MERRIAM'S TURKEY POULT SURVIVAL IN THE BLACK HILLS, SOUTH DAKOTA

Chad P. Lehman[1], Department of Wildlife and Fisheries Sciences, South Dakota State University, Brookings, SD 57007
Lester D. Flake, Department of Wildlife and Fisheries Sciences, South Dakota State University, Brookings, SD 57007
Mark A. Rumble, USDA, Forest Service, Rocky Mountain Research Station, 8221 South Highway 16, Rapid City, SD 57702
Daniel J. Thompson, Department of Wildlife and Fisheries Sciences, South Dakota State University, Brookings, SD 57007

ABSTRACT

We investigated poult survival from hatching to 4 wks of age for Merriam's wild turkey (*Meleagris gallopavo merriami*) poults in the southern Black Hills, South Dakota. We estimated survival from 841 poults reared by 57 radio-marked wild turkeys (n = 52 adult females, n = 5 yearling females). Survival of poults to 4 wks posthatch averaged 33 percent with 54 percent of the mortality occurring in the first 7 days after hatching. Merriam's turkey poult survival in the southern Black Hills was low compared to Merriam's populations found elsewhere in the entire current range. Survival of poults increased with age, fewer precipitation events, and fewer extreme cold and wet events. The interaction of age of poults with cold and wet events through 15 days posthatch indicated that younger poults were more susceptible to cold and wet weather events than older-aged poults. We observed several poults ≤ 3 days of age that apparently died from hypothermia. A fine-scale based weather index that uses individual weather stations for specific areas occupied by turkeys may be a valuable tool for managers to estimate production in Merriam's turkeys if survey or radio telemetry data are not available.

Key words: Black Hills, Merriam's turkey, *Meleagris gallopavo merriami*, ponderosa pine, poult, precipitation, survival, wild turkey

INTRODUCTION

The native range of Merriam's turkeys (*Meleagris gallopavo merriami*) was from northern Colorado, south into Arizona, New Mexico, Oklahoma, and possibly western Texas concurrent with distribution of ponderosa pine (*Pinus ponderosa*) (Ligon 1946, Schorger 1966). The range of Merriam's turkeys has since expanded, and South Dakota Department of Game, Fish and Parks (SDGFP) introduced wild-trapped Merriam's turkeys from Colorado and New Mexico into the southern Black Hills near the towns of Custer and Hot Springs in 1950 and 1951 (Peterson and Richardson 1975). Merriam's turkey populations have fluctuated throughout their entire range historically and predation, human exploitation, and decrease in habitat quality through poor timber and range management practices may have lead to some population declines (Ligon 1946).

Survival of wild turkey poults is a key parameter influencing annual population fluctuations (Kurzejeski and Vangilder 1992). Limited knowledge of factors affecting survival during this critical life stage makes evaluating annual population fluctuations difficult (Hubbard et al. 1999). Survival of Merriam's turkey poults can vary considerably from 36–59 percent (Wakeling 1991) with most poult mortality occurring before poults reach an age of 2 wks (Glidden and Austin 1975, Lehman et al. 2001, Spears et al. 2007). Survival of eastern turkey (*M. g. silvestris*) poults is reduced by low temperatures and precipitation (Roberts and Porter 1998a). Information on factors influencing survival of Merriam's turkey

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[1] Present Address: Custer State Park, 13329 US Highway 16A, Custer, SD 57730

poults is lacking both in its indigenous (Scott and Boeker 1975, Wakeling 1991) and introduced ranges (Crawford and Lutz 1984, Hengel 1990, Flake and Day 1996, Rumble et al. 2003). No studies have correlated weather variables with poult survival within the Merriam's turkey range. Our objectives were to estimate poult survival rates and evaluate the relationship between weather indices and survival of Merriam's turkey poults near the northeastern extension of their expanded range. Understanding natural variation of vital rates for Merriam's turkeys and how climate conditions may affect those vital rates is useful for resource managers (Rumble et al. 2003).

