Pre-incubation movements of female wild turkeys relative to nest initiation in South Dakota

Chad P. Lehman, Lester D. Flake, Mark A. Rumble, Roger D. Shields, and Dan J. Thompson

Abstract Nests of radiotransmittered wild turkeys (*Meleagris gallopavo*) that are destroyed or abandoned prior to incubation are particularly difficult to locate. As a result researchers often report only incubated nests or estimate numbers of nests attempted by localization of movement or other behavioral changes without quantification. We used radiotelemetry to obtain movement data on female wild turkeys during the nesting season (1 Apr–30 Jun) in South Dakota. We collected prelaying (1 April until 14 days before the female initiated incubation) and laying (<14 days before incubation) movement distances from 160 adult female wild turkeys [75 eastern (*M. g. silvestris*), 19 Rio Grande (*M. g. intermedia*), and 66 Merriam's (*M. g. merriami*) wild turkeys]. Our objectives were to quantify the relationship between movement behavior and nesting attempts to allow more accurate determination of initiation of nesting for calculation of nest rates, nesting success, and renesting rates. Daily movements of females decreased abruptly when they transitioned from prelaying to laying behaviors. Movements of females that were less than 364.9 m for eastern turkeys, 115.0 m for Rio Grande turkeys, and 331.0 m for Merriam's turkeys were indicative of nest initiation. Changes in movements of females can identify nesting wild turkeys and can be used post hoc to identify nests that were abandoned or destroyed prior to incubation if sufficient locations are collected. Following our analysis, we estimated that females had an additional 46 nests (eastern = 15, Rio Grande = 7, and Merriam's = 24), which we used in estimating reproduction parameters. Quantitative comparisons of movements between prelaying and laying confirmed a behavioral change of localized movements concurrent with nest initiation in wild turkey females.

Key words laying period, localization, *Meleagris gallopavo*, prelaying period, radiotelemetry, wild turkey

Researchers have been inconsistent in terms of methods used to obtain unbiased estimates of nesting attempts and nesting success in wild turkeys (*Meleagris gallopavo*). This inconsistency is related to the difficulty in locating nests prior to the incubation period. Information on nesting attempts is necessary to accurately estimate parameters such as nest success and renesting rates and is important for understanding the dynamics of wild turkey populations. Nesting rates of turkeys also may be indicators of habitat quality (Wakeling 1991, Hoffmann et al. 1996, Rumble et al. 2003). Several studies estimate nesting attempts based on incubation rates because researchers were unsuccessful in identifying nesting attempts that were destroyed or abandoned prior to incubation (Vander Haegen et al. 1988, Wakeling 1991, Flake and Day 1995). Estimates of nesting attempts per

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female based only on nests reaching the incubation stage are conservative, resulting in inflated nesting success estimates.

Restricted movements of female turkeys during the nesting season, but prior to incubation, are indicative of the initiation of laying (Williams et al. 1974). Researchers have used restricted daily movements, lengthened periods of inactivity as indicated by activity sensors, or other evidence of localized and secretive behavior to identify nesting attempts during the egg-laying stage (Little and Varland 1981, Lutz and Crawford 1987, Rumble and Hodorff 1993, Lehman et al. 2001).

Finding wild turkey nests during the egg-laying period can be difficult because female turkeys seldom are near the nest bowl laying eggs, and females cover clutches with debris to conceal nests while away (Williams et al. 1971, Williams et al. 1974, Williams and Austin 1988). Typically the behavior of females changes dramatically when they begin nesting, and most females avoid other females while searching for a nest site and laying eggs, which contrasts with their normal gregariousness (Healy 1992). Little and Varland (1981) and Rumble and Hodorff (1993) based nesting attempt estimates on restricted movements and direct observations of hen behavior, but these studies did not quantify movement behavior of birds during the laying period compared to the immediate prelaying period. Information describing this pre-incubation behavior in quantitative terms would be useful in helping researchers and managers identify nesting attempts since locating wild turkey nests during laying is difficult. Our objective was to provide a method of quantifying nesting attempts during the laying period for use in estimating parameters such as nesting rates, nesting success, and renesting rates. We provide pre-incubation movement data and logistic regression models for 3 different subspecies of wild turkey.

