Reproductive Effort and Success in a Declining Wild Turkey Population

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Abstract: We monitored reproductive effort and success of a wild turkey (*Meleagris gallopavo*) population on a public wildlife management area in Mississippi for 9 years using telemetry and other indices. Adult hens (N = 143) had a nesting rate of 72.7% (range 54–100) and was greater (P = 0.0001) than the nesting rate (26.7%) of juvenile hens (N = 15). Annual nest success of 104 nests of adult hens averaged 30.8% (range 0–62) and poult survival to >50 days was 22.7% for 27 broods (N = 203 poults). Clutch size averaged 9.1 (SE = 0.54) and 6.7 (SE = 1.1), and hatchability was 93% and 100%, for first and second clutches, respectively. During this period, turkey population estimates and indices (gobbler harvest, hen ancillary observations) declined 250%–350%. Low reproduction was due primarily to high predation of nests and poults and appeared to have caused the population decline. However, environmental factors (i.e., food, rainfall) appeared to significantly impact reproduction in some years. Reproduction was greatest in 1992 following a distemper outbreak among some nest/poult predator populations in 1991.

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Wild turkey population dynamics are poorly understood, yet such knowledge is critical for managing turkey populations (Vangilder 1992). Variation in annual

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rates of reproductive effort and success have appeared to be related to stochastic environmental variation in weather (i.e., snowfall, rainfall) and food (Healy 1992, Vangilder 1992). Further, relationships of predation and turkey population dynamics have not been studied beyond documentation of predation rates on nests, poults, and adults (Miller and Leopold 1992).

We documented reproductive effort and success of a turkey population on a public hunting area in Mississippi for 9 years. We relate these findings to population indices and discuss how environmental variation in food, rainfall, and predation impact reproduction in this turkey population.

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Methods

The study area consisted of 14,410 ha of the Tallahala Wildlife Management Area (TWMA), Strong River District, Bienville National Forest, and associated private lands in Scott, Jasper, and Smith counties. The area was 95% forested and was composed of bottomland hardwood (30%), pine (37%), mixed pine and hardwood forests (17%), and pine and hardwood regeneration areas (11%). Most pine and hardwood stands exceeded 50 years of age. Non-forested areas occurred on private lands and were classified as old field (4%), agriculture (1%), and residential (<1%). Hardwood forests were located in broad alluvial creek drainages. Pine and hardwood regeneration areas averaged 12.7 ha (SD = 7.8) and 5.2 ha (SD = 3.1), respectively.

Complete oak mast (*Quercus* spp.) failures occurred during the winters of 1984–85 and 1987–88. Also, from July 1987 to June 1988 rainfall for Jasper County was 37% below normal (Seiss 1989). Distemper was documented (College of Vet. Med., Miss. State Univ.) in raccoons (*Procyon lotor*) and in grey foxes (*Urocyon cinereoargenteus*) beginning in the summer of 1991 which may have resulted in a reduction in these on the study area (B. D. Leopold and G. A. Hurst, unpubl. data).

Turkey hens were captured by cannon-net during January–February and July–August, 1984–92 following Bailey et al. (1980). Hens were equipped with a 107-g battery-powered, "backpack-style" transmitter with mortality and/or motion switches (Wildl. Materials Inc., Carbondale, Ill.), leg bands, and black patagial wing tags. Hens were classified as adults or subadults (Williams and Austin 1988) and released at the capture site.

Hens were located by triangulation (Heezen and Tester 1967) from 2 telemetry stations using a hand-held 3-element directional Yagi antenna and a Telonics®

(Mesa, Ariz.) TR-2 receiver. Monitoring of hens was conducted at least daily beginning by 14 March each year. Incubating hens were monitored twice daily to determine date of initial incubation, hatching, nest destruction/desertion, or hen mortality. Nests were located as soon as continuous incubation behavior was detected. Nests were marked with surveyor flagging at various points <50 m from the actual nest site. Compass bearings toward the nest were recorded on the flags to facilitate finding the nest after incubation terminated. Nests were classified as successful (≥1 egg hatched), abandoned (eggs undisturbed), or destroyed (≥1 egg destroyed). Clutch size and hatchability were determined from successful nests. Nesting rate was defined as the percentage of hens in the 1 April population that were known to nest. Nesting was confirmed when a hen began continuous incubation behavior, as determined from telemetry. Causes of nest destruction or hen mortality were determined if possible by evidence at the nest site or death site, respectively (Davis 1959). Hen success was defined as the proportion of hens alive 1 April which were successful in first or subsequent nesting attempts. Tests for differences ($P < 0.10$) between rates of nesting or nest success were conducted using Z tests for proportions (Walpole and Myers 1985).

