FACTORS INFLUENCING NEST SURVIVAL OF WHITE-TIPPED DOVES IN THE LOWER RIO GRANDE VALLEY, TEXAS

A Thesis

by

JORDAN CLARENCE GIESE

Submitted to the College of Graduate Studies of
Tarleton State University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Chair of Committee,	Heather A. Mathewson, Ph.D.
Committee Members,	Jeffrey B. Breeden, Ph.D.
	T. Wayne Schwertner, Ph.D.
Head of Department,	T. Wayne Schwertner, Ph.D.
Dean, College of Graduate Studies,	Barry D. Lambert, Ph.D.

December 2016

Major Subject: Agricultural and Natural Resource Sciences

ACKNOWLEDGEMENTS

I thank Texas Parks and Wildlife and Tarleton State University for funding this research; my committee, H. Mathewson, T.W. Schwertner and J. Breeden. Special thanks to J. Meik for assistance with statistical analyses. The project was possible only through the direct involvement and cooperation of agency personnel,: S. Oldenburger, J. Stout, J. De Leon; Estero Llano Grande State Park for housing and access to their beautiful park; J. Hall, J. King, C. McGregor, K. Mote, and D. Wilcox for their hard work as technicians. I would also like to thank my loving family and friends for their support during my 2.5 years at Tarleton. Although it's just a stop in the journey, I've made lifelong friends and memories in Stephenville.

ABSTRACT

Giese, Jordan C., Factors influencing nest survival of white-tipped doves in the Lower Rio Grande Valley, Texas, MASTER OF SCIENCE (Agricultural and Natural Resource Science), December, 2016. 64 pp., 8 tables, 7 figures.

The white-tipped dove (*Leptotila verreauxi*) is a sedentary, secretive columbid that ranges from Argentina to the Lower Rio Grande Valley (LRGV) of south Texas. Since its designation as a game species in 1984, little research has been dedicated to the species' reproductive ecology. My objectives were to (1) identify predators of white-tipped dove eggs and nestling, (2) determine how the predator community differs among land cover types, (3) examine the impact of vegetation and landscape variation in both citrus and woodland land cover types on nest survival, (4) examine the impact of temporal variation on nest survival, (5) provide information on general nest ecology that is currently lacking, (6) investigate movements of doves and examine feasibility of tracking and recapture using a GPS/VHF transmitters pilot study. During the summers of 2015 and 2016, I conducted nest searches in citrus and woodland sites in Hidalgo County, Texas. I placed real-time, infrared emitting camera systems on a subset of nests to monitor predation. I also trapped, banded, and placed backpack transmitters on doves in Estero Llano Grande State Park (ELGSP) In the 2 years, I located 63 dove nests, 34 in citrus and 29 in woodlan. I placed camera systems on 33 nests and identified 9 species of nest predator. Green jays (*Cyanocorax incas*) were our most common nest predator, accounting for 10 of 28 predation events. Other predators were crested caracara (*Caracara cheriway*), Harris's hawk (*Parabuteo unicinctus*), great-tailed grackle (*Quisicalus mexicanus*), tawny crazy ant *(Nylanderia fulva*), rat (*Rattus* spp.), opossum (*Didelphis virginiana*), house cat

(*Felis catus*), and Texas indigo snake (*Drymarchon melanurus erebennus*). Based on AIC candidate model selection, I identified nest stage as the best predictor of daily nest survival rate across both land cover types. By separating land covers for a second step to model selection, I identified different environmental variables as predictors of daily survival rate in each land cover type. In the woodland site, my null model was most important, indicating that no measured variables were important for predicting nest survival. In citrus, canopy cover was the top model. In citrus, a diverse predator community due to heavy human disturbance may have increased the importance of canopy cover and other concealment variables for nest survival. The different predator communities they encounter in the two land cover types that they nest in prioritize much different environmental conditions for nest survival.

TABLE OF CONTENTS

LIST OF GRAPHICS

TABLE **Page**

FIGURE **Page**

CHAPTER I

INTRODUCTION TO SPECIES

There are 289 species of dove and pigeon throughout the world, collectively making up the family Columbidae (Goodwin 1983). At face value, columbids are characterized by limited flying prowess, helpless nestlings, weak beaks, and small clutches of eggs. Despite also being highly edible and hunted by all kinds of predators, columbids have proven extremely adaptable. Researchers can attribute their success to this physical and biological adaptability. For example, if circumstances are unfavorable, eggs and young are expendable due to the ability to recover with short incubation and fledging periods (Baskett et al. 1993).

Ten columbid species currently reside in the state of Texas, of which 3 are considered game species: the mourning dove (*Zenaida macroura*), the white-winged dove (*Z. asiatica*), and the white-tipped dove (*Leptotila verreauxi*) (Taylor et al. 2006). The mourning dove is the most abundant and widespread North American gamebird. It is harvested more than all other migratory gamebirds combined (Baskett et al. 1993). The 2015 state harvest of mourning doves totaled 5,199,400 birds by 276,800 hunters. White-winged doves totaled 1,767,900 birds by 130,400 hunters (Raftovich and Wilkins 2015). There was less certainty in harvests of white-tipped doves; estimates range from 5,000 to 209,924 individuals annually (Texas Parks and Wildlife Department 2010, Purvis 2013).

The white-tipped dove is a widely distributed new world species that does not migrate. The first Texas documentation occurred in 1878 and they were considered common in 1923 (Bent 1932). They have been documented from eastern Argentina and southern Brazil, throughout the Americas, and into south Texas. In Texas, they have been historically identified in the southern counties of Cameron, Hidalgo, Starr, and Willacy. Boydstun and DeYoung documented them in Zapata, Brooks, Kenedy, and Webb counties additionally (1985). Occurrences outside of their traditional range have been reported by various sources, suggesting their range may be expanding north (Waggerman et al. 1994, Rappole et al. 2011).

Dove hunting has great economic impact on the state of Texas. Texas dove hunters make up 25% of the nation's total dove hunting community and generate over $200 million in economic impact annually. A recognized 460,000 dove hunters in the state spend an average of $438 per capita. Hunting effort for doves trails only white-tailed deer (*Odocoileus virginianus*) (Johnson and Polk 2004). Most hunting in Texas requires the use of private property, which makes up 94% of state land. Texas Cooperative Extension estimates that approximately $368 million annually goes to landowners for hunting rights (Johnson and Polk 2004). Additionally, Texas hunters have contributed over $4.3 billion to conservation of wildlife since 1939 (Roberson 2004).

Texas first opened hunting of white-tipped doves in 1984 (Case and Hughes 2011). The Texas Parks and Wildlife Department has maintained the same daily bag limit of 2 birds per hunter since then (Texas Parks Wildlife Department 2014). Little research has been conducted in the last 30 years resulting in a lack of strategic management and planning. White-tipped doves are not detected frequently enough during the Breeding Bird Survey, Dove Call-count Survey, or Texas Parks and Wildlife Department Urban Dove Survey to estimate abundance (Case and Hughes 2011). Mourning doves and white-winged doves are both managed based on federal and state initiatives that ensure sustainable harvest (National Mourning Dove Planning Committee 2003). Similar goals for white-tipped dove harvest cannot be met without a better understanding of abundance, survival, recruitment, and biology of the species.

Bird watching is a growing interest in the United States. In 2011, an estimated 46,741,000 bird watchers spent almost $41 billion in the U.S (U.S. Department of the Interior et al. 2011). Bird watching is recognized as the second fastest growing pastime in the country. In Texas, hunters comprise only 9% of the population while non-consumptive users make up 32% (Adams et al. 1997). More than 600 species of birds have been documented to occur in Texas, and the highly diverse Lower Rio Grande Valley (LRGV) of south Texas provides nesting habitat for 170 species (Brush 2005).

In 2011, the U.S. Fish and Wildlife Service designated white-tipped doves as a priority species for research along with band-tailed pigeons (*Patagioenas fasciata*), zenaida doves (*Zenaida aurita*), and scaly-naped pigeons (*P. quamosal*) (Case and Hughes 2011). The authors pointed to a lack of adequate knowledge of white-tipped dove population abundance and distribution, vital rates, and movements and dispersal in south Texas. They also mentioned the need for research on aspects of life history, nesting, and biology in order for managers to be able to effectively manage the species and its habitat. Studies focusing on nesting habitat requirements and factors that influence nesting success would provide habitat managers with vital information.

Nesting success has been studied more extensively than any other aspect of avian breeding ecology (Best and Stauffer 1980). Avian nesting success is influenced by many factors; the influence of habitat characteristics on nesting success is of particular interest because these factors can be manipulated by managers to provide suitable breeding habitat (Martin 1992). In a small sample size, Hayslette et al. (2000) found white-tipped doves preferred taller nest sites with more canopy coverage than mourning doves and white-winged doves. Both of these habitat variables can be manipulated if further evidence supports the notion that white-tipped doves are selective of mature, enclosed vegetation.

Boydstun and DeYoung (1985, 1987, 1988) conducted the majority of the published research on white-tipped doves in south Texas. Their reproduction study focused on nesting success during the incubation and nestlings periods. They found birds nesting in a variety of plant species including those found in citrus groves. Their nesting work provided baseline data for reproductive success of white-tipped doves. They suggest that further research is needed on nesting success by habitat type (Boydstun and Deyoung 1987). To measure movements, they used VHF (Very High Frequency) radio transmitters over a 9-month period. The found mediate home ranges to be 6.38 to 7.12 hectares. The largest maximum linear distance observed was 1.86 km. (1988). These data suggest white-tipped doves are relatively sedentary.

Hayslette et al. (2000) augmented previous nesting research with a reproduction study that was primarily focused on mourning doves and white-winged doves in the LRGV. They found white-tipped doves to be more selective than their contemporaries, requiring taller habitat with higher canopy coverage. They also preferred to nest in Texas sugarberry (*Celtis laevigata*) and Texas ebony (*Pithecellobium ebano*). Egg and fledgling densities were positively correlated with foliage density (Hayslette et al. 2000). This research, conducted from 1994 to 1995, is the most recent done on white-tipped doves.

Effect of predation on nesting success and the identity of nest predators of white-tipped doves is extremely understudied. High densities of great-tailed grackles (*Quisicalus mexicanus*) was not found to influence reproduction (Hayslette et al. 2000), but mourning dove nests have been found to be extremely vulnerable to predation by avian and mammalian predators (Best and Stauffer 1980, Yahner 1983). This factor has not been researched in respect to white-tipped dove nests. Developing a more thorough understanding of how habitat fragmentation impacts predators can help to develop sound conservation and management strategies (Chalfoun et al. 2002). Effects of seasonal and climactic factors on nesting success of white-tipped doves have also never been analyzed.

The LRGV is fragmented due to agricultural and urban development. An estimated 95% of native vegetation in the LRGV has been destroyed, resulting in isolated remnants of once continuous woodland (Collins et al. 2010). The effect of edge created by fragmentation has drawn research interest because of avian population declines in fragmented landscapes (Paton 1994). Drobney et al. (1998) found that mourning doves favored nesting in edge habitat over continuous habitat although there was no significant difference in nesting success between the two habitat types. Understanding how white-tipped dove reproduction responds to fragmentation in the LRGV would be valuable to managers.

My objectives were to (1) identify predators of white-tipped dove eggs and nestling, (2) determine how the predator community differs among land cover types, (3) examine the impact of vegetation and landscape variation in both citrus and woodland land cover types on nest survival, (4) examine the impact of temporal variation on nest surviva,; (5) provide information on general nest ecology that is currently lacking, (6) investigate movements of doves and examine feasibility of tracking and recapture using a GPS/VHF transmitters pilot study

LITERATURE CITED

Adams, C. E., J.A. Leifester, and J.S. Herron. 1997. Understanding wildlife constituents: birders and waterfowl hunters. Wildlife Society Bulletin 25:653-660.