Study area

Our study areas were in northeastern South Dakota (Marshall, Roberts, and Grant counties) and the southern Black Hills (Fall River and Custer counties). The 2 northeastern study areas were located along the Coteau des Prairie Region and Minnesota River-Red River Lowlands of northeastern South Dakota (Johnson et al. 1995). The Coteau des Prairie was a highland plateau with gently undulating to hilly topography. Elevations ranged from 372-610 m above mean sea level. The northeastern study areas had a continental climate with mean annual precipitation of 48 cm and mean annual temperature of 6°C (National Climatic Data Center 1996). These sites had forests dominated by bur oak (*Quercus macrocarpa*) on the drier slopes. More mesic areas had intermixed populations of trembling aspen (*Populus tremuloides*), green ash (*Fraxinus pennsylvanica*), box elder (*Acer negundo*), and eastern cottonwood (*P. deltoides*) (Knupp Moore and Flake 1994). Exotic and native grasses on the study areas included smooth brome (*Bromus inermis*), bluegrass (*Poa pratensis*), needle and thread (*Hesperostipa comata*), sideoats grama (*Bouteloua curtipendula*), little bluestem (*Schizachyrium scoparium*), and big bluestem (*Andropogon gerardii*) (Johnson and Larson 1999).

The southern Black Hills study area was located within the southern Black Hills physiographic region of southwestern South Dakota (Johnson et al. 1995). The Black Hills study area had elevations ranging from 930-1627 m above mean sea level and a continental climate with mean annual precipitation of 41.81 cm and mean annual temperature of 9.17°C (National Climatic Data Center 2000). The woodland habitat was characteristic of xeric conditions and was dominated by ponderosa pine with an understory of Rocky Mountain juniper (*Juniperus scopulorum*), common juniper (*Juniperus communis*), and western snowberry (*Symphoricarpos occidentalis*) (Hoffman and Alexander 1987). Native grasses included sideoats grama, western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*), and little bluestem (Johnson and Larson 1999).

Methods

Capture and radiotelemetry

We captured wild turkey females in winter using cannon nets (Dill and Thornsberry 1950, Austin et al. 1972) and rocket-nets (Thompson and Delong 1967, Hawkins et al. 1968, Wunz 1974). Adult (≥2 years of age) eastern wild turkey (*M. g. silvestris*) females were trapped in northern Missouri, Iowa, and Kentucky and transported to the northeastern South Dakota study areas during January through March of 1996, 1999, and 2000. We captured adult Rio Grande (*M. g. intermedia*) females on the northeastern South Dakota study areas. We fitted both eastern and Rio Grande females with 55-g necklace-mounted transmitters (Advanced Telemetry Systems, Isanti, Minn.) equipped with a 4-hour mercury-switch mortality sensor. We captured adult Merriam's (*M. g. merriami*) females on the southern Black Hills study area and fitted them with 98-g backpack-mounted radiotransmitters (Advanced Telemetry Systems, Isanti, Minn.) equipped with activity signal, nonmoving signal, and an 8-hour mercury-switch mortality sensor. We located wild turkeys by triangulation using vehicle-mounted null peak antennae systems and hand-held yagi antennae. On average, we completed locations in <8 minutes. We obtained locations evenly among morning (0700-0999), midday (1000-1399), and afternoon (1400-1700) periods, and compared the amount of time elapsed between successive relocations of individuals during prelaying and laying periods to ensure they were similar. We obtained visual observations by carefully approaching birds using hand-held yagi antennae as to not disturb prelaying or laying females. Females did not appear to change their behavior (i.e., change travel directions, run, or fly) because of the visual observations. No females abandoned nests following visual observations, as evidenced by continued egg laying in the same nest bowl.

Localized movements

We monitored females during spring (1 April-30 June) to ascertain when nesting females first localized their daily movements during the process of laying eggs. We obtained 5-6 daily locations per week and recorded the Universal Transverse Mercator (UTM) coordinates. For turkeys fitted with necklace-mounted transmitters, oscillating pitch in transmitter output in combination with observed localized movements identified laying females, and steady pitch at live pulse rates or mortality signals indicated initiation of incubation (Lehman et al. 2001). Similarly, turkeys fitted with backpack transmitters emitted activity signals and movement behavior that indicated initiation of laying; incubation was determined when backpack transmitters began to emit nonmoving signals.