Ancillary observations of all wild turkeys were recorded by project personnel. Observations of hens and hens with broods during May through August were used to obtain a reproduction index. Further, number of hens and hens with broods from summer capture data also were used to obtain a reproduction index. Indices of population size included harvest of gobblers during the spring hunting season, 18 March to 1 May each year, and ancillary observations of adult and subadult hens during summer. Significant ($P < 0.10$) trends in population indices were tested for using simple linear regression (Walpole and Myers 1985).

Results

Spring gobbler harvest declined from 49–59 in 1984–87, to 20–28 in 1988–90, and 16–21 in 1991–92 ($r = -0.89$, $P = 0.002$). Observations of hens also exhibited a negative trend ($r = -0.75$, $P = 0.02$) from 148 in 1984 to 43 in 1992 (Table 1).

A total of 158 (143 adults, 15 juveniles) hens was monitored during the reproductive season by telemetry between 1 January 1984 and 30 December 1992. The nesting rate of adult hens was 72.7% and ranged from 54% in 1988 to 100% in 1987, 1990, and 1992 (Table 2). Nesting success averaged 30.8% for adult hens and ranged from 0% to 62%. Hens' success averaged 27% (range 11%–80%). Poult survival to ≥50 days averaged 22.7% and ranged from 0% to 41.3% (Table 3). Juvenile hens ($N = 15$) had a nesting rate (26.7%) which was lower ($P = 0.0001$; $Z = 3.6$) than adult hens. Of 4 known nest attempts by juvenile hens, none were successful.

Of 71 failed nesting attempts, 58 nests were located. Predators accounted for 93% of known nest failures, which were attributable to unknown predators (48.1%), predation of the hen (24.1%), raccoons (18.5%), skunks (*Mephitis mephitis*) (5.6%), and opossums (*Didelphis virginiana*) (3.7%). Four nests were aban-

Table 1. Spring harvest of wild turkey gobblers and ancillary observations of wild turkey hens and broods during May–August on Tallahala Wildlife Management Area, Mississippi, 1984–92.

Year	Harvest	Hens observed	Broods observed (% of hens)	Poults observed (% of hens)
1984	59	148	44 (29)	220 (149)
1985	49	82	17 (21)	76 (93)
1986	50	156	49 (31)	234 (150)
1987	53	79	41 (52)	155 (196)
1988	21	67	22 (33)	68 (101)
1989	20	95	10 (11)	51 (54)
1990	28	84	15 (18)	111 (132)
1991	21	48	1 (2)	6 (12)
1992	16	43	10 (23)	92 (214)

doned, of which 2 were due to observer influence. Hen mortality was believed to be caused by great horned owls (*Bubo virginianus*), bobcats (*Felis rufus*), and unidentified mammals.

Hens with broods were vulnerable to predation. Of 32 hens with broods, 9 (28.1%) were killed by predators; 78% of which occurred before the brood was 14 days of age. Hens with broods were killed by great horned owls (1), bobcats (2), dogs (*Canis domesticus*), and unidentified mammals (5).

Of 66 hens alive following a failed first nesting attempt, 34.8% renested (i.e., reached continuous incubation), of which 26% were successful. This rate was not statistically different ($P = 0.58$; $Z = 0.57$) from success rate of initial nests. No poults produced from renests were known to survive past 14 days. However, 1 hen

Table 2. Nesting rate, nest success, and hen success for adult female wild turkeys on Tallahala Wildlife Management Area, Mississippi, 1984–92.

Year	*N*	% Nest rate	% Nest success	Available renesters	% Renest rate	% Renest success	% Hen success[a]
1984	10	80.0	62.5	3	33.3	100.0	80.0
1985	22	77.3	41.2	10	40.0	25.0	36.0
1986	15	80.0	16.7	10	10.0	0.0	13.3
1987	4	100.0	25.0	3	66.7	0.0	25.0
1988	28	53.6	20.0	9	11.1	100.0	17.9
1989	36	58.3	28.6	16	18.8	33.3	19.4
1990	10	100.0	50.0	4	100.0	25.0	40.0
1991	9	88.9	0.0	7	71.4	20.0	11.1
1992	9	100.0	33.3	4	50.0	0.0	33.3
Total	143			66			
Average		72.7	30.8		34.8	26.1	27.3

[a] Proportion of *N* which were successful in first or subsequents nest attempts.

Table 3. Survival of poults from hatching to 50 days for transmitter-equipped hens on Tallahala Wildlife Management Area, Mississippi, 1984–92.