Baskett, T. S., and M. W. Sayre. 1993. Characteristics and Importance. Pages 1–6 *in* T. S Baskett, M. W. Sayre, R. E. Tomlinson, and R. E. Mirarchi, editors. Ecology and management of the mourning dove. Stackpole Books, Harrisburg, PA, USA.

Bent, A. C. 1932. Life histories of North American gallinaceous birds (orders Galliformes and Columbiformes), U.S. National Museum Bulletin. 162. Washington D.C., USA.

Best, L.B., and F. Stauffer. 1980. Factors affecting nest success in riparian bird communities. The Condor 82:149-158.

Boydstun, C. P., and C. A. DeYoung. 1985. Distribution and relative abundance of white-tipped doves in south Texas. Southwestern Naturalist 30:567–571.

Boydstun, C. P., and C. A. DeYoung. 1988. Movements of white-tipped doves in southern Texas. Southwestern Naturalist 33:365–367.

Boydstun, C. P., and C. A. DeYoung. 1987. Nesting success of white-tipped doves in south Texas. Journal of Wildlife Management 51:791–793.

Burger, J. 1992. Drinking, vigilance, and group size in white-tipped doves and common ground-doves in Costa Rica. The Wilson Bulletin 104:357-359.

Brush, T. 2005. Nesting birds of a tropical frontier: The Lower Rio Grande Valley of Texas. Texas A&M University Press, College Station, USA.

Case, D. J., and S. J. Hughes. 2011. Priority information needs for band-tailed pigeons, Zenaida doves, white-tipped doves, and scaly-naped pigeons: a funding strategy.

Developed for the Association of Fish and Wildlife Agencies by the Migratory Shore and Upland Game Bird Support Task Force.

Chalfoun, A.D., M.J. Ratnaswamy, and F.R. Thompson III. 2002. Songbird nest predators in forest-pasture edge and forest interior in a fragmented landscape. Ecological Applications 12:858-867.

Collins, M.L., M.F. Small, J.A. Veech, J.T. Baccus, and S.J. Benn. 2010. Dove habitat association based on remotely sensed land cover types in south Texas. Journal of Wildlife Management 74:1568-1574.

Drobney, R.D., J.H. Schulz, S.L. Sheriff, and W.J. Fuemmler. 1998. Mourning dove nesting habitat and nest success in central Missouri. Journal of Field Ornithology 69:299-305.

Goodwin, D. 1983. Pigeons and doves of the world. Third ed. Cornell Univ. Press, Ithaca, New York, USA.

Hayslette, S.E., T.C. Tacha, and G.L. Waggerman. 2000. Factors affecting white-winged, white-tipped, and mourning dove reproduction in Lower Rio Grande Valley. Journal of Wildlife Management 64:286-295.

Johnson, J. L., and W. Polk. 2004. The economic importance of dove hunting in Texas. Pages 24–28 *in* N. J. Silvy and D. Rollins, editors. Dove Biology, Research, and Management in Texas. Texas A&M University Research and Extension Center, San Angelo, USA.

Martin, T.E. 1992. Breeding Productivity consideratins: what are the appropriate habitat features for management? Pages 455-473 *in* J.M. Hagan and D.W. Johnson, editors. Ecology and conservation of neotropical migrand landbirds. Smithsonian Institution Press, Washington D.C., USA.

Murphy, M.T., C.L. Cummings, and M.S. Palmer. 1997. Comparative analysis of habitat selection, nest site and nest success by cedar waxwings (*Bombycilla cedrorum*) and eastern kingbirds (*Tyrannus tyrannus*). American Midland Naturalist 138:344-356.

National Mourning Dove Planning Committee. 2003. Mourning dove national strategic harvest management plan. U.S. Fish and Wildlife Service, Washington D.C., USA.

Paton, P.W.C. 1994. The effect of edge on avian nest success: how strong is the evidence? Conservation Biology 8:17-26.

Purvis, J. 2013. Small game harvest survey results 1993-94 thru 2012-13. Texas Parks and Wildlife Department, Austin, Texas, USA.

Raftovich, R.V., and K.A. Wilkins. 2015. Migratory bird hunting activity and harvest during the 2013-2014 and 2014-2015 hunting seasons. U.S. Fish and Wildlife Service, Laurel, Maryland, USA.

Rappole, J. H., S. Glasscock, K. Goldberg, D. Song, and S. Faridani. 2011. Range change among New World tropical and subtropical birds. Bonner Zoologische Monographien 57:151–167.

Roberson, J.A. 2004. The future of dove hunting. Pages 54-72 *in* N.J. Silvy and D. Rollins, editors. Dove Biology, Research, and Management in Texas. Texas A&M University Research and Extension Center, San Angelo, USA.

Taylor, B., D. Rollin, J. Johnson, J. Roberston, T.W. Schwertner, N.J. Silvy, and R.J. Linex. 2006. Dove management in Texas. Texas Cooperative Extension, College Station, USA.

Texas Parks and Wildlife Department. 2013. 2013–214 hunting and fishing regulations. Texas Parks and Wildlife Department, Austin, Texas, USA.

U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2011 National survey of fishing, hunting, and wildlife-associated recreation.

Waggerman G.L., G.E. Homerstad, R.R. George, and W.A. Shifflett. 1994. White-tipped dove. Pages 53–59 *in* T. C. Tacha and C. E. Braun, editors. Migratory shore and upland game bird management in North America. International Association of Fish and Wildlife Agencies, Washington D.C., USA.

Yahner, R.H. 1983. Site-related nesting success of mourning doves and American robins in shelterbelts. The Wilson Bulletin 95: 573-580.

CHAPTER II

NEST SURVIVAL AND PREDATION

Identification of specific habitat features and associated resources that directly influence reproduction is crucial for the effective management of avian species (Martin 1992). A species' habitat can be perceived from different spatial scales including a larger landscape scale that incorporates both vegetation and land use variation. The evaluation of variation in landscape characteristics at multiple scales can provide additional insight into reproduction (Stephens et al. 2005). For species vulnerable to nest predation, nest survival also may change in relation to one or more temporal variables such as nest age or nest initiation date (Grant et al. 2005).

Nest predation is an important factor in avian population viability and when it differs among habitats or areas, it can be a strong selective agent on birds (Chalfoun et al. 2002). The nest concealment hypothesis states that birds select nest sites surrounded by dense foliage to reduce the ability of predators to visually locate the nest (Martin and Roper 1988, Martin 1992). But the hypothesis has not been supported by a majority of studies examining the relationship for open-cup nesting songbirds in North America (reviewed by Borgmann and Conway 2015).

Given the interaction between predation and vegetation variables, it is important to understand how management of vegetation impacts game species. Doves are the most widely hunted avian game birds in North America. Research on doves has found predation to be an important cause of nest failure (Nice 1923, Pearson and Moore 1939, Swank 1955, Morrow and Silvy 1982, Hosford 1955, Grau 1979, Harris et al. 1963, Yahner 1983, Soutiere and Bolen 1976). Predation of eggs and nestlings is a major factor affecting nest success of doves (Sayre and Silvy 1993). However, most information on dove nest predation is observational and inferences regarding predator identification are based on the visual detection of possible predators in study areas.

Researchers rarely witness predation events first hand and often use nest site evidence to identify potential predators, often incorrectly (Larivière 1999). Opportunistic field observations and use of artificial nests are also associated with extreme bias (Davis et al. 2012). The recent advancement of camera technology has allowed researchers to make strides in knowledge of nest predation and nest ecology of many species. Studies using nest video surveillance of active nests can overturn or substantiate long-standing assumptions regarding nest predator identity (Pietz et al. 2012).

The white-tipped dove (*Leptotila verreauxi*) is a secretive, game species in the Lower Rio Grande Valley (LRGV) Texas first opened hunting of white-tipped doves in 1984 (Case and Hughes 2011). The Texas Parks and Wildlife Department has maintained the same daily bag limit of 2 birds per hunter since then (Texas Parks and Wildlife Department 2016). Little research has been conducted in the last 30 years resulting in a lack of strategic management and planning. The U.S. Fish and Wildlife Service listed white-tipped doves as a species of research concern in 2011, partly due to the lack of information on their nesting ecology and biology (Case and Hughes 2011). Two studies have been published on white-tipped dove reproduction since 1980. Boydstun and DeYoung (1987) provided the first ever reproduction study extending beyond a simple description of nest and eggs.

White-tipped doves have been documented extensively in Starr, Hidalgo, Cameron, and Willacy counties of Texas (Boydstun and DeYoung 1985, Enright 2015, unpublished data), although they occur throughout the Americas into eastern Argentina and southern Brazil (Goodwin 1977). White-tipped doves are permanent residents of the LRGV and nest in both native woodland vegetation and citrus grove agriculture. An estimated 95% of native vegetation has been destroyed due to urban and agricultural expansion, resulting in isolated remnants of once continuous woodland (Collins et al. 2010). Citrus agriculture in the LRGV is also declining. Major freezes in 1983 and 1989 reduced citrus acreage from 69,200 to 12,000 (Anciso et al. 2002). About 83% of today's citrus industry is located in Hidalgo County.

Determining factors that drive variation in nest survival may be beneficial to managers in the LRGV striding for proper conservation and management of the species. This requires that we identify nest predators and factors influencing predator abundance and behavior (Davis et al. 2012). To examine the factors that influence nest survival of white-tipped doves, my objectives were to (1) identify predators of white-tipped dove eggs and nestlings, (2) determine how the predator community differs between land cover types, (3) examine the impact of vegetation and landscape variation in citrus and woodland land cover types on nest survival, (4) examine the impact of temporal variation on nest survival, (5) provide information on general nest ecology that is currently lacking such as differences in nest heights in citrus and woodland land cover types and incubation and nestling period lengths. I hypothesized a lower daily survival rate in citrus groves compared to native woodland due to a lack of vegetative cover. I hypothesized that variables such as overhead cover, side cover, and distance to foliage edge on a nest site scale would affect daily survival rate significantly. Similarly, I hypothesized that variables such as canopy cover and vertical density on a larger spatial scale would influence survival significantly.

STUDY AREA

This study occurred in the LRGV of south Texas. The LRGV has a subtropical climate averaging 66 cm of rainfall annually (Parcher et. al. 2013). The temperature remains relatively constant throughout the year with an average annual temperature range of 18.3 to 28 ^{0}C (Porter 1977). The LRGV has relatively low elevation across the landscape and is topographically consistent. This study occurred in Hidalgo County in corporate and privately owned citrus groves and woodland sites on public lands. Hidalgo County contains the majority of citrus agriculture located in the LRGV. I selected sites based on a previous study of white-tipped dove occupancy that found doves to favor citrus and woodland land covers (Enright 2015).

Citrus sites ranged in size from to 21 to 128 hectares. Orange and grapefruit trees made up the majority of all sites. During the breeding season, groves are intensively managed for weed and pest control. Mechanical and chemical management methods consist of flooding, tilling, pesticide, and herbicide application. Chemical application includes aerial crop dusting and direct foliage spraying throughout the summer.

