INFLUENCES OF VEGETATION CHARACTERISTICS AND INVERTEBRATE ABUNDANCE ON RIO GRANDE WILD TURKEY POPULATIONS, EDWARDS PLATEAU, TEXAS

A Thesis

by

CHARLES JACK RANDEL III

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2003

Major Subject: Wildlife and Fisheries Sciences

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Approved as to style and content by:

Nova J. Silvy (Co-Chair of Committee)	Markus J. Peterson (Co-Chair of Committee)
Fred E. Smeins (Member)	Robert D. Brown (Head of Department)

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ABSTRACT

Influences of Vegetation Characteristics and Invertebrate Abundance on Rio Grande Wild Turkey Populations, Edwards Plateau, Texas.

(December 2003)

Charles Jack Randel III, B.S., University of Nebraska

Co-Chairs of Advisory Committee: Dr. Nova J. Silvy
Dr. Markus J. Peterson

Since 1970, Rio Grande wild turkey (*Meleagris gallapavo intermedia*) numbers in the southern region of the Edwards Plateau of Texas have been declining. Nest-site characteristics and invertebrate abundance were hypothesized as limiting wild turkey numbers in declining regions.

Wild turkeys were trapped and fitted with mortality-sensitive radio transmitters on 4 study areas; 2 within a region of stable (northern Edwards Plateau) populations, and 2 within a region of declining populations. Monitoring occurred from February 2001 to August 2003. Nest-site locations were determined via homing during the breeding season. Following nesting attempts/completions, nest fate, vegetation height, visual obstruction, litter depth, percent cover, and cover scores of forbs, grass, litter, and bare ground at each nest site and surrounding area were sampled. This was done to determine if wild turkey hens selected nest sites with vegetative characteristics differing from surrounding habitat. Brood survival was calculated as >1 poult surviving to 2-weeks. Broods were followed for 6-weeks post-hatch or to brood failure. Invertebrates were collected, via sweep-net and D-vac, at each visually confirmed brood location and a paired random site to determine if wild turkey hens selected brood habitat based on invertebrate abundance. Analyses were performed to determine if invertebrate abundance differed between study regions.

Turkey hens selected nest sites with greater visual obstruction and more litter depth on both regions of stable and declining turkey abundance. No vegetative differences were detected between stable and declining region nest sites. Frequency of Orthoptera was 3–5 times greater at nest sites on stable regions than declining regions in all 3 years. Orthoptera is a noted food source for young galliformes and comprised the majority of dry mass in invertebrate samples, nest sites and brood locations, on both the stable and declining regions. No differences in total invertebrate dry mass were detected between regional brood locations. Nest-site vegetative characteristics did not alter nest success between regions.

The 2 overall objectives of this study were to determine if nest-site vegetation characteristics and invertebrate abundance affected wild turkey numbers in the Edwards Plateau. Regional differences in vegetative characteristics were not detected, thus not likely to be causing differences in turkey numbers between regions. Nest-site invertebrates were found to be 3–5 times greater at stable region nest sites, possibly giving wild turkey poults from stable regions greater initial chances of survival.

ACKNOWLEDGEMENTS

I would like to thank Dr. Nova J. Silvy and Dr. Markus J. Peterson, committee co-chairs for allowing me to work with them on this project. I am grateful for the opportunity to have been able to work closely with them over the past 2 years. I also would like to thank Dr. Fred E. Smeins, committee member, for taking time to guide me both with research and in the classroom. All 3 of these men are exceptionally bright individuals and have taught me a great deal, not all of it wildlife related. Again, I am happy to have been associated with all 3.

I am indebted to the following turkey project graduate students; Dustin Jones, Jody Schaap, and Beau Willsey. Dustin, thanks for having the patience to show me all the details of tracking when I first arrived. Jody, thanks for dealing with my strong personality throughout. Beau, thanks for getting me out of tracking all those times you "broke down" and needed someone to retrieve you and Weiner dog off a ranch.

I would be remiss if I also didn't thank our summer technicians Dean Marquart (2002) and John Michael Hairston (2003) for all the assistance they rendered with tracking and vegetation work. I would like to thank Kerr Wildlife Management Area staff: Donnie Frels Jr., Gene Fuchs, Bill Armstrong, Pablo Gutierrez, Chad Meadows, Jay Carroll, Leroy Fuchs, Mark Edinburgh, and Ebie Gray for their help with the project. Ray Aguirre deserves many thanks for all his help with trapping and helping us locate willing landowners for this project.

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CHAPTER I

INTRODUCTION

Rio Grande wild turkey (RGWT, *Meleagris gallopavo intermedia*) numbers prior to westward expansion across North America were estimated to be between 1.8–2 million birds (Beasom and Wilson 1992). By 1920, wild turkey populations had been eliminated from 18 of 39 states where they had originally occurred (Mosby and Handley 1943). Numbers in Texas from 1928–1940 were estimated at 100,000 birds (Anonymous 1929, Schorger 1966:455). This estimation marked a new low in RGWT numbers compared to historic population figures. Following this low, efforts to enhance turkey numbers increased in many areas and included relocation of RGWTs into both historic and new ranges (Gore 1969). The Edwards Plateau (EP) of Texas has been noted as the geographic center of the RGWTs range (Merrill 1975, Baker 1979, Bareiss et al. 1986), with historically high turkey densities. Following successful reintroduction of RGWTs into other states, such as Oklahoma and Kansas, RGWT numbers in the EP remained stable until the late 1960s and early 1970s (Markus Peterson, TPWD, unpublished data).

In the mid-1970s, Texas Parks and Wildlife Department (TPWD) biologists noticed declining numbers of RGWTs in the southern portion of the EP, while populations in the northern EP remained unchanged (Markus Peterson, TPWD,

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This thesis follows the format and style the Journal of Wildlife Management.

unpublished data). The decline is ongoing and of concern to TPWD, local landowners, and land managers. Causes of the RGWT decline in the southern EP are unknown.