When it became apparent a nest was initiated, we attempted to approach the nest site, using a hand-held yagi antenna, without flushing the female. We marked nests with flags on 4 sides at a distance of 5-20 m depending on topography and signal strength (Lehman et al. 2001). We estimated dates of nest initiation or the start of the laying period, initiation of incubation, and nest hatching to within 1 day.

We classified female behavior as prelaying (i.e., 1 April until 14 days before the female initiated incubation) or laying (i.e., <14 days before the female initiated incubation of nests) based on females confirmed to have nested (i.e., found the nest bowl during laying period or incubation period). Earliest nest initiation occurred on 11 April, and median dates for first nest initiation ranged from 27 April-17 May; therefore, we selected 1 April as a cut-off for first nests for prelaying distances to standardize time periods.

We quantified prelaying and laying movements of female turkeys using the SPIDER DISTANCE command within the Animal Movement SA v2.04 Beta extension (Hooge and Eichenlaub 1997) for ArcView software (Environmental Systems Research Institute 1996). The SPIDER DISTANCE command provides estimates of daily movement distances by female turkeys during the preincubation period. SPIDER DISTANCE calculates a geometric mean center point (i.e., centroid) and creates distance relationships from each location (Hooge and Eichenlaub 1997, Figure 1). We considered each female that incubated a nest as an experimental unit, and distance estimates were subsamples of that unit.

We used paired *t*-tests to compare distances and elapsed time for consecutive relocations between prelaying and laying periods of females (PROC MEANS, PROC UNIVARIATE, SAS Institute Inc. 1989). We tested data for the assumption of normality, and log-transformed non-normally distributed data. We set the significance level at $P=0.05$ for all *t*-tests. Additionally, we used PROC LOGISTIC to build distance models with a maximum likelihood estimate (α) and distance coefficient (β). We set $P=0.10$ for the binary response variable to estimate the 90% probability that a nest had been initiated using the following:

$$\ln (P / 1 - P) = \alpha + \beta \times \text{distance}$$

We tested our models by randomly sampling 3 successive UTM locations from the pre-incubation period for 20% of radiomarked females. We estimated the accuracy of our models for predicting laying distances using known distances from a random sample. Also, we used discriminant function analysis (PROC DISCRIM, SAS Institute Inc. 1989) with a cross-validation procedure (CROSSLIST) to estimate the accuracy of our models.

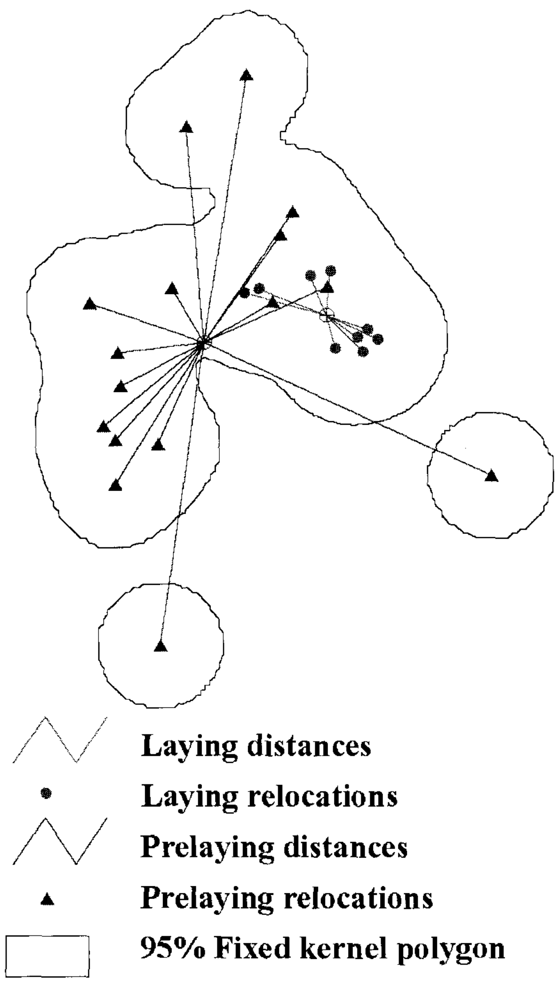

Figure 1. Pre-incubation polygon (Fixed Kernel method- 95%) and polyline of SPIDER DISTANCE analysis for a Merriam's turkey female in the southern Black Hills of South Dakota, 2003. The SPIDER DISTANCE command calculates a geometric mean center point (i.e., centroid) and creates distance relationships from each location.