I searched for nests in 5 woodland sites that included state parks and wildlife management areas throughout the LRGV. I only located nests in Estero Llano Grande State Park (ELGSP) in Weslaco, TX and therefore, this site represents native woodland land cover. ELGSP is a 97-hectare public access park located roughly 7 km north of the

Rio Grande. The site is made up of restored wetland, shrubland, and remnant woodland land covers. Dominant hardwood species in the park in include Texas ebony (*Ebenopsis ebano*), anacua (*Ehretia anacua),* and live oak (*Quercus fusimormis*). Additionally, ELGSP is home to several ornamental species introduced during its time as a residential trailer park. It is a part of the World Birding Center and considered a premier destination for birders (J. De Leon, Texas State Parks, personal communication).

Recently, concerns have risen over the appearance and spread of tawny crazy ants (*Nylanderia fulva*) in ELGSP. They have been observed by state parks employees consuming native arthropods, blinding birds, and causing extensive damage to infrastructure (J. De Leon, Texas State Parks, personal communication). Some of the damage includes impairment of electrical devices and wiring.

METHODS

NEST MONITORING

I conducted nest searches at random points from mid-May to late-July of 2015 and 2016, I established a random point for every 10 ha at each site using ArcMap 10.3.1 (Esri Press, Redlands, California). I visited points twice per week. Upon arrival to a point, I listened for cooing white-tipped doves and attempted to locate the cooing individual. Given the location of the cooing bird, I then attempted to locate or flush its nesting partner. In citrus groves, I accomplished this by walking rows of trees adjacent to the first located individual. In the woodland site, I searched all suitable nesting vegetation adjacent to the first located individual. I located most nests without flushing the attending parent because many doves cooed from the nest. I also located nests incidentally while traversing the study area. I spent equal search effort between both land cover types for most of the study period but after not finding nests for a considerable amount of time in some woodland sites, I removed them from my site visit schedule.

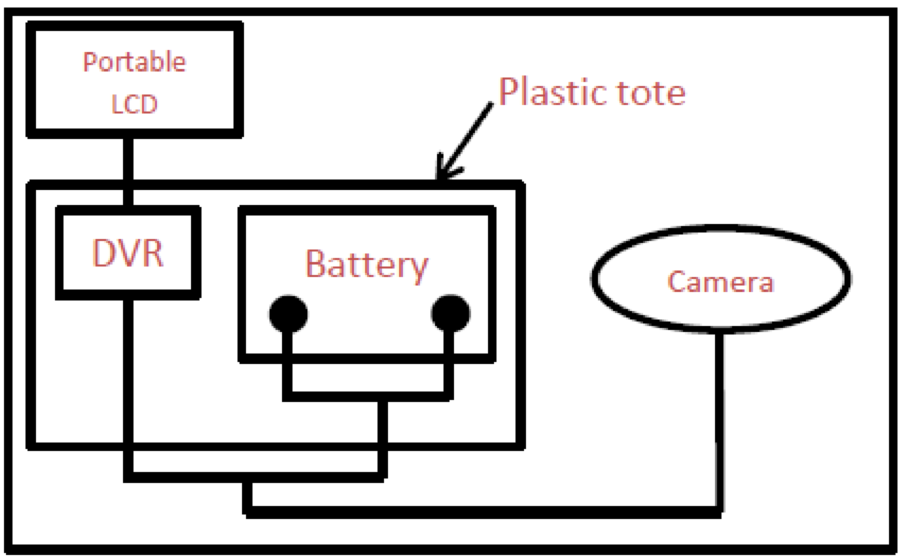
Upon discovery of a nest, I placed flagging tape roughly 10m from the nest site and marked the location in a GPS (Global Positioning System) unit. I checked high nests with a mirror pole device. At each nest check, I recorded the date and time, location, stage, contents and adult activity.

I defined a survival score (yes or no) for each observed interval between nest checks. The time between checks varied from 2-4 days. I considered the number of fledglings for successful nests equal to the number of nestlings at last check before assumed fledge. I confirmed some suspected failures with the use of video surveillance. I concluded other nest failures with the use of site evidence.

VIDEO SURVEILLANCE

I placed real-time infrared emitting cameras on 20 white-tipped dove nests in citrus and on 13 nests in Estero Llano Grande State Park during the summers of 2015 and 2016. Video surveillance systems were comprised of a real-time, infrared emitting camera (GE® 45231) and digital video recorder (Supercircuits® MDVR 14), powered by a 12-volt deep cycle marine battery (Fig. 2.1). I stored batteries and recorders in a camouflaged plastic tote to protect them from environmental conditions. I used a 30 m cable to minimize disturbance to the nest site by placing totes under an adjacent tree. In order to obtain 24-hr surveillance, I switched SD (secure digital) cards in each camera systems every 2-3 days and checked the position of the camera with a portable LCD (liquid crystal display) video display.

Figure 2.1. Illustration of video surveillance system used to monitor white-tipped dove nests in the Lower Rio Grande Valley of Texas, USA, May 2015-July 2016.



VEGETATION SAMPLING

Upon nest conclusion, I measured vegetation characteristics around each nest at two spatial scales: nest site and within 50 m. At the nest sit scale, I measured overhead cover and side cover from each cardinal direction. At 1 m away from the nest, I estimated percentage of the nest that was concealed by vegetation or other obstructions. Also at the nest site, I measured nest height, substrate height, distance to stem, and distance to foliage edge. I considered distance to foliage edge the distance from nest edge to the nearest 100% break in canopy cover.

To measure vegetation characteristics around the nest site, I used a 50 m tape in four random directions from each nest. At every 10 m along the tape, I measured vertical density using a Robel pole (Robel et al. 1970) in 3 divisions: 0-1 m, 1-2 m, and 2-3 m. I also measured canopy cover with a spherical densiometer at each stop (Lemmon 1956). Lastly, I measured ground cover using a Daubenmeier frame, designating cover into 5 categories: Grass, forb, woody, bare and litter. I used a student's *t* test to examine differences in heights of nests between land cover types.

MODELING DAILY SURVIVAL RATES

I conducted all analyses in R 3.1.1 (R Development Core Team 2016) I used logistic exposure survival analysis (Schaffer 2004) to model nest survival as a function of nest-specific predictor variables and to estimate daily nest survival rates. The logistic-exposure approach accommodates fluctuating exposure periods, categorical, continuous, and temporal variables, as well as random effects. I used a stepwise modeling approach. I tested 14 candidate models in our first candidate set (Table 2.3) comprised of nests in both woodland and citrus land cover types. I included temporal, nest stage, land cover type, and presence of camera variables. I excluded vegetative variables in this set due to the large difference of vegetation in woodland and citrus land cover types. I tested nest stage as a categorical variable made up of 3 divisions: incubation, days 0-6 of nestling stage, and days 7+ of nestling stage. I divided the nestling stage to test for differences in parental or nestling behavior as the nestlings mature. Additionally, I included null and global models in the candidate sets. I selected the best approximating model from the first set to incorporate into all models in the next modeling stage. I then used land cover designation (citrus and woodland) to create two separate candidate model sets to test predictor variables in both land cover types. I found this separation necessary because of the stark contrast in vegetation and predator communities between woodland and citrus sites. The predator communities I identified during video surveillance assisted in the formation of model hypotheses during the nest survival analyses.

I tested for correlations between all continuous variables and eliminated any possible models that contained such variables. I considered correlations significant if $R^2 <$ -0.7 or $R^2 > 0.7$. Vertical densities from 1-2 m and 2-3 m were correlated and so were combined into one variable for the sake of model testing. I evaluated and ranked candidate models using Akaike information criterion (AIC_c) adjusted for small sample size and the associated Akaike Weight, w_i (Burnham and Anderson 2002). All candidate models were tied to a biological hypothesis. I formulated hypotheses after analyzing predation results. Most model hypotheses were based around concealment and temporal factors due to predation pressure on dove nests.

To illustrate the effects of land cover, year, and nest stage, I plotted predicted daily survival rates using the logistic-regression equation with selected values for each variable. I used additive models to test the hypothesis that two (or more) variables together performed better than they had separately. I used multimodel inference with $\Delta AIC_c < 2.0$ across all candidate models to obtain estimates of any covariate effects of daily survival rates.

After separating land cover type, I tested slightly different models for both due to differences in predator communities. For example, I constructed models in the citrus candidate set after identifying a high presence of avian predators in citrus groves and in the woodland set after identifying tawny crazy ants as the primary nest predator in Estero Llano. I hypothesized that presence of camera would impact nest survival due to possible attraction of ants to electrical currents.

RESULTS

PREDATION

I placed camera systems on 33 white-tipped dove nests; 12 nests successfully fledged at least one young bird, three of those nests were partially predated, the remaining 21 nests were fully predated, and 4 nests were predated by multiple predators. In total, I documented 28 predation events, defined as any event involving the removal of contents or forced abandonment by a predator. All nest predations during the monitoring period were captured successfully. Nine species were recorded preying upon white-tipped dove nests (Table 2.1). Sixteen nests were predated during the incubation period and the remainder (n = 12) during the nestling period. Twenty predation events occurred on nests in citrus and eight predation events occurred on nests in the woodland. Predation events occurred during the entire 24-hr period, but most occurred during daylight hours (Table 2.2).

Table 2.1. Predators recorded on video preying upon white-tipped dove nests at citrus and woodland sites during the incubation and nestling stages in the Lower Rio Grande Valley, Texas during 2015 and 2016.

Predator	Land Cover Type		Stage	
	Citrus	Woodland	Incubation	Nestling

Green jay (*Cyanocorax yncas*)	10		8	2
Tawny crazy ant (*Nylanderia fulva*)		6	1	5
Crested caracara (*Caracara cheriway*)	4		1	3
Rat (*Rattus* spp.)	2	1	2	1
Great-tailed grackle (*Quisicalas mexicanus*)	1		1	
Opossum (*Didelphis virginiana*)	1		1	
House cat (*Felis catus*)	1		1	
Harris's hawk (*Parabuteo unicinctus*)		1		1
Texas indigo snake (*Drymarchon melanurus erebennus*)	1		1	

Table 2.2. Time of day (MDT) predators appeared in view of camera (Arrival Time) and age in days of nestlings at time of predation (Age) in the Lower Rio Grande Valley, Texas in 2015 and 2016.

Predator	Stage	Age	Arrival Time
Green Jay	Inc	*	12:30
Green Jay	Inc	*	8:53
Green Jay	Inc	*	14:39
Green Jay	Inc	*	12:07
Green Jay	Inc	*	18:42
Green Jay	Inc	*	9:24
Green Jay	Inc	*	13:55

Green Jay	Inc	*	18:08
Green Jay	Nest	10	13:59
Green Jay	Nest	2	16:06
Tawny Crazy Ant	Inc	*	10:08
Tawny Crazy Ant	Nest	2	10:22
Tawny Crazy Ant	Nest	1	6:30
Tawny Crazy Ant	Nest	1	11:10
Tawny Crazy Ant	Nest	1	9:51
Tawny Crazy Ant	Nest	3	7:16
Crested caracara	Inc	*	19:35
Crested caracara	Nest	8	18:03
Crested caracara	Nest	2	12:07
Crested caracara	Nest	8	7:46
Rat	Inc	*	4:12
Rat	Inc	*	1:50
Rat	Nest	6	2:18
Great-tailed grackle	Inc	*	16:06
Opossum	Inc	*	1:12
House cat	Inc	*	4:32
Harris's Hawk	Nest	10	19:20
Texas indigo snake	Inc	*	10:26

*Nests were located at different times during the incubation period, not allowing for confident aging of eggs.