With 3 decades of declining RGWT numbers, research was necessary to determine causes of this decline so it could be addressed through better informed management. Objectives of this study were to determine differences in: (1) vegetation characteristics that might limit RGWT nest success in the southern EP, and (2) determine differences in invertebrate dry mass and frequencies that might limit brood survival in the southern EP.

STUDY AREAS

Two study areas were selected within regions of declining turkey numbers and 2 study areas were selected within regions of stable turkey numbers. Study areas were located in Bandera, Real, and Kerr counties, Texas (Fig. 1.1). Study areas within stable regions were located in Real and Kerr counties. The Kerr County study area (stable study area 1) was approximately 4,843 ha and located northwest of Hunt, Texas. The Real County study area (stable study area 2) was approximately 984 ha and located north of Leakey, Texas. Two study areas within declining regions were located in Bandera County. One area was located northwest of Medina, Texas and was approximately 8,858 ha (declining study area 1). The second study area in Bandera County was south of Bandera, Texas, and was approximately 2,910 ha (declining study area 2). Study areas designated with a 2 were not added to the study until early (January-March) 2002.

Livestock grazing occurred on all study areas except that in Real County. Study areas located south of Bandera and in Kerr counties had calf-cow operations as a major source of income with lease hunting as a supplemental income. No turkey hunting occurred on any of the study areas. However, surrounding ranches allowed turkey hunting during the spring and fall hunting seasons.

The EP had a precipitation range of 38.1–83.8 cm from west to east (Gould 1962). Typically, rainfall was abundant in May and June as well as September. Soils of the EP were generally shallow, ranging in textures from dark clayey and loamy to moderately alkaline silty-clay to non-calcareous clay and clay loams, on a limestone base (Natural Resources Conservation Service 1990*a*, 1990*b*, 1991*a*, 1991*b*). A typical range site in the EP included adobe hills, shallow uplands, rough stony hills and deep soils (Gould 1962).

Predominate climax grasses included switchgrass (*Panicum verigatum*), bluestems (*Andropogon spp., Bothriochloa spp.,* and *Schizachyrium scoparium*), gramas (*Bouteloua spp.*), Indiangrass (*Sorghastrum natans*), wildrye (*Elymus spp.*), curly mesquite (*Hilaria belangeri*), and buffalograss (*Buchloe dacytloides*) (Gould 1962, Correll and Johnson 1970). Due to decreased fire frequency, there are now dense stands of Ashe juniper (*Juniperus ashei*) interspaced with live-oak (*Quercus fusiformis*) savanna (Fowler and Dunlap 1986, Miller et al. 1995). Land management practices such as high intensity, low frequency grazing regimes and prescribed burning of rangelands are currently being used to reduce the amount of Ashe juniper invasion and create a mosaic landscape for improved wildlife habitat (Bill Armstrong, TPWD, personnel communication).

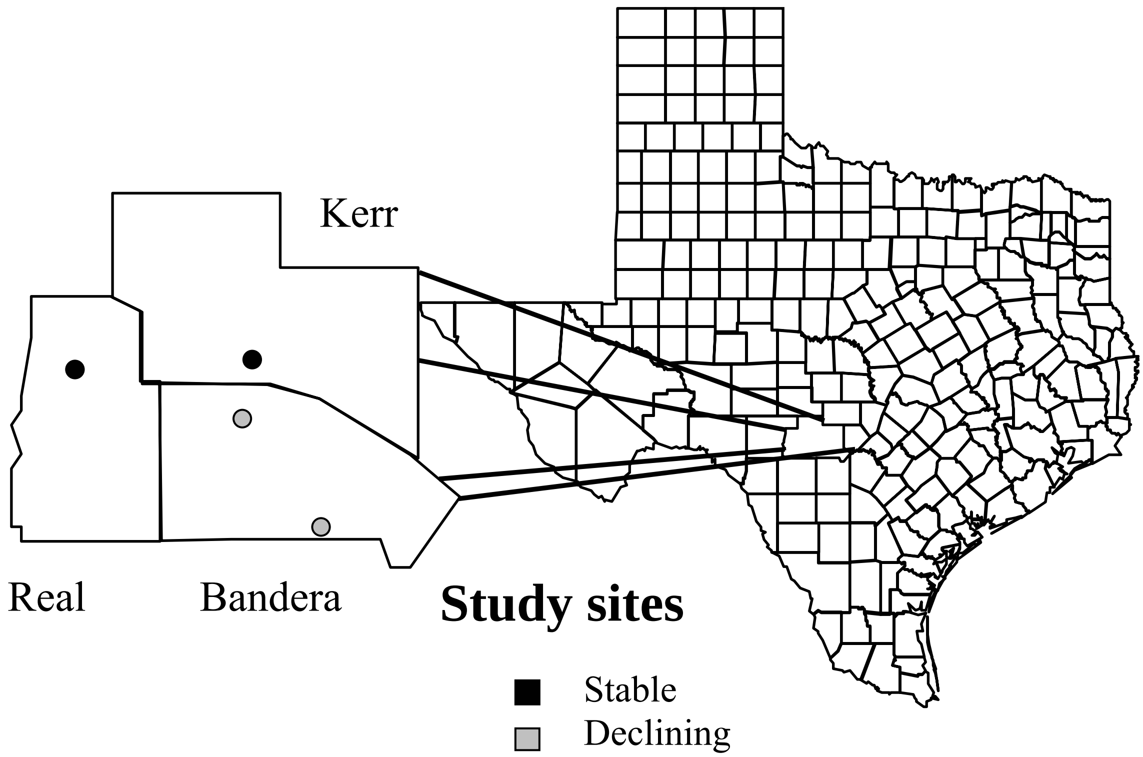

Fig 1.1. Location of study areas in stable and declining regions in the Edwards Plateau, Texas, 2001–2003.

