the model equivalent to our descriptive results (DSR $_{A1=A2\neq T1=T2=R}$; Table 1). Rather, model selection suggested that unhandled artificial nests were lost at the same rate as control nests (wild turkey nests without cameras), whereas handled artificial and treatment nests (wild turkey nests with cameras) were lost at an equal or higher rate than unhandled and control nests. An equal percentage of control and treatment nests failed via predation; however, the loss rate differed between these 2 groups as treatment nests exhibited lower survival probability over a 28-day incubation period (0.0177) than did control nests (0.064). Results from our South Texas Plains study (Table 5) provide similar evidence to that found in the Edwards Plateau. Our estimate of daily survival based on the best approximating model (DSR $_{T1\neq A1=A4\neq A2\neq A3}$) suggests that live nest survival differed from unhandled artificial nests, and that handled artificial nests had lower daily survival than unhandled artificial nests.

We suggest that the low number of live wild turkey nests during the South Texas Plains study was due to poor reproductive conditions during 2009 (drought), which is known to limit wild turkey nest initiation rates (Collier et al. 2009). During the 2010 nesting season, categorized as a high precipitation year, we have had 100% nest initiation rates by hens and >75% successfully hatched nests. Thus, the low number of live nests during 2009 was due to variable reproductive activity due to drought rather than other biological factors.

Protocols for data collection at control and treatment nests differed only in the use of cameras, so our results indicate that cameras negatively impacted nest survival of Rio Grande wild turkey hens. Our results contrast with those of Pharris and Goetz (1980) and Leimgruber et al. (1994) who found that cameras had no effect on nest success. Similarly, Herranz et al. (2002) found that cameras that were not camouflaged repelled predators. Additionally, 27% of the cameras that we placed at random points without eggs photographed known nest-predator species. As expected, estimates of daily nest survival were much higher for randomly located camera locations without eggs; however, the frequency of predator activity at these locations supports the contention that cameras, or at least the action of setting up cameras, can draw nest predators to camera locations (Hernandez et al. 1997). Whether predators photographed at random points without eggs were just passing by, investigating the camera, following our scent, or following trails in the vegetation made by researchers is unknown. Regardless, event frequency at these random points implies that predation of nests within this system could be, to some degree, a random process tied to the specific search image of the predator (Wilson and Cooper 1998).

Attracting predator species that typically would not predate an active nest is a concern for those conducting studies using artificial nests (Major and Kendal 1996). Avian species often are reported as unnatural nest predators in artificial nesting studies (Willebrand and Marcstrom 1988) and, given the vegetative communities on our South Texas Plains study site (brush lands with low canopy cover), we expected more predation from avian species on our artificial nests. This hypothesis seemingly was verified in the South Texas Plains study, as the 2 most common artificial nest predators were green jays and crested caracaras (Table 4). However, on the Edwards Plateau, treatment nests and handled artificial nests were predated actively by raccoons (Table 2), the most frequent nest predator in the region (Schwertner et al. 2004), whereas unhandled artificial nests and random camera points were unvisited by raccoons. Thus, we hypothesize that raccoons might follow trails or movement (hen or human) into nesting areas (Picman and Schriml 1994). Results from both study areas show that a wide variety of species predate wild turkey nests and nest predator communities seem to vary depending on geographic location.

Given the importance of sound nesting studies to avian conservation, it is imperative that researchers and conservation biologists understand the reliability and consequence of methods such as artificial nests and automatically triggered cameras. There is evidence, based on our replicated studies in 2 different ecosystems during 2 different years, that camera effects are additive to effects of nest disturbance, but cameras seem to have stronger negative impacts on artificial nests than on live nests.

Summary and Implications

Digital cameras are used to study nesting ecology of many avian species because they allow researchers to monitor nests without disturbing nesting birds. Artificial nests also have several advantages to researchers who study avian productivity related to time, cost, and labor (Butler and Rotella 1998). Based on our results, however, we suggest that cameras and/or repeated human activity around nests locations may increase nest loss, at least for Rio Grande wild turkeys in our study areas. If artificial nesting studies do not predict predation reliably, or if nest camera use negatively influences avian nest survival, then their use should be limited to stable or increasing populations. Moreover, artificial nests may bias loss rates low compared to true estimates of nest predation. Future research addressing the use of digital cameras and artificial nests should incorporate a detailed examination of how predator movements and search image (Miller and Leopold 1992) vary among species in the predator community.

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