Green jays (*Cyanocorax incas*) were the most common predator of white-tipped dove nests (Table 2.2), though they most often predated nests during incubation (n = 8, Fig. 2.2) and this was observed only in citrus groves. I documented multiple jays predating the same nests in 3 events. Jays predated nestlings successfully on two occasions; during one event, a green jay removed a 2-day old nestling and during another event, a green jay dragged a 10-day old nestling from the nest and disappeared from frame (Fig. 2.3). During a predation of eggs, the incubating parent attempted to defend the nest but eventually flushed after jays removed the eggs from below. Nest defense was not a normal occurrence. I commonly detected jays in the woodland but did not document a jay nest predation there.

Figure 2.2. Documentation of a green jay predating white-tipped dove eggs on 26 May 2015 in the Lower Rio Grande Valley, Texas.

Figure 2.3. Documentation of a green jay removing nestling on 5 July 2015 in the Lower Rio Grande Valley, Texas.

Crested caracaras (*Caracara cheriway*) were only observed predating nests in citrus groves (n = 4). After its nest mate was predated by a caracara at 8-days old, one nestling fledged the nest at 13-days after the caracara returned to the nest a second time. Great-tailed grackles, formerly assumed to be the primary predator of white-tipped dove nests (Hayslette et al. 2000) predated only one during our observation period. It occurred in 2015 and only after the nest was first predated by a green jay. A Harris's hawk (*Parabuteo unicinctus*) was the only avian predator documented in the woodland. An opossum nocturnally predated eggs in a citrus grove. A house cat (*Felis catus*) predated eggs in a citrus grove in 2015. The only snake predation was by a Texas indigo snake

(*Drymarchon melanurus erebennus*) in a citrus grove in 2016. I frequently noticed indigo snakes basking in groves throughout both summers. Invasive rats (*Rattus* spp.) predated nests (n = 3) in the woodland and one citrus grove. During 1 nocturnal event, a rat jumped on the back of the attending parent, causing it to flush. It then ate both 6-day old nestlings over a span of about 2 hours.

Tawny crazy ants accounted for 6 predation events. Five events occurred during 2016. During the only event in 2015, the attending dove kicked both nestlings out of the nest while attempting to remove ants that had infested. I discovered both nestlings being consumed by ants on the ground below the nest shortly after. During 2016, ants predated 3 nests shortly after the first egg hatched. In addition to nests with cameras, I documented tawny crazy ant predations via nest site evidence (Fig. 2.4).

Figure 2.4. Documentation of tawny crazy ant predation of a white-tipped dove nest in the Estero Llano Grande State Park in Weslaco, Texas, USA, June 2016.

SURVIVAL

I located 63 white-tipped dove nests during this 2-yr study; 34 nests were in 5 citrus sites and 29 nests in the woodland. In our first candidate set the most important model was nest stage (Table 2.3, AIC_cWt = 0.29), indicating a difference in nest survival throughout the nesting cycle. I found a positive linear trend in nest survival as nest stage increased (Fig. 2.5), indicating lower survival during the incubation stage than the nestling stage. The daily survival rate estimate for the incubation period was 0.923 (95% CI =0.889–0.947). The daily survival rate estimate for the first 6 days of the nestling period was 0.958 (95% CI = 0.910–0.981) and days 7+ was 0.984 (95% CI = 0.951–0.995). Presence of camera was the least important model in the set (AIC_cWt= .00).

Nests in woodlands experienced slightly higher survival than those in citrus cites. My predicted daily survival rate for nests in woodland was 0.960 (95% C I= 0.933–0.976). My predicted daily survival rate for nests in citrus was 0.934 (95%CI = 0.901–0.957). Compounded to a 25-day nesting cycle these rates result in estimates of 0.360 and 0.181, respectively. Nests monitored in 2015 had a predicted daily survival of 0.962 (95% CI = 0.929–0.980) and nests monitored in 2016 has a predicted daily survival of 0.939 (95% CI = 0.912–0.958). Nests without camera systems 0.956 (95% CI = 0.926–0.974) had higher predicted daily survival than those with cameras 0.940 (95% CI = 0.909–0.961).

In my woodland nests model set (Table 2.4), our top model was the null, indicating that I did not incorporate an important predictor variable in the candidate set.

The null model was also the only one with $\Delta AIC_c \leq 2.0$. The model including presence of camera was weak ($\Delta AIC_c = 4.35$; $AIC_cWt = 0.04$).

In my citrus nests model set, our top model (Table 2.5) was an additive of nest stage and canopy cover (Fig. 2.5; $AIC_cWt=0.39$). The top five models in the set included concealment variables and accounted for 88% of model weight. Null ($AIC_cWt = 0.00$) and global ($AIC_cWt = 0.00$) models were the two least important models in the candidate set.

Table 2.3. Summary of model selection of the evaluation of the influence of land cover type, temporal, and other abiotic variables on the daily survival rate of white-tipped dove nests in the Lower Rio Grande Valley of Texas, USA, May 2015 – July 2016.

Models [e]	K [a]	AIC_c	ΔAIC_c	Wt	CumWt [d]	LL[e]
Stage	3	234.45	0.00	0.29	0.29	-114.19
LandCover+Year+Stage	5	234.78	0.33	0.24	0.53	-112.30
Year*Stage	6	235.15	0.70	0.20	0.73	-111.45
LandCover*Stage	6	235.95	1.49	0.14	0.86	-111.85
Global	7	237.87	3.42	0.05	0.92	-111.77
Date	2	239.74	5.29	0.02	0.94	-117.85
LandCover	2	240.71	6.26	0.01	0.95	-118.34
null	1	240.87	6.41	0.01	0.96	-119.43
Year	2	241.17	6.72	0.01	0.97	-118.57
LandCover*Date	4	241.40	6.94	0.01	0.98	-116.64
Camera	2	242.04	7.59	0.01	0.99	-119.00
LandCover*Year	4	242.12	7.67	0.01	0.99	-117.00
Year*Date	4	242.43	7.98	0.01	1.00	-117.16
Camera	4	243.98	9.53	0.00	1.00	-117.93

[a] number of parameters in the model (K)
[b] Akaike's Information Criterion adjusted for low sample size(AICc)
[c] Difference in AICc from the top ranked model (ΔAICc)
[d] Cumulative Weight (CumWt)
[e]Log-likelihood

Figure 2.5. Predicted daily survival rates and 95% confidence intervals by nest stage (1 = incubation, 2 = hatch day through day 6 of nestling stage, 3 = day 7 until end of nesting) of white-tipped dove nests in the Lower Rio Grande Valley, Texas.

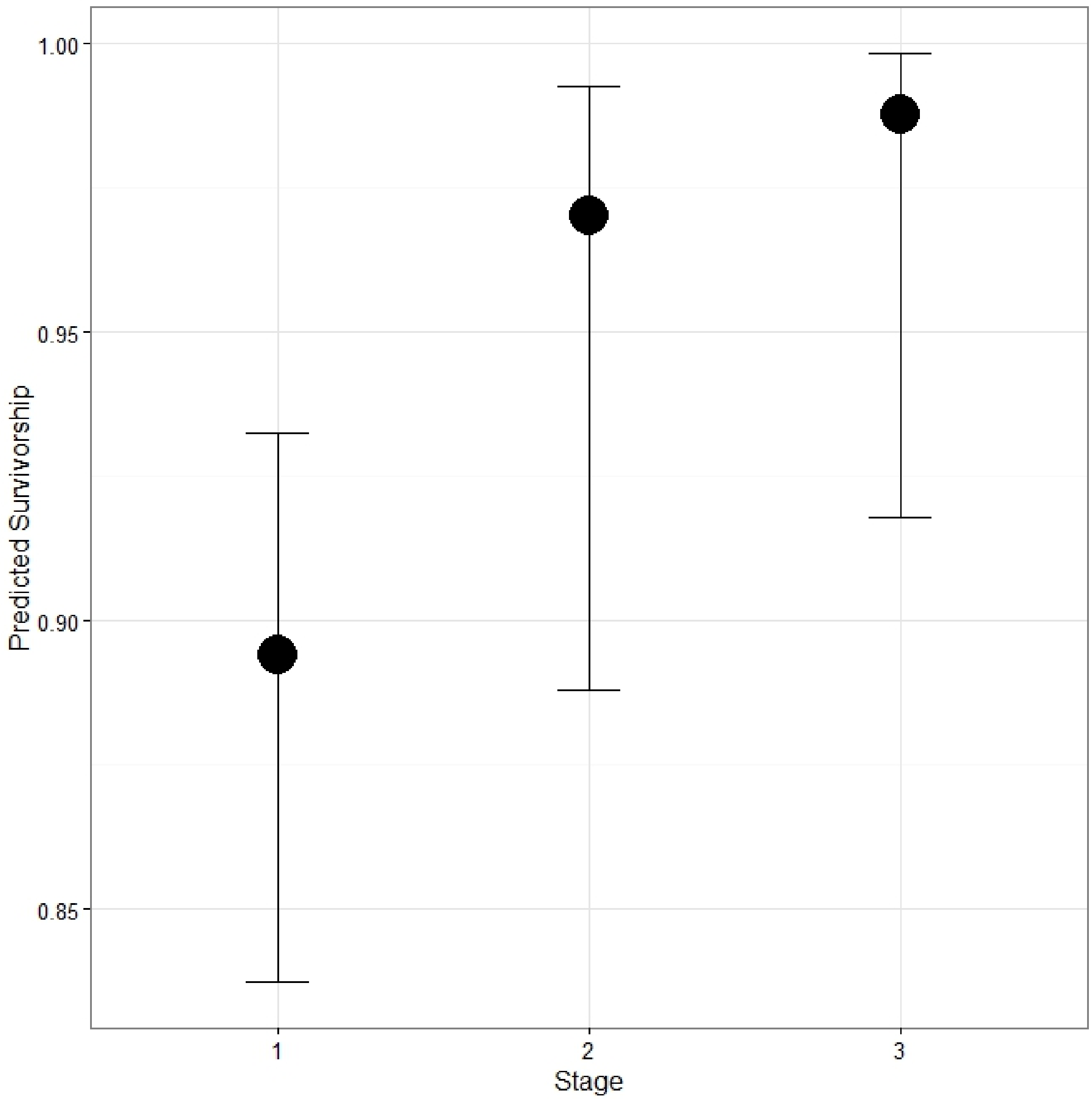


Table 2.4. Summary of model selection of the evaluation of the influence of variables associated with nests found in Estero Llano Grande State park on the daily survival rate of white-tipped dove nests in the Lower Rio Grande Valley of Texas, USA, May 2015 – July 2016.