STUDY AREA

Our study area (1213 km^2) was located in Custer and Fall River counties in the southern portion of the Black Hills physiographic region (Johnson et al. 1995). Elevations in the southern Black Hills range from 930 to 1627 m above mean sea level with a varied topography of rocky ridges, drainages, canyon walls, and mountain valleys (Kalvels 1982). The study area has a continental climate with mean annual precipitation of 44.2 cm and mean annual temperature of 7.8 ºC (National Climatic Data Center 1971–2000). Land cover types were mostly ponderosa pine forest (48 %) and meadows (23 %). Twenty-nine percent of the study area was burned by wildfires in 2000 and 2001. Rocky Mountain juniper (*Juniperus scopulorum*) and deciduous draws comprised < 1 percent of the study area. Western snowberry (*Symphoricarpos occidentalis*) and common juniper (*Juniperus communis*) were the most common shrubs beneath the forest canopy, whereas serviceberry (*Amelanchier alnifolia*), bearberry (*Arctostaphylos uva-ursi*), and chokecherry (*Prunus virginiana*) occurred less frequently (Hoffman and Alexander 1987). Common grasses included needle-and-thread (*Stipa comata*), western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*), little bluestem (*Schizachyrium scoparium*), and prairie dropseed (*Sporobolus heterolepis*) (Larson and Johnson 1999).

METHODS

Capture and Radio Telemetry

We captured female Merriam's turkeys in winter from 2001 to 2003 using cannon nets (Dill and Thornsberry 1950, Austin et al. 1972), rocket nets (Thompson and Delong 1967, Hawkins et al. 1968, Wunz 1984), and drop nets (Glazener et al. 1964). We recorded age of captured females as either adult ($\geq$ 1 yr old) or yearling (< 1 yr old) based on presence or absence of barring on the ninth and tenth primary feathers (Williams 1961). We fitted females with 98-g backpack mounted radio transmitters equipped with activity, loafing, and mortality signals (Advanced Telemetry Systems, Isanti, MN, USA). We obtained locations of female turkeys systematically throughout nest initiation and incubation to identify nesting females as described in Lehman et al. (2008). After nests hatched we located radio-marked females and their broods 5–6 days/week primarily by direct observation. Visual observations of poults May through August, 2001-2003, were used in poult survival analyses.

Poult Survival Analyses

We estimated poult survival ($\hat{S}$) from the initial number of poults that hatched from successful nests to the number surviving to 4 wks posthatch. Initial number of poults was determined at each successful nest site based on egg shell and membrane remains. Poults were counted at 1 wk, 2 wks, and 4 wks posthatch. If poults were found dead, necropsy of carcasses determined causes of death, and we classified mortality as mammalian predation, avian predation, or weather-related. Death was attributed to predation when examination of carcasses revealed hemorrhaging accompanied by puncture wounds. When necropsy of poults did not reveal wounds or injuries that suggested predation, we concluded the mortalities were likely the result of weather conditions.

Poults 1 wk of age were counted by observing broods feeding in open areas or by counting poults observed at ground roosts (Thompson 2003). For ground roost observations, observers would watch the female and poults leave the ground roost site immediately after sunrise to obtain counts. Poults were counted 2 and 4 wks posthatch by visually observing broods while foraging in open areas; however, if dense vegetation hampered observations, broods were flushed to count poults (Glidden and Austin 1975, Vangilder et al. 1987, Hubbard et al. 1999). Broods may form crèches after poults reach 2 wks of age and is fairly common after poults reach 4 wks of age (Vangilder and Kurzejeski 1995). When radio-marked females with broods form creches it is difficult to differentiate individual females and their poults during the day so we counted these poults in late evenings or early mornings while they roosted in trees with the hen. On several observations, we noted broods would group together but were composed of slightly different age classes. Our roost observations indicated similarly aged poults would roost with the brood hen, suggesting we were counting the correct number of poults per female with this method.

We estimated poult survival using a modified Kaplan-Meier model (Kaplan and Meier 1958, Flint et al. 1995). This method allows interchange of individuals among broods and relaxes the assumption that poults within broods have independent survival probabilities. The modified model uses repeated observations of radio-marked adult females and their poults (Flint et al. 1995). We compared poult survival rates among years using a chi-square hypothesis testing procedure (Sauer and Williams 1989) using the program CONTRAST (Hines and Sauer 1989). End-point poult survival distributions were compared between age classes (adults and yearlings) of females using a *Z*-test described by Pollock et al. (1989). Significance level was set at α = 0.10 for all comparisons. We selected α = 0.10 since the 0.05 level can fail to identify comparisons that might be relevant (Hosmer and Lemeshow 2000).