CHAPTER II

NEST-SITE CHARACTERISTICS

Rio Grande wild turkeys are ground nesting birds, because of this nest-site habitat is critical to nest success. Nest fate has been identified as important to the long-term viability of populations of RGWT by affecting the annual recruitment into a population (Everett et al. 1980, Vander Haegen et al. 1988). Cook (1972) stated that over a 4-year period (1968–1971), 61.2% of RGWT nests failed (produced 0 poults). Similar studies on nesting ecology found nest failure rates ranging from 90% over the 1983–1984 nesting season on the Welder Wildlife Refuge of south Texas (Ransom et al. 1987) to 0% nest failure of Merriam's wild turkey (*M. g. merriami*) in New Mexico (Jones 1981).

Nest-site location also is important to brood survival ($\geq$1 poult surviving to 14 days). After hatching, poults can spend up to 24 hours in the area adjacent to the nest (Cook 1972). Additionally, wild turkeys may select nest sites based on proximity to brood-rearing habitat, with the distance from brood-rearing locations becoming less as the reproductive season progresses (Lazarus and Porter 1985). During this period, poults begin feeding on solid foods as the yolk sac is absorbed. Poults need higher amounts of protein than adults during this period of rapid growth (Hurst 1992). The majority of dietary protein for poults is obtained from invertebrate matter.

The overall objective of this study was to determine if nest site vegetative characteristics could be influencing RGWT population trends in the northern and southern EP. Specific objectives were to determine if: (1) there were differences in nest success between regions of stable and declining turkey populations, (2) there were differences in vegetation characteristics at nest sites between regions of stable and declining turkey populations, and (3) hens selected areas of vegetation differing from vegetation in surrounding areas. Research hypotheses were: (1) nest success will be higher in stable regions of RGWT populations than in declining regions of RGWT populations, (2) there were no differences in vegetation characteristics of RGWT nest sites between stable and declining regions of RGWT populations, and (3) RGWT hens do not select nest sites based on vegetation characteristics.

METHODS

Trapping of RGWT occurred during winter 2001–2003 with the collaboration of TPWD personnel. Walk-in funnel traps (Davis 1994, Peterson et al. 2003) were used to trap turkeys. Study areas were pre-baited with milo and cracked corn to determine areas of RGWT activity. Once turkeys were observed using the bait, traps were erected.

Trapping occurred from early to mid-morning (0500-1100 hours). Birds were removed from traps when numbers were deemed sufficient or signs of stress (e.g., attempted flight while in trap, increased pecking among birds, or decreased feeding activity) were observed. Turkeys were removed from traps using a golf club shaft modified with a shepherd's crook on the end. After each RGWT was hooked by the legs and removed from the trap, it was immediately placed into a darkened plywood box (1m X 1m X 0.5m) constructed of marine grade, 1.9-cm plywood until processing occurred.

Processing of RGWT involved a physical inspection of the bird for external injuries and parasites. Information taken from each bird was: body mass (fish scales

[Berkley Fishing, Spirit Lake, Iowa, USA]), sex, and age (juvenile or adult). Birds were fitted with an aluminum numbered leg band (supplied by TPWD with individual identification numbers and TPWD mailing address) and a mortality sensitive radio-transmitter (Advanced Telemetry Systems Inc, Isanti, Minnesota, USA). Blood samples also were taken via jugular puncture and later used to determine disease presence within the RGWT populations. Once released, all birds were observed to determine if they ran or flew after release, and if they were having trouble adjusting to the transmitters.

Monitoring

After trapping, RGWT were followed using radio-telemetry techniques (Samuel and Fuller 1996) until either transmitters failed or death occurred. Rio Grande wild turkeys were usually tracked 3 times per week. Tracking was performed with established georeferenced radio-telemetry receiving stations on the 4 study areas and referenced on topographical maps. Daily locations were determined by taking individual signals from ≥3 stations with signal directions (determined by compass) plotted on a map to determine location polygons for each given bird.

When RGWT hens were located in the same area >3 times, nest initiation was assumed to have occurred. If hens remained at the same location > 6 times (2 weeks) an attempt was made to locate the nest. Nest-site location was determined by walking with a hand-held 3-element yagi antenna and tracking receiver (Advanced Telemetry Systems Inc, Isanti, Minnesota, USA) and circling the hen. Nesting hens were monitored >3 times per week with radio-telemetry. Nest fate was determined when hens were found off the nest > 2 times in succession. This was done to lower the chances of disturbing nesting hens that were feeding or watering at time of radio-telemetry locations.

After nest sites were located, hens were monitored 3 times per week to determine hatch date or cause of nest failure. Post-hatching hens were monitored 3 times per week for 6 weeks. Six weeks was chosen because poults feed primarily on invertebrates during this period, but thereafter have diets similar to adults (Hurst 1992). Brood habitat was determined by visually locating hens with poults via radio telemetry.

Vegetation Analysis

Tree density, shrub density, and tree canopy coverage at brood locations were determined using a point-center-quarter (PCQ) method (Cottam and Curtis 1956). Measurements taken were distance to nearest tree (height > 2 m), shrub (height < 2 m), and edge (i.e. rivers, fences, and roads) in 4 quadrants centered at the nest site, and a mean calculated for each variable.

A 20 X 50 cm-quadrat frame (Daubenmire 1959), constructed of 1.3 cm diameter PVC pipe, was used to determine percent bare ground, forbs, and grass at nest sites and 10 m from the nest site in the 4 cardinal directions. Percent cover was determined using 1-6 scale following Daubenmire (1959). Additional measurements taken within the quadrat frame were vegetation height (measured from the base of the stem to the apex of the plant, with a measuring tape) and litter depth (measured by inserting a metal pin with 0.5-cm markings into the litter) in the 4 corners of the quadrat frame. Measurements taken from quadrats from the 4 cardinal directions were averaged during data analysis.

A Robel pole (Robel et al. 1970) was used to determine horizontal obstruction of vision (OV). The Robel pole was placed in the center of the nest site, and 10 m from the center of the nest in the 4 cardinal directions. Measurements taken at the 4 cardinal directions were averaged during data analysis.