Models [e]	K [a]	AIC_c	ΔAIC_c	Wt	CumWt [d]	LL[e]
null	1	106.05	0.00	0.36	0.36	-52.01
Stage	3	108.31	2.26	0.12	0.47	-51.09
Stage+VD1+VD2	5	109.09	3.04	0.08	0.55	-49.37
Stage+Nheight	4	109.18	3.13	0.07	0.63	-50.47
Stage+Year	4	109.41	3.37	0.07	0.69	-50.59
Stage+CC	4	109.74	3.70	0.06	0.75	-50.76
Stage+Date	4	110.17	4.12	0.05	0.79	-50.97
Stage+LD	4	110.33	4.28	0.04	0.84	-51.05
Stage+OvCov	4	110.38	4.33	0.04	0.88	-51.08
Stage+Scov	4	110.39	4.35	0.04	0.92	-51.08
Stage+Camera	4	110.40	4.35	0.04	0.96	-51.09
Stage+Dfol	4	110.40	4.36	0.04	1.00	-51.09
Global	14	116.81	10.76	0.00	1.00	-43.12

[a] number of parameters in the model (K)

[b] Akaike's Information Criterion adjusted for low sample size(AICc)

[c] Difference in AICc from the top ranked model (ΔAICc)

[d] Cumulative Weight (CumWt)

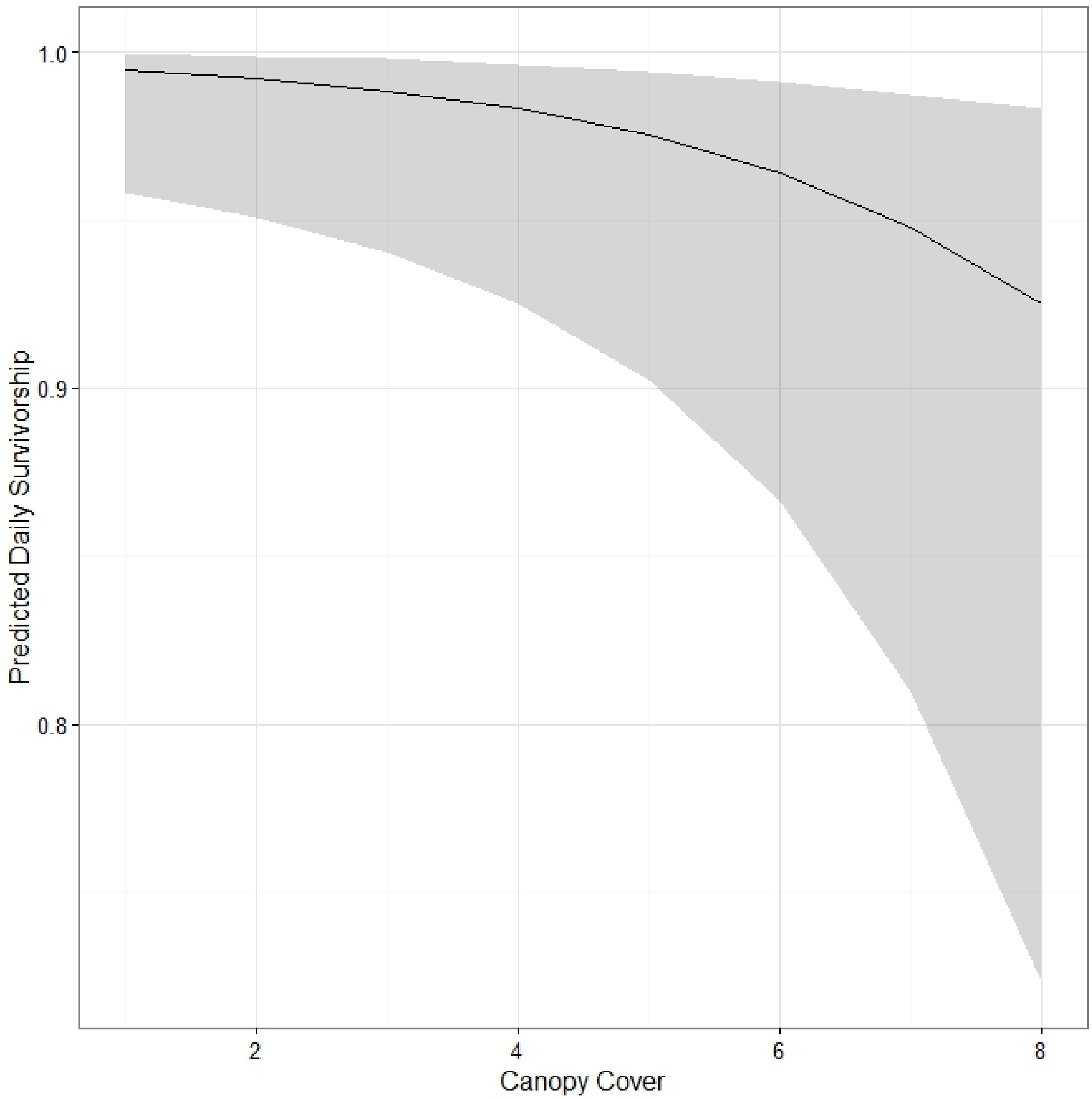
[e]Log-likelihood

Table 2.5. Summary of model selection through of the evaluation of the influence of variables associated with nests found in citrus sites on the daily survival rate of white-tipped dove nests in the Lower Rio Grande Valley of Texas, USA, May 2015-July 2016.

Models [e]	K [a]	AIC_c	ΔAIC_c	Wt	CumWt [d]	LL[e]
Stage+CC	4	122.03	0.00	.39	.39	-56.89
Stage+VD2	4	122.97	.94	.24	.63	-57.36
Stage+CC+OvCov+Scov	6	123.51	1.48	.18	.81	-55.49
Stage+VD1	4	125.63	3.60	.06	.88	-58.69
Stage+Scov	4	127.27	5.24	.03	.90	-59.51
Stage	3	127.67	5.64	0.02	.93	-60.76
Stage+OvCov	4	128.74	6.71	0.01	0.94	-60.24
Stage+Date	4	128.88	6.85	0.01	0.95	-60.31
Stage+OvCov+Scov	5	129.00	6.97	0.01	0.97	-59.31
Stage+Dfol	4	129.05	7.02	0.01	0.98	-60.40
Stage+Camera	4	129.50	7.47	0.01	0.99	-60.62
Stage+Nheight	4	129.77	7.74	0.01	0.99	-60.76
Stage+Site	7	130.67	8.64	0.01	1.00	-57.98
null	1	134.68	12.65	0.00	1.00	-66.33
Global	18	143.27	21.24	0.00	1.00	-51.29

[a] number of parameters in the model (K)
[b] Akaike's Information Criterion adjusted for low sample size(AICc)
[c] Difference in AICc from the top ranked model (ΔAICc)
[d] Cumulative Weight (CumWt)
[e]Log-likelihood

Figure 2.5. Predicted daily survival rates and 95% confidence interval by canopy cover for white-tipped dove nests in citrus in the Lower Rio Grande Valley, Texas, USA May 2015 – July 2016.



GENERAL ECOLOGY

I located white-tipped dove nests in 8 substrate species in the woodland site- anacua, brasil (*Condalia hookeri*), coma (*Bumelia celastrina*), Texas ebony, spiny hackberry (*Celtis ehrenbergiana*), live oak, honey mesquite (*Prosopis glandulosa*) and an ornamental shrub (*Eleagnus* sp.) The most common species was Texas ebony, used in ten nest attempts. Two nest from the second year of the study were reused sites from successful nest attempts in the first year. I located dove nests in both orange and grapefruit trees in citrus groves. There was a significant difference in nest height between woodland and citrus land cover types (n = 63, df = 31.136, $P \leq 0.001$).

All nests monitored during the incubation stage contained one or two eggs. I located 4 nests that contained one egg or nestling throughout the observation period. In some cases, one egg may have been removed from the nest by predators prior to observation. In 5 nests, 1 egg hatched and developed into a mature nestling while the other did not. Via video surveillance, I chronicled an incubation stage lasting 11-12 days followed by a nestling stage lasting 12 – 15 days.

DISCUSSION

Green jays were the most common predator of white-tipped dove nests during the study period. Avian predators were more prevalent than all other taxa, accounting for 16 of 28 predation events. I identified nest stage as the most important predictor variable of nest survival with incubating nests experiencing the lowest predicted survival. Video surveillance allowed us to identify diurnal and nocturnal predators of white-tipped dove nests in south Texas. Prior to this study, the identities of suspected dove nest predators in the LRGV were based solely on circumstantial evidence and opportunistic field observations. Hayslette et al. (2000) compared great-tailed grackle density to productivity but did not find a significant impact. Grackles were considered a common nest predator of white-tipped dove and white-winged dove nests in the LRGV (Boydstun and DeYoung 1987, Blankinship 1966). In our study, grackles predated only one nest, providing further evidence that great-tailed grackles may not be an important predator.

My study found a corvid to be the most common nest predator. Another corvid species, blue jays (*Cyanocitta cristata*), are often pegged as the primary predator of mourning dove (*Zenaida macroura*) nests, having been observed attacking nests and stealing eggs or killing nestlings (Nice 1923, Pearson and Moore 1939, Swank 1955). Other recognized predators include common grackles (*Quisicalus quiscula*), American crows (*Corvus brachyrhyncos*) and house cats (*Felis catus*) (Hosford 1955, Grau 1979, Harris et al. 1963).

Previously, green jays had only been reputed to eat eggs and nestlings of other birds (Gayou 1984). I documented the first instance of green jays predating nests and jays were our most common predator. Jays predated eggs most often. They also attempted to remove old nestlings and were successful in one event, dragging a 10-day old bird from the nest. I frequently detected jays in citrus groves and woodlands throughout the LRGV. Given similarities in nesting substrate and nest structure of doves in the LRGV, I suspect jays are also common predators of mourning and white-winged doves. Several studies have found that corvids respond to both landscape and local-scale habitat features (Chalfoun et al. 2002). Hoover et al. (1995) determined that blue jays and American crows were more abundant in small forest patches than in large patches. If investigation into green jay abundance reveals similar results, doves in the LRGV should be expected to experience higher nest predation rates in smaller patches. This may be compounded by the extreme fragmentation of the region.

It should be noted that we detected common predators of citrus nests in and around the state park. Differences in predation rates of these predators is likely due to differences in vegetation and food availability. For example, green jays may be more likely to predate the lesser concealed white-winged dove and mourning dove nests (J.C. Giese, Tarleton State University, unpublished report). White-winged doves are also colonial nesters (Cottam and Trefethan 1968) and we came across very few white-winged dove nests in citrus groves compared to mourning and white-tipped doves. Jays may have experience a higher density of food availability in the woodland due to a higher density of white-winged dove nests.

Crested caracaras and Harris's hawks were expected predators, given their wide ranging diet (Whitacre et al. 1982, Santander et al. 2011). I commonly detected both species perched on trees and power lines throughout the LRGV. Mammals predated nests nocturnally, primarily in citrus groves. Extreme disturbance in citrus groves may favor edge species such as opossums, house cats, invasive rats, and others. Invasive rats exhibited extremely aggressive behavior towards attending parents, perhaps attempting to kill adult doves before detecting nestlings and eggs. *Rattus* spp. are known to take eggs and nestlings wherever introduced, and often cause major declines in nest survival of endemic birds (Sparklin et al. 2010).

Tawny crazy ants, our second most common predator, predated six nests in the woodland, primarily during the nestling period (n = 5). Three nestling predations occurred within 24 hours of the first egg hatching. White-tipped doves, who take part in continuous parental care of the nest, attempted to rid nests of ants regularly during infestations. It is possible that ELGSP is in the middle of a population boom of crazy ants as has been documented in the species (Wetterer et al. 2014). Even so, short term ecological damage should be expected to be extensive with several endemic species nesting in the park.