Results

Capture and radiotelemetry

We captured and radiomarked 160 adult female turkeys on 3 study areas from 1996–2003 (75 eastern females, 19 Rio Grande females, and 66 Merriam's females). We collected 6,554 relocations (n=3,262 eastern, n=2,625 Merriam's, n=667 Rio Grande) on radiomarked birds. During nesting 23% of relocations were visual observations and 77% were triangulated (Merriam's: mean polygon error=0.76 ha [SE=0.17], mean number of bearings=3.94 [SE=0.06], eastern and Rio Grande: mean polygon error=1.67 ha [SE=0.03], mean number of bearings =2.68 [SE=0.05]) (Lehman 1998, Shields 2001). We collected relocations evenly among morning (32%), midday (32%), and afternoon (36%) time periods. Time between successive relocations did not differ between prelaying and laying periods for female turkeys on all study areas (Table 1).

Localized movements

Wild turkeys incubated 283 nests (eastern=91 first nests, 18 renests; Rio Grande=28 first nests, 10 renests; Merriam's=98 first nests, 38 renests). We were unable to pool first nests and renests for distance comparisons for all subspecies ($F \geq 6.59$, df=1, $P \leq 0.01$). SPIDER DISTANCES decreased ($P \leq 0.0005$) between prelaying and egg laying for both first nests and renests for each subspecies (Table 2). Distances decreased abruptly in transition from prelaying to laying (Figure 2).

Using PROC LOGISTIC, 3 models were used in predicting nest attempts (Table 3). Logistic models estimated that when SPIDER DISTANCES were less than 364.9 m for eastern turkeys, 115.0 m for Rio Grandes, and 331.0 m for Merriam's, a nest had been initiated at accuracy rates ≥75% (Table 3). Analyses revealed groups of decreased distances (e.g., 3 successive relocations with SPIDER DISTANCES less than model estimated points) indicating probable nest initiations. Using the 90% prediction probability, we estimated an additional 46 nests (eastern=15, Rio Grande=7, Merriam's=24), and the percentage of false-positives (i.e., percentage of females predicted to be laying but were not) was ≤7.1% for all subspecies (Table 3).

Discussion

Comparing results of different nesting studies on wild turkeys is problematic because of differences in field methods, parameter definitions, and analyses (Healy and Powell 1999). Among nesting studies for wild turkeys, it is difficult to make comparisons because some studies included nests initiated during the laying period in nesting analyses (Little and Varland 1981, Rumble and Hodorff 1993, Lehman et al. 2001), while others have based nesting parameters on estimates made from incubated nests (Vander Haegen et al. 1988, Wakeling 1991, Flake and Day 1995). Failure to locate and include unsuccessful nest attempts underestimates mortality or nest loss rates (Mayfield 1975). Flake and Day (1995) noted that actual nesting rates probably were higher than the incubation rates they reported. Thus, their nest success estimates were greater than the actual nest

Table 1. Mean and standard error (SE) for the amount of time (hrs) between successive relocations (first nests and renests combined) for eastern, Rio Grande, and Merriam's subspecies of wild turkey females in South Dakota, 1996–2003.

Subspecies	Mean	SE	*t*-ratio[a]	df[a]	*P*-value[a]
Eastern					
Prelaying	42.0	0.9	0.59	108	0.56
Laying	41.4	0.8			
Rio Grande					
Prelaying	39.6	2.0	0.42	37	0.67
Laying	38.6	1.4			
Merriam's					
Prelaying	36.8	1.0	0.49	135	0.31
Laying	37.4	0.9			

[a] Statistical values of *t*-ratios, degrees of freedom (df), and probabilities (*P*-value) represent the comparisons made between time periods (prelaying and laying).

Table 2. Number of distances calculated (N), means, and standard error (SE) of preincubation movement distances (m) calculated using the SPIDER DISTANCE command for eastern, Rio Grande, and Merriam's subspecies of wild turkey females in South Dakota, 1996–2003.