Statistical Analysis

Vegetation characteristics were analyzed three separate ways. Firstly vegetation was analyzed between years to determine differences occurring over the 3 study years. Secondly vegetation was analyzed to determine differences between study regions within a given year. Thirdly vegetation was analyzed based on study region to determine if RGWT hens selected vegetation characteristics at random for nest sites from the immediately adjacent areas. Data were analyzed to check for the assumption of normality and was found to be non-normal, therefore, non-parametric tests were used in analysis.

Kruskal-Wallis tests were used to compare nest sites of stable and declining regions between years (2001-2003). Tests were performed on the means of cover height, percent cover, OV at the nest site and at the surrounding areas, vegetation height at the nest site and surrounding areas, litter depth at the nest site and surrounding areas, average edge distance, tree canopy area, tree density, and shrub density.

Mann-Whitney U tests were used to determine differences between regions of turkey abundance within years (i.e. stable 2001 vs. declining 2001). Tests were used in analyses of the means for cover height, percent cover, OV at nest and surrounding area, vegetation height at nest and surrounding area, litter depth at nest and surrounding area, average edge distance, tree canopy area, tree density, and shrub density.

Wilcox tests were conducted on vegetation characteristics (OV, vegetation height, litter depth, forbs score, grass score, litter score, and bare ground score) taken from stable and declining nest sites and the respective surrounding areas. Tests were performed to determine if RGWT hens selected vegetation characteristics in significantly greater or lower proportion to those available in the surrounding areas of the same region. Statistical Package for the Social Sciences (SPSS) statistical software (SPSS Inc. 2003, Chicago, Illinois, USA) was used to analyze data.

RESULTS

Nest success for 2001 was 47% on the stable region and 55% on the declining region (D. A. Jones, Texas A&M University, unpublished data). Nest success for 2002 was 16% on the stable region and 16% on the declining region. Nest success rates for 2003 were 40% on the stable region and 25% on the declining region. For the 3-year study, combined nests in the stable region (n = 37) had a success rate of 36%, while nests (n = 36) on the declining regions had a success rate of 42%.

Study areas from stable and declining regions were compared over the 3-year period. No statistical differences were found between nest sites at the 2 study areas within the stable region. When nest sites in study areas within the declining region were compared between years, results showed less (P = 0.012) vegetation height at the nest site in 2002, greater (P = 0.021) vegetation height surrounding nest sites in 2003, and greater (P = 0.022) litter depth at nest sites in 2002 (Table 2.1).

Comparisons of 2001 ($n = 35$) nest-site-vegetation characteristics between stable and declining regions showed greater ($P = 0.034$) average edge distance on stable study regions (Table 2.2). Due to low sample size in 2002 ($n = 25$) and 2003 ($n = 13$), data from 2002 and 2003 nest sites were pooled for analysis. No statistical differences were detected when pooled 2002 and 2003 vegetation characteristics at nest sites in stable and declining regions were compared (Table 2.2).

Rio Grande wild turkey hens on both stable and declining regions selected nest sites with greater visual obstruction ($P_{stable} < 0.0001$, $P_{declining} < 0.0001$), shorter vegetation height ($P_{stable} = 0.004$, $P_{declining} < 0.0001$), greater litter depth ($P_{stable} < 0.0001$, $P_{declining} = 0.002$), less forb cover ($P_{stable} = 0.001$, $P_{declining} = 0.002$), less grass cover ($P_{stable} = 0.002$, $P_{declining} = 0.003$), greater litter cover ($P_{stable} < 0.0001$, $P_{declining} < 0.0001$), and less bare ground cover ($P_{stable} < 0.0001$, $P_{declining} < 0.0001$) (Table 2.3).

Table 2.1. Vegetation characteristics at nest sites (N) and surrounding areas (S) in regions of stable and declining Rio Grande wild turkey populations, Edwards Plateau, Texas, 2001–2003.

	Stable			Declining		
	2001 (n = 17)	2002 (n = 12)	2003 (n = 5)	2001 (n = 18)	2002 (n = 13)	2003 (n = 8)
Vegetation characteristics	$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)
Percent cover	71.7 (6.2)	74.5 (7.5)	38.8 (13.2)	71.3 (7.6)	63.3 (9.7)	56.4 (14.4)
Cover height (m)	0.5 (0.1)	0.3 (0.04)	2.1 (1.8)	3.6 (3.3)	0.3 (0.04)	0.2 (0.1)
Robel pole (dm) (N)	5.1 (0.7)	4.6 (1.06)	3.9 (0.9)	4.6 (0.8)	5.2 (0.8)	3.5 (1.4)
Robel pole (dm) (S)	6.0 (0.3)	2.2 (0.7)	1.9 (0.4)	1.7 (0.3)	2.6 (0.8)	2.1 (0.2)
Vegetation height (cm) (N)	12.2 (4.4)	10.6 (7.0)	10.6 (4.5)	9.0 (5.5)	7.6* (1.9)	15.5 (2.5)
Vegetation height (cm) (S)	12.6 (1.5)	20.6 (3.8)	20.4 (5.8)	10.2 (2.1)	19.5 (3.2)	24.4* (6.3)
Litter depth (cm) (N)	4.5 (0.7)	5.6 (1.0)	3.1 (0.7)	3.6 (0.4)	4.9* (0.9)	3.8 (0.3)
Litter depth (cm) (S)	1.4 (0.3)	2.2 (0.4)	4.1 (1.9)	1.7 (0.4)	3.9 (0.9)	1.9 (0.5)
Trees (trees/ha)	926.8 (594.4)	528.2 (260.4)	2,312.3 (4,243.5)	215.6 (96.1)	176.7 (63.3)	1,688.8 (3,478.1)
Canopy area (m2)	42.1 (10.1)	43.7 (12.8)	127.9 (145.1)	38.8 (6.2)	53.5 (9.2)	97.8 (70.5)
Edge (m)	62.1 (6.4)	51.1 (11.2)	46.2 (7.9)	7.6 (5.6)	44.1 (8.2)	81.3 (15.3)
Shrubs (shrubs/ha)	177,037.8 (138,401.4)	607,399.6 (51,881.8)	169,791.8 (353,878.7)	10,695.6 (5,624.0)	29,295.2 (16,826.6)	84,72.3 (15,585.1)

* Significant at $P < 0.05$

Table 2.2. Vegetation characteristics comparisons, mean (standard error), at nest sites (N) and surrounding areas (S) in regions of declining and stable Rio Grande wild turkey populations, Edwards Plateau, Texas, 2001–2003.