	Initial nests		Renests	
Year	Poults hatched	Poults surviving (%)	Poults hatched	Poults surviving (%)
1984	43	13 (30.2)	5	0
1985	60	13 (21.7)	15	0
1986	25	0 (0)	0	0
1987	12	1 (8.3)	0	0
1988	5	0 (0)	5	0
1989	29	7 (24.1)	4	0
1990	29	12 (41.3)	9	0
1991[a]	0	0 (0)	9	
1992[a]	26	0[b]	0	0
Total	203	46 (22.7)	38	0 (0)

[a] Excluded from totals due to inconclusive results.
[b] Hens killed before 28 days, fate of poults unknown.

in 1991 raised 7 of 9 poults to 14 days at which time her transmitter failed and contact was lost.

Ancillary observations indicated moderate reproduction during 1984, 1986, and 1987. Low reproduction occurred following winters associated with hard mast crop failure (1984–85, 1987–88) and drought (1987–88). Reproductive indices from capture and ancillary observations indicated the highest reproduction occurred in 1992 (Table 1, 4).

Clutch size of successful nests (N = 27) averaged 9.1 eggs (SE = 0.54) of which 93% hatched. Successful renests (N = 7) had an average of 6.7 eggs (SE = 1.1) of which 100% hatched.

Table 4. Number of wild turkey hens and poults captured during July and August on Tallahala Wildlife Management Area, Mississippi, 1984–92.

Year	Hens without poults	Hens with poults (% of total)[a]	Total poults (poults/hen)
1984	22	8 (26.7)	38 (1.3)
1985	25	2 (7.4)	5 (0.19)
1986	13	5 (27.8)	23 (1.3)
1987	32	12 (27.3)	48 (1.1)
1988	20	5 (20.0)	11 (0.4)
1989	15	3 (16.7)	17 (0.9)
1990	11	8 (42.1)	38 (2.0)
1991	6	4 (40.0)	17 (1.7)
1992	8	16 (66.7)	61 (2.5)

[a] N hens with poults/total number hens.

Discussion

That turkey reproduction is highly variable from year to year due to many interrelated and apparently stochastic factors (Vangilder 1992) was supported by our data. Factors which influenced reproductive output of this turkey population included predation, food resources, and weather, specifically rainfall (Seiss 1988, Palmer 1990). Unfortunately, our ability to accurately measure reproductive parameters was hindered by low sample sizes and different measures of reproductive output often provided conflicting results. However, we believe that some insights into reproductive ecology and population dynamics can be drawn from our study.

The turkey population on TWMA markedly declined between 1984 and 1992. A decline was observed in gobbler harvest while hunter effort was relatively constant (Palmer et al. 1990). That 78% of gobbler mortality was due to hunter harvest (Godwin et al. 1991) and hunters reported >95% of harvests (Gribben 1986) improves the suitability of gobbler harvest as a population index on our study area. In addition to the decline in gobbler harvests, ancillary observations of hens during spring and summer declined over 350% between 1986–92, even though the number of personnel on the study area increased. Significant declines in gobbler call counts (Palmer et al. 1990) and gobbler population estimates (Lint 1990) further support our conclusion that the turkey population on TWMA declined.

We believe low reproduction on TWMA resulted in a population decline. Staggered entry, Kaplan-Meier annual survival rates (Pollock et al. 1989) of adult hens (1984–89) averaged 66% and ranged between 45% and 81%, and were similar to turkey populations elsewhere (Vangilder 1992). Mean adult hen success (27%), however, was low relative to hen success from other studies. Vangilder (1992) reported mean hen success of 51% (range 35%–83%) from 11 studies. Both mean nesting success (31%) and mean nesting rate (74%) appeared low in our study. Mean nesting rate in 6 studies was 95.2% (range 88%–100%) and nest success for 5 studies was 42.2% (range 30.7%–62.0%) (Vangilder 1992). Wheeler (1948) concluded that nesting success in wild turkeys was about 50% and his conclusions have been supported by others (Speake et al. 1969, Glidden 1977, Hon et al. 1978, Everett et al. 1980, Campo et al. 1984, Exum et al. 1987, Holbrook et al. 1987, Williams and Austin 1988). However, on TWMA, nesting success of radio-equipped hens was below 50% in 7 of 9 years studied.

Renesting did not contribute to the reproduction of this turkey population. Only 9.1% of hens available to renest produced a brood and, aside from the 1 hen whose radio failed when her clutch was 14 days old, no poults from renests survived past 21 days. Similar results have been presented elsewhere (Speake et al. 1969, Everett et al. 1980, Campo et al. 1984). However, Williams and Austin (1988) in Florida found that renests helped to maintain reproduction following predation of initial nest attempts. Juvenile hens were not important to the reproduction of this population. In 1984, 2 juvenile hens killed during August had not laid eggs that spring. Other studies have reported juvenile hens to be equal to adults in nesting rate (Glidden and Austin 1975, Vangilder et al. 1987, Vander Haegen et al. 1988) and success (Glidden and Austin 1975, Williams et al. 1976). Most studies

have concluded that juvenile hens tend to be less productive overall, either due to lower nest success or survival of their poults (Vangilder 1992). Reasons for the lower nesting rate on our study area are unclear.