Recently, tawny crazy ants have become widespread in ELGSP. The species was first recorded in the U.S. in Brownsville, Texas in 1938 (Trager 1984). Recent population explosions in the southern U.S. have caused concern about long-term ecological and agricultural damage (Wetterer et al. 2014). Red imported fire ants (*Solenopsis invicta*) have been found to decrease nest survival in songbirds (Campomizzi et al. 2009). If the situation at ELGSP is any indication of things to come, tawny crazy ant control will become an important issue in the LRGV. Assumedly, crazy ants affect nest survival of other avian species. White-tipped doves, who take part in continuous parental care of the nest (J. Hall, unpublished data, Tarleton State University), attempted to rid nests of ants regularly during infestations. Other species, that do not take part in continuous parental care, may experience great declines in nest survival due to nest infestation. I discovered nests of clay-colored thrush (*Turdus grayi*), green jay, plain chachalaca (*Ortalis vetula*), common pauraque (*Nyctidromus albicollis*), long-billed thrasher (*Toxostoma longirostre*), great kiskadee (*Pitangus sulphuratus*), among others in the park that could be heavily impacted by crazy ant nest predation. Further research on the prominence of tawny crazy ants as nest predators and other ecological damage they cause in the LRGV should be investigated further. The potential impacts to nesting birds in the LRGV may be short-lived due to this ant's extreme boom and bust population tendencies. Factors that drive tawny crazy ant population size remain unknown and deserve further attention (Wetterer et al. 2014).

The diverse predator community of the LRGV leaves white-tipped doves extremely vulnerable throughout a 24-hr time period and entire breeding season. Other nesting columbid species may be just as vulnerable. Further research on identification of nest predators provides managers with important information on conservation and management of species. Video surveillance of game species may be of special interest to wildlife agencies attempting to properly manage game populations and their predators.

White-tipped dove nest survival was higher in the woodland site than in citrus sites, possibly due to increased predation pressure in citrus. Nest survival was also higher during the nestling stage than incubation. All nest failures were attributed to predation through either video surveillance or nest site evidence. Green jays were the primary nest predator in citrus groves and of 10 predation events by jays, 8 were during the incubation stage. Due to the findings in the predator identification portion of this study, higher survival during the nestling stage might be explained by predation pressure of green jays in the LRGV and their inclination to predate eggs more often than nestlings. Other possible predators such as great-tailed grackles, crested caracaras, rats, and snakes were all seen in both the woodland and citrus sites throughout the study period. Though often due to increased likelihood to flush and abandon nests, mourning doves and white-winged doves have been documented with lower survival during the incubation stage

(Sayre and Silvy 1993, Hayslette 2000 et al.). Lower survival during the incubation stage of white-tipped doves is most likely explained by the predator community of the LRGV as I did not document nest abandonment.

The 2 land covers in which I monitored dove nests differed greatly in appearance and management. They also differed in predator assemblage In turn, the environmental factors influencing nest survival should be expected to contrast. In citrus, nest survival was most influenced by canopy cover, although it was a negative relationship. Other concealment variables such as vertical density, distance to foliage edge, overhead cover, and side cover were also important predictors of nest survival. This may be explained by intense predation pressure by green jays. Another common species, crested caracaras, were documented predating nests in citrus groves. Increased nest concealment has been found to have a positive impact on mourning dove nest success (Westmoreland and Best 1985). Video surveillance systems did not seem to cue predators to nest location as presence of camera was not among our top models.

In the woodland, no measured variables were important predictors of nest survival. I hypothesize the infestation of tawny crazy ants affected this result. Variables that might be tied to ant abundance such as nest height, distance to foliage edge, and temporal effects were not good predictors of nest survival, nor were they correlated. Further research on the impacts that tawny crazy ant infestation has on avian nest survival should be conducted in the LRGV.

In the 5 nests with eggs that did not hatch, the eggs may have been unfertilized. I documented nests that were only partially predated and ones that only contained 1 egg or nestling when I located them. The use of video surveillance has allowed for documentation of partial predations in songbirds (Latif et al. 2012). Occurrences of partial predation may be common in columbid species as well.

Boydstun and DeYoung (1987) found nests in 11 tree species and no significant difference in nesting success between citrus and woodland habitats. They assumed a 14-day incubation period followed by a 10-day nestling period and found a higher probability of survival during the latter period. I documented doves up to 15-days of age posthatching before eventually fledging. I also documented predation of nestlings 10-15 days old. The methods used by past researchers are therefore flawed due to premature assumed fledging. This may have biased their estimated nesting success in a positive manner. Similar biases may be prevalent in other columbid studies that assume fledging at a certain nestling age. Pietz et al. (2012) used video surveillance on grassland passerine nests to determine fledging age and times of day when nestlings were most likely to fledge. Video surveillance provides the tool to correct fledging ages for columbids.

MANAGEMENT IMPLICATIONS

I found white-tipped dove nest survival to be heavily affected by nest stage. Nests in the incubation period experienced lower daily survival than those in the nestling period. This result is most likely tied to green jay predation pressure, specifically in citrus groves. Tawny crazy ants, an understudied invasive in the LRGV, may significantly impact nest survival of columbids and other endemic species. Management strategies aimed at reducing the impact of crazy ants on avian reproduction should be reviewed and implemented immediately. The entire LRGV should take notice of the current situation at ELGSP if it wants to conserve its endemic avian species.

Literature Cited

Anciso, J.R., J.V. French, M. Skaria, J.W. Sauls, and R. Holloway. 2002. IPM in Texas citrus. Texas Cooperative Extension, College Station, USA.

Blankinship, D.R. 1966. The relationship of white-winged dove production to control of great-tailed grackles in the Lower Rio Grande Valley of Texas. North American Wildlife and Natural Resources Conference 31:45-48.

Borgmann, K.L., and C.J. Conway. 2015. The nest-concealment hypothesis: New insights from a comparative analysis. Wilson Journal of Ornithology 127:646-660.

Boydstun, C.P., and C.A. DeYoung. 1985. Distribution and relative abundance of white-tipped doves in south Texas. Southwestern Naturalist 30:567-571.

Boydstun, C.P., and C.A. DeYoung. 1987. Nesting success of white-tipped doves in south Texas.

Burnham, D.M., and D.R. Anderson. 2004. Multimodel selection and multi-model inference: a practical information-theoretic approach, 2nd ed. Springer-Verlag, New York, NY.

Campomizzi, A.J., M.L. Morrison, S.L. Farrel, R.N. Wilkins, B.M. Drees, and J.M. Packard. 2009. Red imported fire ants can decrease songbird nest survival. The Condor 111:534-537.

Case, D. J., and S. J. Hughes. 2011. Priority information needs for band-tailed pigeons, Zenaida doves, white-tipped doves, and scaly-naped pigeons: a funding strategy. Developed for the Association of Fish and Wildlife Agencies by the Migratory Shore and Upland Game Bird Support Task Force.

Chalfoun, A.D., M.J. Ratnaswamy, and F.R. Thompson III. 2002. Songbird nest predators in forest-pasture edge and forest interior in a fragmented landscape. Ecological Applications 12:858-867.

Collins, M.L., M.F. Small, J.A. Veech, J.T. Baccus, and S.J. Benn. 2010. Dove habitat association based on remotely sensed land cover types in south Texas. Journal of Wildlife Management 74:1568-1574.

Cottam, C., and J.B. Trefethan. 1968. White-wings: The life history, status, and management of the white-winged dove. D. Von Nostrand, Princeton, New Jersey, USA.

Davis, S.K., S.L. Jones, K.M. Dohms, and T.G. Holmes. 2012. Identification of sprague's pipit nest predators. Pp. 173-182 *in* A. Ribic, F.R. Thompson III, and P.J. Pietz, editors. Video surveillance of nesting birds. Studies in Avian Biology (no. 43), University of California Press, Berkeley, CA, USA.

Enright, T.A. 2015. White-tipped dove detection probability, land cover associations, patch occupancy, and distribution in the Lowe Rio Grande Valley, Texas. Thesis, Tarleton State University, Stephenville, Texas, USA.

Gayou, D.C. 1984. The behavioral ecology of Texas Green Jays. PhD Thesis, University of Missouri, Columbia.

Goodwin, D. 1977. Pigeons and doves of the world. 2nd ed. Cornell Univ. Press, Ithaca, N.Y. 466pp.

Grant, T.A., T.L. Shaffer, E.M. Madden, and P.J. Pietz. 2005. Time-specific variation in passerine nest survival: New insights into old questions. Auk 122:661-672.

Grau, G.A. 1979. Crow predation on attended mourning dove eggs. Jack-Pine Warbler 57:169.

Harris, S.W., M.A. Morse, and W.H. Longley. 1963. Nesting and production of the mourning dove in Minnesota. American Midland Naturalist 69:150-172.

Hayslette, S.E., T.C. Tacha, and G.L. Waggerman. 2000. Factors affecting white-winged, white-tipped, and mourning dove reproduction in Lower Rio Grande Valley. Journal of Wildlife Management 64:286-295.

Hoover, J.P., M.C. Brittingham, and L.J. Goodrich. 1995. Effects of forest patch size on nesting success of wood thrushes. Auk 112:146-155.0

Hosford, H.J. 1955. Nesting and migration of the mourning dove in norther Indiana. Indiana Audubon Quarterly 33:3-10.

Larivière, S. 1999. Reasons why predators cannot be inferred from nest remains. Condor 101:718-721.

Latif, Q.S., S.K. Heath., and G. Ballard. 2012. The nest predator assemblage for songbirds in Mono Lake Basin riparian habitats. Western North American Naturalist 72:276-287.

Lemmon, P.E. 1956. A spherical densitometer for estimating forest overstory density. Forest Science 2:314-320.

Martin, T.E. 1992. Breeding Productivity consideratins: what are the appropriate habitat features for management? Pages 455-473 *in* J.M. Hagan and D.W. Johnson, editors. Ecology and conservation of neotropical migrand landbirds. Smithsonian Institution Press, Washington D.C., USA.

Martin, T.E., and J.J. Roper. 1988. Nest predation and nest-site selection of a Istern population of the hermit thrush. Condor 90:51-57.

Morrow, M.E. and N.J. Silvy. 1982. Nesting mortality of mourning doves in central Texas. Proc. Ann. Conf. Southeast Assoc. Fish and Wildlife Agencies 37:19-22.

Nice, M.M. 1923. A study of the nesting of mourning doves. Part 2. Auk 40: 37-58.

Parcher, J.W., D.M. Papoulias, D.G. Woodward, and R.A. Durall. 2013. United States-Mexican borderlands, facing tomorrows challenges through USG. Page 36 *in* The borderlands- a region of physical and cultural diversity. U.S. Geological Survey,VA, U.S.A.

Pearson, A.M. and G.C. Moore. 1939. Nesting habits of the mourning dove in Alabama. Transcontinental North American Wildland Conference 4:468-473.

Pietz, P.J., D.A. Granfors, and T.A. Grant. 2012. Hatching and fledging times from grassland passerine nests. Pp. 47-60 *in* C.A. Ribic, F.R. Thompson III, and P.J. Pietz (editors). Video surveillance of nesting birds. Studies in Avian Biology (no. 43), University of California Press, Berkely, CA, USA.

Porter, C.C. 1977. Ecology, zoogeography and taxonomy of the Lower Rio Grande Valley Mesostenines (Hymenoptera, Ichneumonidae). Psyche 84:28-91

Robel, R.J., J.N. Briggs, A.D. Dayton, and L.C. Hulbert. 1970. Relationships between visual obstruction measurements and Iight of grassland vegetation. Journal of Range Management 23:295-297.

Santander, F.J., S. A. Alvarado, P.A. Ramirez, and R.A. Figueroa. 2011. Prey of Harris's hawks during autumn and winter in a coastal area of central Chile. The SouthIstern Naturalist 56:417-422.

Sayre, M.W., and N.J. Silvy. 1993. Nesting and production. Pages 81-104 *in* T.S. Basket, M.W. Sayre, R.E. Tomlinson, and R.E. Mariachi, editors. Ecology and management of the mourning dove. Stackpole Books, Harrisburg, PA, USA.

Schaffer, T.L. 2004. A unified approach to analyzing nest success. Auk 121:526-540.