	2001		2002/ 2003	
Vegetation characteristics	Declining (n = 18) $\bar{x}$ (SE)	Stable (n = 17) $\bar{x}$ (SE)	Declining (n = 21) $\bar{x}$ (SE)	Stable (n = 17) $\bar{x}$ (SE)
Percent cover	71.3 (7.6)	71.7 (6.2)	54.4 (7.0)	59.4 (6.8)
Cover height (m)	3.6 (3.3)	0.5 (0.1)	0.8 (0.6)	0.9 (0.6)
Robel pole (dm) (N)	4.6 (0.8)	5.1 (0.7)	4.5 (0.6)	4.1 (0.6)
Robel pole (dm) (S)	1.7 (0.3)	1.6 (0.3)	2.3 (0.4)	2.1 (0.4)
Vegetation height (cm) (N)	9.0 (5.5)	12.2 (4.4)	10.0 (1.8)	11.6 (3.6)
Vegetation height (cm) (S)	0.2 (2.1)	12.6 (1.5)	20.7 (2.6)	21.3 (2.8)
Litter depth (cm) (N)	3.6 (0.4)	4.5 (0.7)	4.1 (0.5)	4.4 (0.6)
Litter depth (cm) (S)	1.7 (0.4)	1.4 (0.3)	3.8 (0.7)	2.9 (0.7)
Tree (trees/ha)	215.6 (96.1)	926.8 (594.4)	1,121.9 (569.4)	1,545.1 (628.5)
Canopy area (m2)	38.8 (6.2)	42.1 (10.1)	166.3 (26.7)	144.4 (30.7)
Edge (m)	47.6* (5.6)	62.1* (6.4)	48.5 (5.8)	52.6 (6.6)
Shrub (shrubs/ha)	10,695.6 (5,624.0)	'7,037.8 (138,401.4)	68,520.5 (40,035.2)	362,062.1 (259,764.0)

*Significant at $P < 0.05$

Table 2.3. Vegetation characteristics, mean (standard error), at nest sites and surrounding areas in regions of declining and stable Rio Grande wild turkey populations, Edwards Plateau, Texas, 2001–2003.

	Stable (n = 37)		Declining (n = 36)	
Vegetation characteristics	Nest	Surrounding	Nest	Surrounding
Robel pole (dm)	4.7* (0.5)	1.9* (0.3)	4.7* (0.5)	2.1* (0.3)
Vegetation height (cm)	11.4* (3.1)	16.9* (1.9)	9.4* (2.9)	15.5* (2.0)
Litter depth (cm)	4.5* (0.5)	2.4* (0.5)	4.1* (0.4)	2.5* (0.4)
Forb cover (%)	1.0* (2.5)	3.0* (0.5)	1.0* (0.5)	4.0* (1.0)
Grass cover (%)	4.0* (1.0)	21.0* (1.0)	3.0* (1.0)	11.0* (1.0)
Litter cover (%)	67.5* (3.0)	13.0* (1.0)	67.5* (1.0)	13.0* (1.0)
Bare ground cover (%)	2.0* (1.0)	11.0* (1.0)	2.5* (0.5)	11.0* (1.0)

*Significant at $P < 0.05$

DISCUSSION

Hens from the 4 study areas selected similar vegetation characteristics at nest sites. Hens also selected nest sites with greater visual obstruction, greater litter depth, and greater litter cover. Hens appeared to avoid areas with high grass, forb, or bare ground percent cover and areas of tall vegetation on all sites. Avoidance of areas with high percent scores for grass, forbs, and bare ground could be a relic of nest-site selection of areas with high OV, as areas with high OV tends to occur within shrubs which would reduced the amount of grass, forbs, and bare ground. Trends in these data were similar for RGWT hens in both stable and declining regions, suggesting no behavioral differences between populations. My results were similar to those found in other studies of RGWT nesting. For example, RGWT hens in northeast Colorado had nest plots that were characterized by greater canopy cover, more shrubs, fewer grasses, and greater under story cover, than random paired plots (Schmutz et al. 1989). Similarly, Lutz and Crawford (1987) found that RGWT hens in Oregon selected nest sites with significantly ($P < 0.05$) higher shrub densities and visual obstruction values.

Vegetation characteristics of the 2 stable study areas showed no statistical differences between years, suggesting vegetation characteristics remained relatively consistent between years on stable areas. Vegetation characteristics of the 2 declining study areas showed more variability, such as, greater vegetation height and litter depth at nest sites in 2002 than other years, and greater surrounding area vegetation height in 2003. Greater average edge distance on the stable region in 2001 was the only difference detected between regions. Our findings are consistent with the notion that hens select nest sites with more dense vegetation than surrounding areas to increase concealment and to better see approaching predators (Day et al. 1991).

One would expect, based on previously reported literature (Lutz and Crawford 1987, Schmutz et al. 1989, Day et al. 1991), that visual obstruction and litter depth at nest sites would have been greatest in 2001 when nest success was highest. This was not the case. Furthermore, vegetation characteristics appeared to remain relatively consistent on both stable and declining regions throughout this study, with the majority of differences found on declining study regions between years. While differences were found in vegetative characteristics at nest sites, large variation within the collected measurements could have confounded analysis and prevented accurate detection of relevant differences. Therefore, it is difficult to determine what, if any, influence vegetation characteristics were having on RGWT population trends in the EP.