Relationship of Weather to Survival of Poults

We obtained weather data from the nearest of five weather stations (National Climatic Data Center 2001-2003) in or adjacent to our study area. Because precipitation can be patchy from convection storms, daily precipitation represents an approximation at brood sites.

Weather variables for each individual brood survival interval included: heating degree days (HDD) (Roberts and Porter 1998a) calculated as HDD = 11 °C – average of the maximum and minimum temperature for each day; HDD = 0 if the average temperatures were ≥ 11 °C. HDD values were averaged for the number of days during the survival interval. Maximum, minimum, and average daily temperatures during a 24-hr period for days in the survival interval were also averaged. Total amount of precipitation and number of precipitation events (days with rain) were summed over the survival interval.

Temperatures < 11 °C in combination with precipitation can cause weather-related mortality in poults, particularly for poults < 15 days of age (Healy and Nenno 1985). Therefore, we also calculated a cold-wet index, which was calculated as 11 °C – the minimum temperature on the coldest day during the interval multiplied by the amount of precipitation on that day. If multiple days had the same minimum temperatures with precipitation, then the day with the most precipitation was used. When no days received precipitation during the interval the cold-wet index was given a 0. Values were summed for the interval between successive observations.

We modeled poult survival with several weather covariates through 15 days of age using generalized estimating equation (GEE) models with repeated measures (PROC GENMOD, SAS Version 9.01, 2005) using the information-theoretic approach (Burnham and Anderson 1998, 2002). Models were ranked using the Quasilikelihood under the Independence model Criterion with variance inflation factor statistic (QIC_u) (Pan 2001), which is comparable to Akaike's information criterion comparing models fit with likelihood-based methods (Burnham and Anderson 2002). For model selection uncertainty, we model-averaged the best ranking models with ΔQIC_u values ≤ 2 (Burnham and Anderson 2002).

Relationship of Weather to Poult:hen Ratios

We obtained annual poult:hen ratios compiled by the SDGFP from 1971 through 2006 (unpublished data, SDGFP, Rapid City). SDGFP collects ratio data from field staff opportunistically with visual observations from the entire area of the Black Hills. We estimated the primary brood rearing period to be during the month of June based on observations from this study (unpublished data, South Dakota State University) and another conducted by Rumble and Anderson (1996) in the central Black Hills. We obtained weather data from three weather stations spread across the Black Hills for the period 1971-2006 (National Climatic Data Center 1971–2006).

We averaged weather station values for the month of June and used these data to analyze relations of poult:hen ratios to number days with precipitation events, number of days with precipitation events where average temperature was < 11 °C, and a June cold-wet index. The June cold-wet index was calculated as follows: for days in June in which minimum temperature was < 11 °C and precipitation occurred that day, we multiplied the difference between the minimum temperature and 11 °C by the precipitation on that day. For days in June that received no precipitation, or for days in which minimum temperatures were ≥ 11 °C and precipitation occurred that day, the daily values were given a 0; values greater than 0 were averaged for the month of June. We then used linear regression to estimate the relations between poult:hen ratios and these June weather variables using PROC REG (SAS Version 9.01, 2005).

RESULTS

Poult Survival to 4 Weeks

Fifty-seven female turkeys (52 adults, 5 yearlings) hatched 841 poults from 2001-2003. Years combined, poults reared by yearling female turkeys had lower (Z = 1.99, P = 0.05) survival ($\hat{S}$) (n = 47 poults, $\hat{S}$ = 0.11 ± 0.10 [SE]) than poults raised by adult females (n = 794 poults, $\hat{S}$ = 0.33 ± 0.05 [SE]) to 4 wks posthatch. Poult survival rates at 1, 2, and 4 wks posthatch did not differ ($\chi_2^2 \leq 1.02$, $P \geq 0.60$) among years for poults raised by adult females (Table 1). Survival of poults hatched from first nest attempts (n = 515 poults, $\hat{S}$ = 0.26 ± 0.05 [SE]) was lower (Z = 1.65, P = 0.10) than survival of poults hatched from renests (n = 279 poults, $\hat{S}$ = 0.46 ± 0.11 [SE]) at 4 wks posthatch.