Soutiere, E.C., and E.G. Bolen. 1976. Mourning Dove nesting on tobosa grass-mesquite rangeland sprayed with herbicides and burned. Journal of Rangeland Management 29:226-231.

Sparklin, B.D., T.R. Malcom, C.N. Brosius, and J.P. Vetter. 2010. Effects of *Rattus* spp. control measures and nesting substrate on nest depredation, East Maui, Hawaii. Vertebrate Pest Conference 24:18-22.

Stephens, S.E., J.J. Rotella, M.S. Lindberg, M.L. Taper, and J.K. Ringelman. 2005. Duck nest survival in the Missouri Coteau of North Dakota: Landscape effects at multiple spatial scales. Ecological Applications 15:2137-2149.

Swank, W.G. 1955. Nesting and production of the mourning dove in Texas. Ecology 36:495-505.

Texas Parks and Wildlife Department. 2016. 2015–2016 hunting and fishing regulations. Texas Parks and Wildlife Department, Austin, Texas, USA.

Trager, J.C. 1984. A revision of the genus *Paratrechina* (Hymenoptera: Formicidae) of the continental United States. Sociobiology 9:49-162.

Westmoreland, D., and L.B. Best. 1985. The effect of disturbance on mourning dove nest success. Auk 102:774-780.

Wetterer, J.K., O. Davis, and J.R. Williamson. 2014. Boom and bust of the tawny crazy ant, *Nylanderia fulva* (Hymenoptera: Formicidae), on St. Croix, U.S. Virgin Islands. The Florida Entomologist 97:1099-1103.

Whitacre, D., D. Ukrain, and G. Falxa. 1982. Notes on the hunting behavior and diet of the crested caracara in northeastern Chiapas and Tabasco, Mexico. The Wilson Bulletin 94:565-566.

Yahner, R.H. 1983. Seasonal dynamics, habitat relationships, and management of avifauna in farmstead shelterbelts. Journal of Wildlife Management 47:85-104.

CHAPTER III

A NEW LONGEVITY RECORD AND OTHER RECENT ENCOUNTERS

While investigating movements and morphology of white-tipped doves (*Leptotila verreauxi*) during the summers of 2015 and 2016 in the Lower Rio Grande Valley (LRGV) of south Texas, I documented a new longevity record for the species. The study was conducted in conjunction with Texas Parks and Wildlife Department (TPWD) at Estero Llano Grande State Park near Weslaco, Texas. I banded and collected morphological measurements on 139 white-tipped doves while also recapturing previously banded individuals. Those recaptured had been banded in Estero Llano from 2007-2009 by Texas Parks and Wildlife.

One individual recaptured on July 1, 2016, proved to be a new longevity record for the species. At encounter, the dove was at least 9 years and 1 month having been originally banded June 3, 2008 as an after hatch-year bird. Other encounters of previously banded birds can be found in Table 3.1. The previous longevity record for white-tipped doves was 8 years and 7 months (BBL 2016).

All doves I recaptured during the study were originally banded in Estero Llano, supporting the findings of Boydstun and DeYoung (1988) that proclaimed white-tipped doves to be sedentary compared to mourning doves (*Zenaida macroura*) and white-winged doves (*Zenaida asiatica*). They found no evidence of migration or daily feeding flights as frequently traveled by their contemporaries. Individuals that I recaptured have probably spent their entire lives in Estero Llano and find all daily requisites in the park.

White-tipped doves are a relatively understudied species. In 2015, TPWD began banding white-tipped doves when captured during white-winged dove and mourning dove banding operations in south Texas (S. Oldenburger, TPWD, personal communication). The morphological measurements I collected on white-tipped doves are the only collected on the species in south Texas (Appendix B). Adult white-tipped doves were much heavier than the 150g commonly reported (Sibley 2014), with the mean mass of an after hatch year bird being 196g. The longevity record, band number 1613-07929, weighed 215g. For comparison, adult white-winged doves average about 150g (Dunning 1993) and mourning doves average about 130g (Mirarchi 1993).

The current longevity record for mourning doves is 30 years and 4 months. The record for white-winged doves is 21 years and 9 months (BBL 2016). Both of these species have extensive accounts of longevity and published demographic information. Theoretically, white-tipped doves live much longer than current banding and longevity information suggests. Increased banding effort by TPWD in the subsequent years will reveal much needed information on survival, harvest, and population characteristics of this secretive gamebird.

Table 3.1. Encounters of banded white-tipped doves in Estero Llano Grande State Park, Weslaco, TX, May 2015-July 2016.

Year	Band number	Initial band date	Age	Recapture date	Minimum age at encounter
2015	1613-95513	7/12/2007	Hatched in 2007 or earlier	6/17/2015	8 years
2015	1703-04055	8/11/2009	Hatched in 2008 or earlier	6/19/2015	7 years
2015	1703-04022	7/18/2009	Hatched in 2008 or earlier	6/22/2015	7 years
2016*	1703-04022	7/18/2009	Hatched in 2008 or earlier	6/6/2016	8 years
2015	1693-14270	6/4/2009	Hatched in 2008 or earlier	7/12/2015	7 years, 1 month
2016*	1693-14270	6/4/2009	Hatched in 2008 or earlier	6/26/2016	7 year
2015	1613-07929	6/3/2008	Hatched in 2007 or earlier	7/16/2015	8, 1 month

Literature Cited

Bird Banding Laboratory [BBL]. 2016. Summaries of Banding and Encounter Data. <https://www.pwrc.usgs.gov/BBL/homepage/start.cfm>. Accessed 31 Aug 2016.

Boydstun, C.P., and C.A. DeYoung. 1988. Movements of white-tipped doves in southern Texas. The Southwestern Naturalist 33:365-367.

Dunning, J.B., Jr. 1993. CRC handbook of avian body masses. CRC Press, Boca Raton, FL, USA.

Giese, J.C. 2016. Factors influencing nest survival of white-tipped doves in the Lower Rio Grande Valley, Texas. Thesis, Tarleton State University, Stephenville, Texas, USA.

Mirarchi, R.E. 1993. Growth, maturation, and molt. Pages 129-140 *in* T.S. Basket, M.W. Sayre, R.E. Tomlinson, and R.E. Mariachi, editors. Ecology and management of the mourning dove. Stackpole Books, Harrisburg, PA, USA.

Sibley, D.A. 2014. The Sibley guide to birds. Second edition. Alfred A. Knopf, New York, New York, USA.

APPENDICES

APPENDIX A

Figure A.1. Movements of white-tipped dove fitted with GPS backpack transmitter June 17-July 9, 2015.

APPENDIX B

Table B.1. Banding and morphological measurements of captured white-tipped doves in the Lower Rio Grande Valley, Texas 2015-2016.

Prefix	*Suffix*	*Year*	*Age*	*Molt*	*Bill*	*Wing*	*Toe*	*Tarsus*	*Culmen*	*Head*	*Mass*
1094	10930	2015	AHY	3	20.67	147	29.43	36.8	14.33	48.29	236
1094	05742	2015	AHY	0	22.96	146	28.34	36.81	16.24	47.05	165
1094	05720	2015	AHY	5	23.59	155	28.7	37.97	16.71	46.58	211
1094	10937	2015	AHY	2	22.81	149	25.74	36.2	16.25	47.78	183
1094	10939	2015	HY	2	20.4	151	24.61	35.37	16.15	45.68	163
1094	10941	2015	AHY	4	20.45	142	28.87	37.17	15.08	45.39	184
1094	10942	2015	HY	4	21.73	138	29.12	37.96	16.45	46.14	166
1094	05750	2015	HY	3	23.2	142	27.16	36.67	17.06	46.01	168
1094	05751	2015	AHY	10	20.4	135	29.05	34.89	14.49	41.76	178
1094	05757	2015	AHY	2	21.97	159	29.02	39.99	15.25	45.18	183
*1613**	95513	2015	AHY	3	22.68	147	31.02	36.99	16.75	48.07	223
1094	05758	2015	AHY	3	23.71	152	29.03	36.92	15.06	47.77	208
1094	05765	2015	AHY	6	20.28	144	27.18	36.26	14.75	46.12	194
1094	05772	2015	AHY	4	21.22	144	27.29	35.47	15.93	45.23	185
1094	05774	2015	AHY	4	20.57	138	29.52	36.11	15.43	44.73	185
1094	10964	2015	AHY	4	21.39	159	29.64	36.01	15.14	46.42	215
1094	10965	2015	AHY	5	22.89	141	31.54	33.51	15.6	47.73	186
1094	05775	2015	AHY	3	21.67	133	27.66	34.08	15.72	42.38	190
1094	05779	2015	AHY	10	21.79	145	31.88	38.69	16.06	47.5	209
1094	05780	2015	AHY	2	21.77	140	30.98	36.89	15.66	47.32	205
*1703**	04055	2015	AHY	2	22.17	146	25.98	35.08	15.29	48.89	186
1094	05784	2015	HY	3	20.52	126	27.53	34.98	14.81	44.57	162
1094	05788	2015	AHY	5	22.25	150	28.47	38.19	15.64	46.29	184
1094	05793	2015	HY	4	21.11	140	27.45	38.4	17.01	46.09	169
1094	05797	2015	AHY	4	21.82	134	30.39	37.44	16.05	47.99	166
1094	05798	2015	HY	5	19.62	136	27.1	35.83	15.5	44.27	169

1094	05799	2015	HY	3	22.11	132	28.57	34.37	16.2	47.2	160
1094	10919	2015	AHY	4	21.9	138	29.34	35.67	17.58	48.26	215
1094	10920	2015	AHY	3	21.15	147	30.63	33.04	18.03	43.07	175
1094	10921	2015	HY	4	20.05	125	26.7	33.78	17.83	45.21	173
1094	10943	2015	AHY	0	21.81	152	33.18	35.25	15.94	48.07	210
1703 *	04022	2015	AHY	2	22.91	150	29.13	33.24	18.19	47.45	192
1094	06539	2015	AHY	0	20.52	151	26.94	35.14	15.44	47.01	183
1094	06550	2015	AHY	5	20.78	150	29.68	36.64	15.45	47.89	201
1094	11026	2015	AHY	5	20.34	142	32.54	37.28	17.12	48.27	171
1094	11027	2015	AHY	0	20.31	149	30.08	39.37	15.18	47.43	202
1094	11030	2015	AHY	5	22.87	140	31.86	39.49	17.68	49.41	174
1094	11032	2015	AHY	7	20.77	143	29.33	32.17	15.49	47.46	205
1094	11036	2015	AHY	6	20.16	142	28.77	36.24	15.08	48.89	216
1094	11037	2015	HY	5	20.52	138	29.42	34.37	15.54	46.3	172
1094	11038	2015	AHY	5	20.3	141	29.93	37.8	15.05	45.69	196
1693 *	14270	2015	AHY	5	21.42	149	30.28	36.54	15.76	46.46	192
1094	11049	2015	AHY	8	20.93	150	29.86	37.22	16.05	49.89	211
1094	11052	2015	AHY	5	19.98	144	29.26	36.61	15.96	49.32	237
1094	11053	2015	HY	2	20.76	141	30.09	35.57	18.35	45.82	158
1094	11060	2015	AHY	4	19.07	143	28.65	37.47	15.97	41.58	175
1094	11068	2015	AHY	4	20.19	152	30.04	38.31	15.43	46.07	199
1094	11071	2015	AHY	4	20.4	145	30.98	35.92	16.63	45.65	167
1094	11080	2015	AHY	7	20.29	147	30.93	36.17	15.91	48.01	195
1094	11082	2015	AHY	4	20.06	144	28.14	38.74	15.74	45.97	198
1094	11086	2015	AHY	5	20.68	148	30.37	37.25	15.24	48.07	202
1094	11095	2015	AHY	3	19.71	142	28.95	36.23	15.56	43.41	175
1094	11096	2015	AHY	5	19.52	148	30.47	36.24	15.06	46.46	193
1094	11098	2015	AHY	4	19.86	147	29.55	36.6	15.07	47.12	203
1094	11105	2015	AHY	4	19.48	144	29.9	36.19	15.14	45.74	188
1094	11113	2015	AHY	3	20.35	143	29.35	36.84	15.08	47	178
1094	11114	2015	AHY	4	20.56	145	28.91	35.92	15.72	46.59	174