Subspecies	*N*	Mean	SE	*t*-ratio[ab]	df[b]	*P*-value[b]
First nests						
Eastern						
Prelaying	91	1,780.0	113.4	77.54*	90	<0.0001
Laying	91	367.0	24.2			
Rio Grande						
Prelaying	28	596.9	51.8	27.77*	27	<0.0001
Laying	28	228.4	26.9			
Merriam's						
Prelaying	98	1,804.9	184.7	48.85*	97	<0.0001
Laying	98	413.9	18.9			
Renests						
Eastern						
Prelaying	18	1,025.4	145.4	5.57	17	<0.0001
Laying	18	342.5	29.5			
Rio Grande						
Prelaying	10	379.1	37.2	5.28	9	0.0005
Laying	10	176.5	47.6			
Merriam's						
Prelaying	38	848.8	73.4	34.36*	37	<0.0001
Laying	38	374.6	27.4			

[a] An asterisk (*) marks distances that were log transformed before t-test comparisons to maintain a normal distribution.

[b] *Statistical values of t-ratios, degrees of freedom (df), and* probabilities (*P*-value) comparing prelaying and laying time periods of first nests and renests.

Table 3. Distance models for eastern, Rio Grande, and Merriam's subspecies in South Dakota, 1996–2003. Includes accuracy of prediction models using 2 methods, and the number of additional nests (mean ± SE) estimated using decreased movements.

Subspecies	Prediction equation	Accuracy method 1[a]	Accuracy method 2[b]
Eastern	$\ln(P/1-P) = -4.3868 + 0.006*\text{distance}$	78.60%	86.20%
Rio Grande	$\ln(P/1-P) = -3.34 + 0.00994*\text{distance}$	75.00%	81.30%
Merriam's	$\ln(P/1-P) = -4.6632 + 0.00745*\text{distance}$	84.90%	76.10%

	Estimate of additional nests				
	Total nests	Mean no. nests/year[c]	SE	False-positives[d]	False-negatives[e]
Eastern	15	3.75	0.48	7.10%	14.30%
Rio Grande	7	3.50	0.50	0.00%	25.00%
Merriam's	24	8.00	1.00	6.00%	9.10%
Combined	46	5.11	0.81	5.50%	12.70%

[a] The accuracy of models using random samples of 3 successive distances from 20% of radiomarked females.

[b] The accuracy of models using a cross-validation procedure.

[c] Number of additional nests estimated with SPIDER DISTANCES that can be used to more accurately calculate nest rates, nesting success, and renesting rates.

[d] False-positives indicate the percentage of females that were predicted to be laying but were not.

[e] False-negatives indicate the percentage of females that were predicted to not be laying but were laying.