Poult survival was only 23% for broods with transmitter-equipped hens. Based on the telemetry sample alone, fewer than 0.30 hen poults per hen alive at the beginning of the nesting season were produced. Although sample sizes for some years (i.e., 1984, 1987, 1991, 1992) were not large enough to provide accurate estimates of nest success or poult survival (Everett et al. 1980), poult/hen ratios supported the conclusion of low reproduction from telemetry hen samples. Poult/hen ratios averaged only 1.2 and 1.3 poults per hen from ancillary and capture records, respectively. Using average values of hen survival and reproductive parameters, the finite rate of increase for the hen population on TWMA was 0.84.

The primary cause of nest failure was predation. Many studies have documented the impact of predators on nest success and poult survival (Miller and Leopold 1992). The main nest predators on our study area were mammalian and have been observed elsewhere (Hon et al. 1978, Everett et al. 1980, Speake 1980, Campo et al. 1984, Vangilder et al. 1988). In 1991, distemper was documented on our study area in raccoons and grey fox. While only correlative, it is interesting that in 1992, the poult/hen ratios from ancillary observations and summer capture data were greater than in any other year. In fact, 67% of hens captured that summer were accompanied by broods and more poults were captured than in any previous year, even though hen numbers were considered to be low. Transmitterequipped hens, however, did not significantly improve reproduction in 1992, but sample size was low. Distemper can cause significant mortality in many mammalian turkey predators (Baker et al. 1987). That reproduction should increase following a natural reduction in predator numbers is supported by some predator removal studies. Miller and Leopold (1992) concluded that predator control had a positive effect on hatching success and that intensive predator control can improve reproduction.

Environmental conditions, primarily rainfall and acorn production, were related to wild turkey reproduction. During spring of 1988 reproduction was low; only 54% of adult hens reached incubation and only 11% of the transmittered hens were successful nesters. Also, ancillary observations and summer capture data in 1988 indicated low reproduction. Pattee (1977) reported that turkeys in poor condition did not attempt to nest. One hen was interrupted by researchers while hatching her eggs which resulted in nest abandonment. Poults from her nest exhibited symptoms of vitamin B deficiencies (Seiss 1989), presumably due to poor hen nutrition. Low reproduction during 1985 may have been influenced by a complete oak mast failure on the study area during the previous fall/winter. Transmitter-equipped hens did not reflect the low reproduction, but poult/hen ratios were low for both ancillary observations and summer captures. During both years with mast crop failure, nest initiation was later than the 5 year average (1984–88) (Seiss 1989) and gobbling call counts were lower than expected (Palmer et al. 1990). Previous studies have shown relationships between environmental conditions (i.e.,

rainfall and food resources) and wild turkey reproduction through the impact of the environment on the physical condition of breeding hens (Jonas 1968, Pattee 1977, Porter et al. 1983).

During spring 1984, 1986, 1987, 1989, 1990, 1991, and 1992, however, no unusual environmental conditions were observed. However, while rainfall was not limiting, rainfall conditions were observed. However, while rainfall was not limiting, rainfall during incubation of initial nests, in years without hard mast crop failures (1985 and 1988), was related ($r = -0.85$; $P = 0.08$) to nesting success (Palmer 1990). This was further investigated in 1989, when sample size of transmitter-equipped hens was greatest ($N = 40$). Predation on incubating hens and/or nests appeared to be related to the last rainfall event. The average time span between date of last rainfall and a predation event was 1.5 days which was less ($P = 0.07$) than the mean time span between rainfalls for the period encompassed by the first and last nest failure (Palmer 1990). Therefore, it appeared as though rainfall increased the efficiency of nest predators, presumably by increasing scent around the nest or improving scenting conditions for predators.

In conclusion, reproduction on Tallahala has been low for over 5 years and has resulted in a drastic decline in turkey numbers and lower spring harvest of gobblers. Several environmental factors have been important to the low reproduction observed. Lack of rainfall and poor mast crop production appeared to influence reproduction in some years. However, it appeared that predation of nests and poults limited the growth of this turkey population. Following a distemper outbreak in 1991, which may have resulted in a natural reduction in predator numbers, reproductive indices of turkeys were greater than in any other year. Further research is needed to elucidate relationships between predation processes and turkey reproduction. Whether reproductive success is more a function of predator density or environmental/habitat conditions which may influence predator efficiency or hen vigilance is unknown. While telemetry is a valuable tool for monitoring nesting rate and success, sample sizes should be >30 animals or results may be misleading. This emphasizes the need for additional research on validating different reproductive indices that do not rely on telemetry.

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