1094	11117	2015	HY	4	18.93	139	28.87	34.55	15.43	45.46	166
1094	11124	2015	HY	1	20.05	137	29.33	35.84	19.41	44.76	138
1094	11126	2015	AHY	4	19.58	154	30.79	38.99	16.01	48.78	233
1094	11127	2015	AHY	1	20.16	145	29.41	37.26	16.06	46.78	202
1094	11130	2015	HY	5	19.89	144	28.57	35.86	14.92	48	179
1094	11135	2015	HY	6	21.17	140	29.71	37.74	16.13	48.87	171
1094	11137	2015	HY	6	19.68	139	28.47	35.12	14.86	45.34	161
1613	07929	2015	AHY	4	20.6	150	30.52	38.33	15.95	50.09	203
1094	11139	2015	HY	4	21.02	140	30.52	37.56	17.05	47.21	172
1094	11143	2015	AHY	3	21.69	150	31.26	39.33	16.81	49.37	212
1094	11144	2015	AHY	3	20.66	144	29.08	36.32	16.11	47.2	188
1094	11145	2015	AHY	3	20.18	146	28.92	37.06	16.11	46.82	182
1094	11146	2015	HY	5	20.17	139	27.75	34.79	15.74	48.27	164
1094	11148	2015	AHY	4	20.89	151	31.48	39.83	15.9	48.19	180
1094	11149	2015	HY	6	18.8	133	30.61	36.15	16.4	44.98	155
1094	11158	2015	HY	3	19.95	144	30.1	38.84	15.88	47.87	165
1094	11160	2015	HY	1	20.21	139	29.6	35.72	16.44	16.99	122
1094	11162	2015	HY	3	19.46	139	28.81	35.61	16.02	46.35	153
1094	11163	2015	HY	4	20.84	142	31.68	36.89	15.71	47.68	140
1094	11175	2015	HY	2	21.1	144	25.71	35.26	18.69	44.13	131
1094	11176	2015	AHY	5	21.3	149	30.93	37.51	16.56	48.42	180
1094	11177	2015	HY	3	20.59	143	31.69	35.83	16.36	46.98	132
1094	06481	2015	HY	2	19.5	140	29.89	35.86	16.51	46.26	151
1094	06482	2015	AHY	9	19.51	140	29.55	34.18	14.94	47.74	174
1094	06483	2015	AHY	5	21.08	142	27.72	36.45	16.39	48.51	204
1094	06484	2015	AHY	6	21.09	149	31.34	37.91	15.71	47.28	212
1094	06485	2015	AHY	7	20.82	141	26.69	37.75	16.06	48.61	184
1094	06486	2015	AHY	5	18.45	146	30.97	37.08	14.22	45.88	210
1094	06487	2015	HY	5	19.54	139	31.81	36.27	16.79	47.01	180
1094	06488	2015	AHY	5	21.66	150	33.66	38.91	17.67	50.46	229
1094	06493	2015	HY	4	19.82	135	30.73	34.85	15.11	45.83	151

1094	06494	2015	AHY	5	21.26	145	30.15	37.14	17	48.84	200
1094	06495	2015	AHY	5	20.79	146	29.51	37.26	16	48.14	182
1094	11192	2015	HY	4	20.36	141	31.8	38.97	17.02	49.34	171
1094	11193	2015	AHY	4	20.81	149	32.31	38.29	17.83	49.41	212
1094	10989	2015	AHY	6	20.44	145	31.91	38.43	15.69	48.95	208
1094	10997	2015	HY	2	21.98	142	30.41	37.1	18.33	46.54	159
1094	10999	2015	AHY	7	21.56	149	31.46	37.15	16.43	47.39	212
1094	36702	2016	AHY	2	21.71	144	27.67	35.18	16.05	48.55	206
1094	37605	2016	AHY	1	20.26	143	29.3	37.69	16.59	47.55	196
1094	36706	2016	AHY	2	27.72	151	29.87	36.52	17.47	48.2	217
1094	36715	2016	HY	3	21.67	128	27.05	33.77	16.52	46.32	144
1094	36716	2016	HY	4	19.84	139	27.65	35.3	15.47	44.54	160
1094	36721	2016	HY	2	21.01	135	29.71	34.58	18.68	46.02	148
1094	36723	2016	AHY	3	22.63	149	32.38	38.09	17.28	47.35	205
1094	36727	2016	HY	1	19.06	135	27.35	35.97	18.7	46.2	109
1094	36729	2016	AHY	3	20.99	147	30.66	37.66	16.53	44.33	203
1094	36730	2016	AHY	1	21.07	148	31.24	36.13	17.44	48.02	201
1094	36734	2016	HY	1	20.27	132	30.25	35.96	18.8	47.95	147
1094	36735	2016	HY	3	20.78	138	28.12	34.92	17.84	48.59	152
1094	36743	2016	HY	3	20.71	136	31.61	37.16	16.79	47.83	152
1094	36747	2016	AHY	2	21.45	154	31.18	35.83	16.65	48.32	222
1094	36749	2016	AHY	1	21.57	146	32.53	36.44	16.6	48.67	195
1094	36751	2016	AHY	4	20.27	147	28.4	32.81	15.33	47.87	178
1094	37701	2016	AHY	3	17.93	144	27.32	36.36	15.33	45.74	179
1094	37702	2016	AHY	3	20.17	155	29.78	36.18	15.5	46.96	206
1094	37703	2016	AHY	1	20.29	148	28.43	36.14	15.37	45.95	182
1094	37705	2016	AHY	3	19.98	140	28.96	34.36	15.73	47.15	212
1094	37707	2016	AHY	3	19.52	145	27.5	35.51	16.66	45.58	180
1094	37708	2016	AHY	4	20.99	141	31.14	37.81	16.79	48.29	183
1094	37709	2016	AHY	3	20.77	14	29.48	37.33	16.79	48.55	202
1094	37715	2016	HY	1	19.85	136	28.95	35.6	18.8	47.26	130

1094	37719	2016	AHY	3	19.83	141	29.16	36.72	17.66	46.64	178
1094	37759	2016	HY	5	21.21	140	28.44	35.28	17.14	48.06	148
1094	37761	2016	HY	6	20.92	139	30.88	36.97	17.5	48.17	168
1094	37762	2016	HY	1	17.86	140	28.78	36.48	18.73	47.2	147
1094	37763	2016	AHY	4	22.72	143	29.55	37.89	17.51	50.15	204
1094	37771	2016	AHY	5	19.18	141	29.15	35.21	15.63	48.99	165
1094	37775	2016	HY	7	17.73	143	30.55	35.45	14.54	44.87	172
1094	37776	2016	HY	5	21.84	140	30.6	38.76	17.76	47.78	180
1094	37777	2016	AHY	4	21.4	154	32.38	41.96	18.05	48.63	213
1094	37779	2016	AHY	3	22.03	149	28.31	36.92	16.33	47.5	198
1094	37783	2016	HY	6	20.35	139	29.84	37.86	15.94	48.59	172
1094	37793	2016	AHY	5	22.73	141	27.97	35.7	16.58	51.78	162
1094	37810	2016	AHY	3	22.05	149	28.23	36.23	16.72	47.68	185
1094	37811	2016	AHY	6	21.21	147	28.57	36.91	16.91	49.19	182
1094	37813	2016	AHY	3	21.29	154	31.72	38.53	16.47	48.87	215
1094	37855	2016	HY	3	20.58	138	30.26	35.85	15.84	45.19	145
1094	37869	2016	AHY	4	19.47	147	28.87	35.18	14.79	45.06	188
1094	37870	2016	AHY	0	20.24	142	31.59	34.34	16.11	46.19	171
1094	37896	2016	AHY	3	20.6	153	30.91	36.1	16.11	47.37	210
1094	37899	2016	AHY	4	19.51	148	28.38	34.42	15.54	44.03	190

*Banded before 2015.

Notes: Prefix and suffix refer to leg band. Age for hatch year birds given as “HY” and for after hatch year birds as “AHY.” Molt refers to primary feather replacement. Bill measured from behind gape to tip of beak. Culmen measured as top portion of bill in front of eye to tip of beak. Head measured from back of head behind eye to tip of beak.

APPENDIX C

Table C.1. Morphological data and banding information from 2016 recaptured white-tipped doves.

Prefix	Suffix	Month	Day	Molt	Bill	Wing	Toe	Tarsus	Culmen	Head	Mass	Band Year
1094	11135	6	2	3	20.85	138	29.31	32.61	15.3	46.31	204	2015
1094	11038	6	4	0	19.17	144	27.21	37.7	16.13	46.84	161	2015
1094	11082	6	6	2	20.28	148	30.07	37.2	16.41	46.23	200	2015
1094	05757	6	6	2	20.6	150	31.68	37.62	15.58	47.88	195	2015
1703	04022	6	6	2	21.92	151	28.25	33.23	17.78	47.64	180	2009
1094	05720	6	7	3	20.08	149	29.46	35.52	15.32	48.64	210	2015
1094	11135	6	7	3	20.58	138	28.44	36.62	15.53	46.5	198	2015
1693	14270	6	8	2	21.3	149	30.3	35.24	16.74	47.31	200	2009
1094	11098	6	22	3	19.54	148	28.26	36.62	16.52	46.88	199	2015
1094	10926	6	24	1	17.73	147	28.82	37.88	16.95	48.42	201	2015
1094	11095	6	27	4	18.99	147	28.76	35.58	15.81	46.1	170	2015
1094	06486	6	27	4	17.08	144	31.86	35.28	15.08	47.08	202	2015
1094	05750	6	29	4	20.89	147	29.16	35.4	17.84	46.65	162	2015
1094	05758	6	29	4	22.47	150	33.16	38.14	17.2	49.73	201	2015
*1613**	07929	7	1	4	21.27	152	26.67	36.72	17.04	43.19	215	2008
1094	01193	7	1	3	21.58	153	29.82	36.85	16.89	49.25	208	2015
1094	11105	7	3	6	19.1	147	31.2	35.87	14.91	45.39	201	2015
1094	11049	7	3	4	21.59	149	30.46	36.23	17.25	49.34	195	2015
1094	05772	7	3	6	20.47	153	28.58	36.84	16.64	46.47	190	2015
1094	11113	7	3	4	20.27	145	31.1	35.95	15.85	46.8	189	2015
1094	05751	7	5	3	19.55	149	31.1	36	15.88	46.17	182	2015
1094	06550	7	5	4	20.11	149	30.81	36.89	17.1	48.57	197	2015
1094	05772	7	6	6	21.27	146	29.29	34.34	17.08	47.1	188	2015
1094	06484	7	6	5	20.17	151	29.61	35.79	16.28	49.8	199	2015
1094	11193	7	6	3	21.18	154	29.39	37.36	17.14	48.75	223	2015

*New longevity record for species.