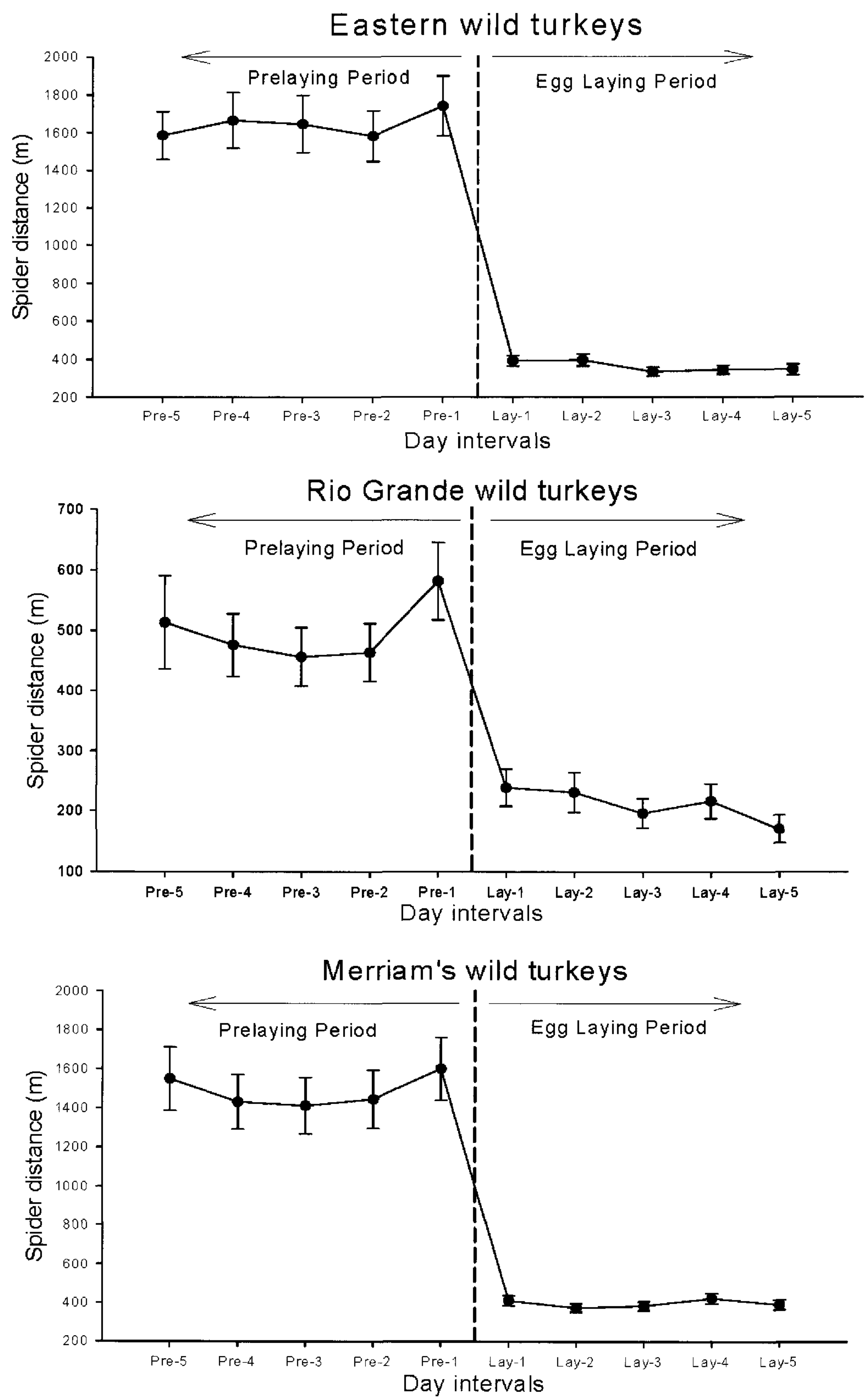

Figure 2. Transition of SPIDER DISTANCES from turkey prelaying to laying periods. Distances are presented at 1–2 day intervals for each subspecies of wild turkey in South Dakota, 1996–2003.

success rate for the population because they had no information on nests destroyed or abandoned during the laying period. Standardizing the collection of nesting data by using daily telemetry locations should reduce this problem.

Past researchers have anecdotally reported an abrupt change in behavior without quantification of movements indicating nest initiations (Williams et al. 1971, Little and Varland 1981, Rumble and Hodorff 1993). Our study quantified this change in behavior using restricted movements of females during the transition from prelaying to laying periods. Logistic models in our study predicted nest initiations with accuracy rates ranging from 75.0-86.2%. Rio Grande wild turkeys from northeastern South Dakota may not represent Rio Grande turkeys from other regions due to possible hybridization with game-farm-released turkeys or domestic turkeys (Lehman et al. 2001). Rio Grande daily movements and spring dispersal distances were shorter than those of eastern turkeys from northeastern South Dakota and compared to Rio Grande turkeys from its indigenous range (Thomas et al. 1966, Logan 1973, Lehman et al. 2001).

Infrared camera photograph of radiomarked female approaching nest bowl during the laying period in the southern Black Hills, South Dakota, 2003.

We estimated 46 additional wild turkey nests at a false-positive rate of 5.5%. Without our movement data, we would have underestimated the number of nests used to estimate nesting rates, nest success, and renesting rates. Simulation modeling of turkey populations indicates that nesting rates and nest success are important parameters affecting annual population change (Wakeling 1991, Vangilder and Kurzejeski 1995, Roberts and Porter 1996). Nesting success estimates in several studies (Lehman et al. 2001, Shields 2001, Lehman unpublished data) would have been estimated 7-23% higher without our application of the models to predict nest initiations. Quantification of pre-incubation movements and estimating additional nests with model predictions will allow researchers and managers to better estimate reproductive parameters.