In summary, hens appeared to select certain vegetation characteristics at nest sites. Further, there was no difference in nest success within years, but there were differences between years, which was consistent with the boom-bust population recruitment of many galliform bird species. Lastly, no differences were found between regions of stable and declining RGWT numbers in the EP. Based on this study, future research on nest site vegetation should focus on vegetation that is used as nesting substrates (i.e., grasses and shrubs). With more detail on preferred vegetation types of both nest site and surrounding habitat it may be easier to predict areas that could serve as potential nesting habitat. This could allow land-managers to determine areas needing special consideration during months of turkey nesting.

CHAPTER III

INVERTEBRATES

Invertebrates are a valuable food for young galliforms, including gray partridge (*Perdix perdix*; Southwood and Cross 1969, Potts 1970, Green 1984, Itamies et al. 1996, Panek 1997, Bro et al. 2000), willow grouse (*Lagopus lagopus*; Spidoso 1980), red grouse (*L. l. scoticus*; Moss 1972, Savory 1977, Park et al. 2001), greater sage grouse (*Centrocercus urophasianus*; Klebenow and Gray 1965, Johnson 1990), sharp-tailed grouse (*Tympanuchus phasianellus*; Mitchell and Riegert 1994), greater prairie chicken (*T. cupido*; Svedarsky and Van Amburg 1996), black grouse (Starling-Westeberg 2001), ring-necked pheasant (*Phasianus colchicus*; Hill 1985, Whitmore et al. 1986), common quail (*Coturnix coturnix*; Badenhort and Kerley 1996), and northern bobwhite (*Colinus virginianus*; Palmer et al. 2001).

Invertebrates comprise the majority of turkey poult diets through the 5th week post-hatch (Hurst 1992), and provide a valuable source of protein for growing birds. There are limited data, however, on invertebrates and their relation to survival of wild turkey poults. Based on the importance of invertebrates to the survival of young galliform birds of other species, there is a need to determine whether invertebrate availability is a factor in the decline of turkey populations on the southern EP.

In black grouse (*Tetrao tetrix*) and capercaillie (*T. urogallus*) nesting may be timed to converge with invertebrate emergence to meet nutritional requirements of young (Baines et al. 1996). It is unknown whether this occurs with Rio Grande wild turkey (RGWT).

The overall objective for this study was to determine if differences in invertebrate dry mass and frequency could be causing the differences in RGWT populations between the northern and southern Edwards Plateau (EP). Specific objectives were to determine differences in (1) invertebrate dry mass and frequencies (based on order) at nest sites, (2) invertebrate dry mass and frequencies (based on order) at brood-location sites, and (3) brood survival on study areas in both stable and declining regions.

Research hypotheses were: (1) stable regions of RGWT populations will have higher invertebrate dry mass and frequency at nest sites, (2) brood location invertebrate dry mass and frequency will be greater on stable regions than declining regions, and (3) brood survival will be greater on stable regions than declining regions.

METHODS

Invertebrate Collection

Invertebrates were collected at nest sites, brood-location sites, and a paired-random site using sweep nets (35 cm aperture [Forestry Suppliers Inc., Jackson, Mississippi, USA]) and suction sampling (22.9-cm aperture), also known as a Dietrick vacuum (D-vac, John W. Hock Company, Gainesville, Florida, USA). Sweep netting consisted of 25 sweeps at all sites (samplings transects, approximately 10 m, were centered over nest sites and brood-location sites) and were made at the nest site and at each brood-location site. At the same time sweep-net collections were being made, a D-vac collection also was made, and sampled an area of about 0.5 m^2. Suction samples were compensatory to sweep-net collections (i.e., sweep nets tended to sample flying invertebrates and invertebrates on the vegetation while the vacuum tended to sample invertebrates on the ground or in the litter). Invertebrate collections were made when a brood was observed to be feeding. Once feeding was determine to be occurring transects were taken following immediately behind the brood. Invertebrates collected were cataloged, based on order, to determine potential food for RGWT poults.

Random-paired-invertebrate collections were made to determine if hens were selecting areas with greater invertebrate abundance. A random-number generator was used to select a distance (between 200–800 m) from nest sites and brood-location sites for each paired-invertebrate collection. After the distance was determined, a random compass direction was assigned to determine locations of paired collections. Dry mass of invertebrates from nest sites, brood-location sites, and paired collections were used to determine if hens selected nest sites and brooding sites with greater invertebrate abundance than available at random sites. Sweep-net and D-vac collections were combined to obtain total dry mass of each collection site.

Invertebrates were placed in a freezer over night to facilitate sorting and massing procedures. After freezing, invertebrates were sorted based on taxonomic orders and massed. After initial mass was recorded, invertebrates were placed into a drier at 170 C and dried to a constant mass. In addition to sorting and massing, invertebrates were counted and frequency of occurrence of each order was determined for comparisons between stable and declining study sites.

Statistical Analysis

Descriptive statistics (means and standard errors [SE]) were used to describe invertebrate dry mass at nest sites, brood-location sites, and paired sites by year. The assumption of equal variance between samples was violated and prevented parametric (paired and 2 sample t-tests) and non-parametric analysis (Mann-Whitney U test) of dry masses. Frequency was calculated for all orders from all years at nest sites. Chi-squared analyses were performed to determine differences between frequencies of invertebrate orders at nest sites, brood-location sites, and paired sites as well as differences in brood survival between stable and declining sites.

RESULTS

Invertebrates at Nest Locations

Sixty invertebrate sweep-net samples (25 in 2001, 22 in 2002, and 13 in 2003) at nest sites were obtained (Table 3.1). Total invertebrate dry mass was found to be 3–5 times greater on stable region nest sites than on declining region nest sites (Fig. 3.1). Orthoptera occurred at a greater ($P < 0.0001$, 2001; $P = 0.014$, 2002; $P < 0.0001$, 2003) frequency on study areas within the stable region during all 3 years (Table 3.2). Lepidoptera and Homoptera occurred with greater ($P < 0.0001$) frequency study areas within the stable study region in 2001. Coleoptera, and Hemiptera occurred with greater ($P < 0.0001$) frequency on the stable region in 2003. Nueroptera and Odanata occurred with greater ($P < 0.0001$) frequency on the declining region in 2001. Hymenoptera occurred with greater ($P < 0.0001$) frequency on the declining region in 2002.