Healy (1992) reports that laying hens that encountered humans or other hens when approaching their nest moved away quickly. We obtained visual observations of females both near nest bowls and remote from nest sites, and we did not observe any change in movements or abandonment of nests during the laying period due to investigator disturbance. Williams and Austin (1988) observed that a high percentage (62%) of females flushed from the nest during the laying period did not return. In this study females subsequently returned to nests to lay eggs following visual observations, and this was most likely the result of investigators carefully approaching females while obtaining the visual observations. Furthermore, visual observations were important in locating nest bowls during the laying period that otherwise would not have been located.

Management implications

We suggest that investigators quantify pre-incubation movements and develop logistic regression models to predict nesting attempts in their regions. We observed movements of ≤365 m for eastern turkeys, ≤115.0 m for Rio Grandes, and ≤331.0 m for Merriam's turkeys during nest initiation. In the absence of quantified models, we recommend using percent reductions in SPIDER DISTANCE estimates of at least 64% for eastern turkeys, 71% for Rio Grandes, and 61% for Merriam's turkeys to help researchers predict nesting attempts. Our estimates for Rio Grande turkeys of SPIDER DISTANCE = 115 m (71% reduction) may not be suitable for determining nest attempts in other regions. Average SPIDER DISTANCES declined abruptly from prelaying to laying for all subspecies, and we believe these procedures will indicate greater numbers of nesting attempts and more accurate estimates of nesting parameters will result.

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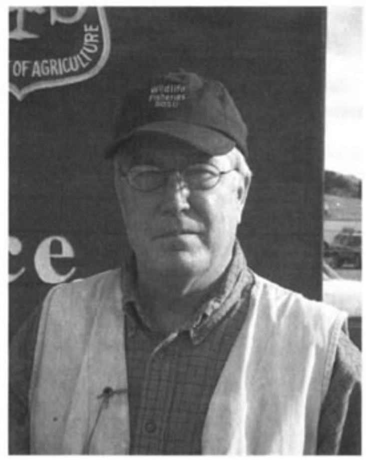
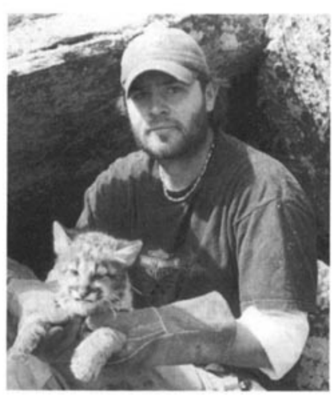
Chad P. Lehman (left) is a graduate research assistant and doctoral candidate at South Dakota State University. He received a B.S. in biological science from the University of Minnesota-Duluth and an M.S. in wildlife science from South Dakota State University. His research interests focus on wild turkey population ecology, particularly the influence of weather and habitat selection/availability on survival and reproduction. He works closely with state and federal agencies on wild turkey management issues as a wildlife biologist for the National Wild Turkey Federation. ***Lester D. Flake*** (top right) retired from South Dakota State University in August of 2002 after 31 years on the faculty and was appointed Distinguished Professor Emeritus. He is still advising graduate students and remains involved with several projects in South Dakota. In his free time Les enjoys visiting grandchildren, hiking in the mountains of Utah, reading, fly-fishing, bow-hunting, and chasing pheasants with old friends in South Dakota. Les has a Ph.D. in zoology from Washington State University (1971) and an M.S. in zoology from Brigham Young University (1966).

Mark A. Rumble (below, left) received a B.S. in wildlife biology from Washington State University, an M.S. in wildlife science from South Dakota State University, and a Ph.D. in zoology from the University of Wyoming. Mark has worked for the U.S. Forest Service for 25 years, and 24 years for the Rocky Mountain Research Station in Rapid City, South Dakota. His professional interest includes understanding the effects of land management on wildlife habitat with an emphasis on developing information in formats that are usable by forest and range managers.



Roger D. Shields (below, right) is currently a wildlife biologist with the Florida Fish and Wildlife Conservation Commission (FWC). He received a B.S. from Brigham Young University and an M.S. from South Dakota State University. His work with the FWC has focused on wild turkey management and research, first as a member of the Wild Turkey Management Section and now as a member of the Fish and Wildlife Research Institute.

Dan J. Thompson (below, left) received his M.S. in wildlife science in 2003 and is currently pursuing a Ph.D. at South Dakota State University. He has worked on various projects addressing wild turkey population dynamics. His interests include large-carnivore ecology and expansion, along with carnivore–human–prey interactions.



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