Homoptera occurred with greater ($P < 0.0001$) frequency on the declining region in 2003.

Table 3.1. Invertebrate dry mass (g) at nest sites in stable and declining regions of Rio Grande wild turkey abundance, Edwards Plateau, Texas, 2001–2003.

	2001			2002			2003		
	n	$\bar{x}$	SE	*n*	$\bar{x}$	SE	*n*	$\bar{x}$	SE
Stable	17	0.184	0.069	9	0.150	0.086	5	0.155	0.119
Declining	18	0.040	0.017	13	0.060	0.023	8	0.03	0.028

Table 3.2. Frequencies (%) of invertebrate orders at nest sites in regions of stable and declining Rio Grande wild turkey abundance, Edwards Plateau, Texas, 2001–2003.

	2001		2002		2003	
Invertebrate order	Stable	Declining	Stable	Declining	Stable	Declining
Diptera	59	50	11	8	40	38
Orthoptera	82*	28*	67*	46*	40*	13*
Coleoptera	65	61	33	31	40*	13*
Lepidoptera	29*	11*	0	0	0	0
Hymenoptera	18	17	0*	15*	20	13
Homoptera	29*	11*	11	15	40*	63*
Hemiptera	35	28	22	23	60*	13*
Nueroptera	0*	17*	0	0	20	13
Araneae	35	39	44	38	40	38
Odanata	0*	6*	0	0	0	0

*Significant at $P < 0.05$

Invertebrates at Brood Locations

Invertebrate collections ($n = 41$) were made at brood locations in the stable ($n = 29$) and declining regions ($n = 12$) in 2002. During summer 2003, 6 invertebrate collections on the stable region and 1 on the declining region were made at brood locations. Each collection consisted of a brood-location site and a paired collection, for comparison (Table 3.3).

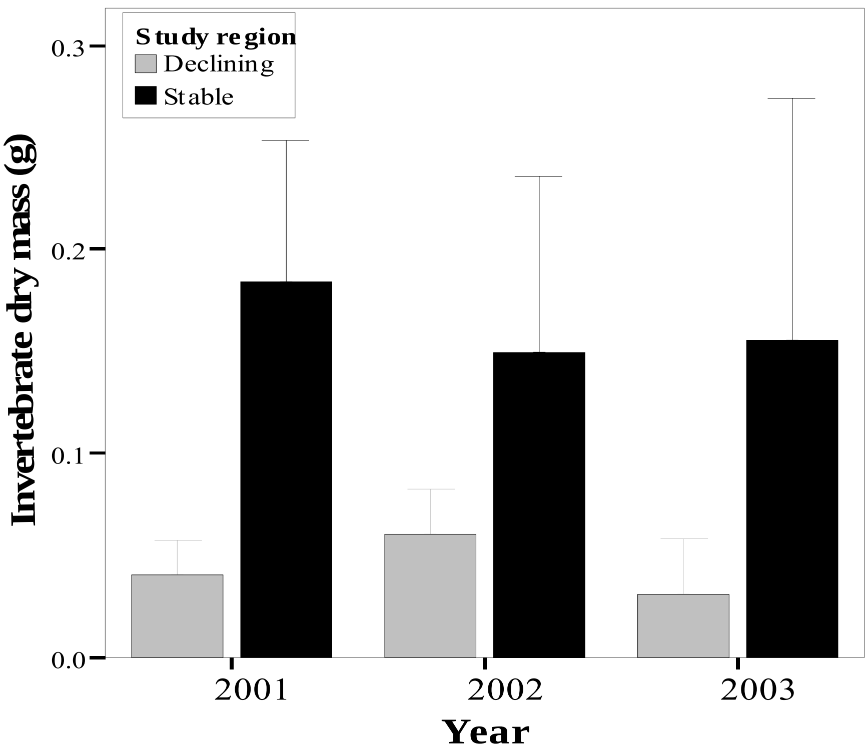

Fig 3.1. Invertebrate dry mass at stable and declining region nest-site locations, Edwards Plateau, Texas, 2001–2003.

Table 3.3. Invertebrate dry mass (g) at brood locations of Rio Grande wild turkey poults and paired sites on stable and declining regions, Edwards Plateau, Texas, 2002–2003.

	2002 Brood			2002 Paired		2003 Brood			2003 Paired	
	n	$\bar{x}$	SE	$\bar{x}$	SE	*n*	$\bar{x}$	SE	$\bar{x}$	SE
Stable	29	0.171	0.029	0.304	0.052	6	0.208	0.138	0.198	0.091
Declining	12	0.107	0.032	0.307	0.087	1	0.128		0.201	

Lepidoptera ($P < 0.0001$), Hemiptera ($P < 0.0001$), and Araneae ($P < 0.0001$) all occurred with greater frequency at stable brood-location sites in 2002 (Table 3.4). The frequency was calculated for individual invertebrate orders at brood-location sites (Table 3.4). Lepidoptera ($P < 0.0001$) and Hemiptera ($P < 0.0001$) occurred with greater frequency at paired sites within the stable region than on paired sites within the declining region in 2002.

Table 3.4. Frequencies (%) of invertebrate orders at brood locations of Rio Grande wild turkey poults and paired sites at stable and declining regions, Edwards Plateau, Texas, 2001–2003.

	2002 Brood		2002 Paired	
Invertebrate order	Stable	Declining	Stable	Declining
Diptera	24	25	21	17
Orthoptera	90	83	86	100
Coleoptera	40	33	31	33
Lepidoptera	21*	8*	14*	0*
Hymenoptera	55	41	45	42
Homoptera	21	25	28	0
Hemiptera	45*	8*	48*	25*
Nueroptera	3	0	3	0
Araneae	62*	25*	55	58
Odanata	0	0	3	0

*Significant at $P < 0.05$

Brood Survival

Brood survival on the stable region (100%, $n = 8$) during 2001 was greater ($P < 0.0001$) than on the declining region (50%, $n = 10$) (D. A. Jones, Texas A&M University, unpublished data). Brood survival during 2002 on the stable region (100%, *n* = 2) was greater ($P < 0.0001$) than on the declining region (50%, $n = 2$). Brood survival during 2003 on the stable region (100%, $n = 2$) was greater ($P < 0.0001$) than on the declining region (33%, $n = 3$)]. Combined brood survival from 2001-2003 on the stable region (100%, $n = 12$) was greater ($P < 0.0001$) than on the declining region (46%, $n = 15$).

DISCUSSION

My study investigated the influences of invertebrates on a RGWT turkey numbers in the EP of Texas. I found that turkey hens on the northern (stable) portion of the EP had greater amounts of invertebrates at nest-site locations than did hens in the southern (declining) of the EP. This supported the hypothesis that there would be greater amounts of invertebrates at nest-site locations on the stable regions of the EP than declining regions. Due to the low total number of successful nests in each study region comparisons between successful and unsuccessful nests was not determined. Because of this, and high variability in temporal invertebrate collections, nest site selection cannot be said to be based on invertebrate abundance.

The dietary composition of 386 poults collected in Mississippi ate primarily insects (79% of dry weight) in the first week post hatch (Hurst and Stringer 1975). In subsequent weeks the amount of animal matter that is consumed by poults declines to approximately 13% in the 4th week, which is similar to an adult dietary ratio. Results from Hurst and Stringer (1975) are important because they show that turkey poults, like other galliform young, are dependant on invertebrates for growth and development.

Dependence on invertebrates ranges from 5% in red grouse (Moss 1972) to 90% in grey partridge (Southwood and Cross 1969) over the initial 5 weeks post hatch.

My results showed that Orthoptera was found in greater amounts based on dry mass and frequency at both nest-site locations and brood locations on the stable region than on the declining region. Orthoptera has been noted as an important invertebrate order for poult diet and growth (Hurst 1992) and occurred at greater frequency on study areas in the stable region throughout the study. With Orthoptera occurring more frequently in all years on the stable region, the biological significance of more abundant Orthoptera should be investigated further. While Orthoptera was found in to have a higher dry mass and frequency at brood locations on stable regions than on declining regions the total amount of invertebrate dry mass was similar on both stable and declining regions.

Invertebrate collections from 2002 brood locations and paired sites indicated a greater abundance of Lepidoptera, Hemiptera, and Araneae on the stable region than on the declining region. Of these orders, only Lepidoptera has been shown to be a significant food source for galliform young (Southwood and Cross 1969, Green 1984, Hill 1985, Johnson 1990). Hemiptera and Araneae are not considered highly energetic food sources for galliform young (Beck and Beck 1955). Based on total invertebrate dry mass from brood-location sites, support for the hypothesis of greater invertebrate dry mass on the stable study region was lacking and warrants further investigation.

Brood survival was greater on the stable region in all 3 years of this study. Hens successfully hatching broods on the stable region had 100% brood survival in all 3 years, compared to 50% in 2001 and 2002, and 33% in 2003, on declining regions. Greater abundance of Orthopterans on stable regions may have an effect on RGWT brood survival in the EP. Differences in brood survival were found between the northern (stable) region and the southern (declining) region in this study. This supported the hypothesis that brood survival would be higher on the stable study region. With greater amount of Orthoptera at nest site and brood locations on stable sites invertebrates may influence brood survival of RGWT within the EP, however, with no investigation of brood habitat characteristics other than invertebrates, confounding factors may be involved.

Future research emphasis should be directed toward determining causes for discrepancies in invertebrate dry mass and frequency between stable and declining regions. Studies also should be conducted on invertebrate community ecology to determine which aspects of the study regions determine the presence of desirable invertebrate order (i. e. Orthoptera, Lepioptera, and Coleoptera).

CHAPTER IV

CONCLUSIONS

The 2 overall objectives of this study were to determine if nest-site vegetation characteristics were limiting nest success in the southern Edwards Plateau (EP) and invertebrates were limiting brood survival in the southern EP. No differences were detected in nest success between stable and declining regions. Results indicated that in years of high nest success, vegetation height and percent cover at nest sites were greater than years with low nest success. Additionally, in years with high nest success, vegetation characteristics at nest sites from declining regions were more similar to those found at nest sites in stable regions. Results also indicated RGWT hens in the EP chose nest sites with greater litter depth and more OV than available in surrounding areas. These results were consistent those of previous studies (Lutz and Crawford 1987, Schmutz et al. 1989, Day et al. 1991).

The second overall objective was to determine if invertebrates were limiting brood survival in the southern EP. Differences were detected in brood survival between stable and declining regions, with greater brood survival on the stable regions. For this reason, the dry mass and frequency of invertebrates were compared between study regions. This study found greater invertebrate dry mass at stable region nest-site locations and no difference between invertebrate dry mass at brood locations. Both nest-site locations and brood locations on the stable region did have a greater frequency of Orthoptera than did the nest site and brood locations on the declining study region. Because of the importance of Orthoptera as a food source of galliform young (Klebenow and Gray 1965, Southwood and Cross 1969, Potts 1970, Green 1984, Johnson 1990, Badenhort and Kerley 1996) invertebrate dry mass was deemed biologically significant, because of associated protein amounts of Orthopterans (Beck and Beck 1955). With Orthoptera occurring at a higher frequency on the stable study region the assumption is that poults hatching on the stable study region would develop faster and increase survival to 2 weeks.

Due to the large discrepancy in invertebrate dry mass between nest-site locations on stable and declining regions, future research should focus on possible explanations of this phenomenon. Invertebrate community ecology is one aspect that should be investigated, this could be used to determine how and if vegetation is affecting the invertebrate community assemblage. A more detailed analysis of both nest site vegetation and brood location habitat characteristics and vegetative characteristics of brood locations could prove useful in determining causes of declining RGWT populations in the southern EP.

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