Relationship of Weather to Survival of Poults

Six models exhibited support for predicting poult survival with weather covariates (ΔQIC_u < 2.0). The model with the greatest support included age of poults (positive) and precipitation events (negative) (Fig. 1). The second best model included

Table 1. Poult survival ($\hat{S}$ ± standard error [SE]) at 1-, 2-, and 4-wk posthatch intervals for Merriam's broods reared by radio-marked adult females in the southern Black Hills, South Dakota, 2001–2003.

		Survival at Posthatch Intervals				
Year	n a–n b	0–1 ± SE	n c	0–2 ± SE	n d	0–4 ± SE
2001	213–92	0.43 ± 0.21	67	0.32 ± 0.20	49	0.23 ± 0.16
2002	243–122	0.51 ± 0.07	84	0.35 ± 0.10	81	0.33 ± 0.09
2003	338–147	0.44 ± 0.08	142	0.42 ± 0.08	135	0.40 ± 0.08
Pooled Years	794–361	0.46 ± 0.06	296	0.37 ± 0.06	265	0.33 ± 0.05

a – initial number of poults alive that left the nest bow
b – number of poults alive at 1 week of age
c – number of poults alive at 2 weeks of age
d – number of poults alive at 4 weeks of age

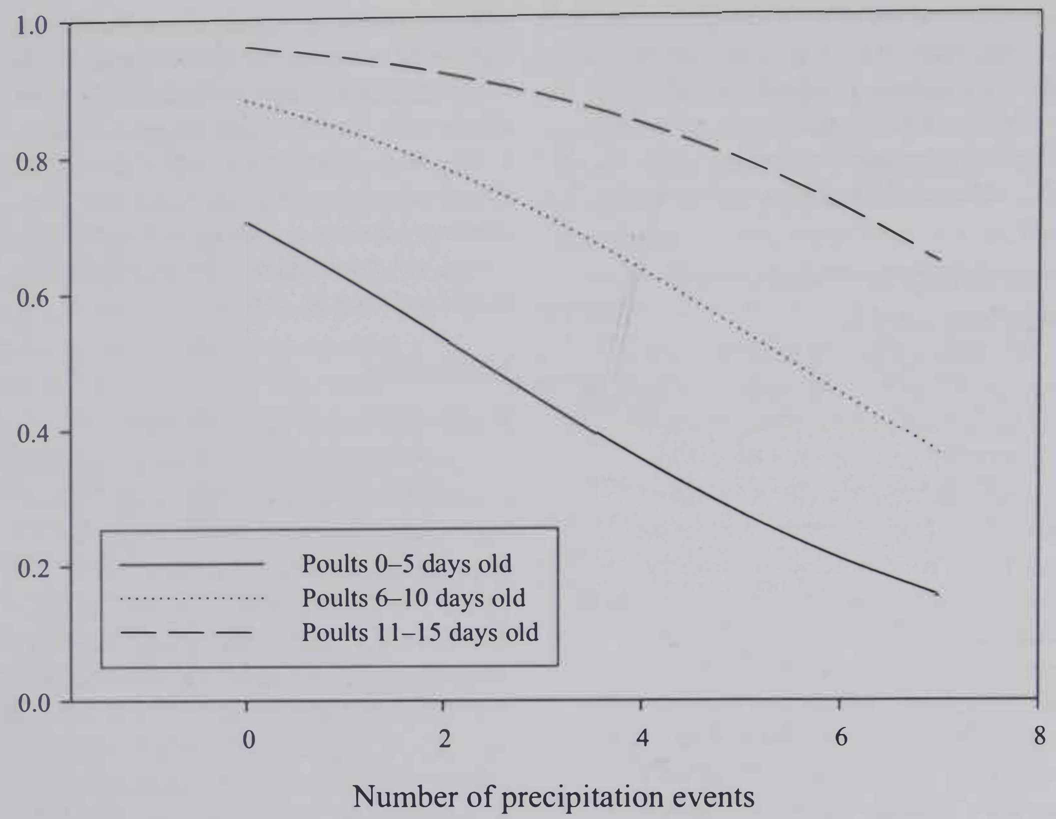

Fig. 1. Predicted survival of poults during 3 intervals (0–5, 6–10, 11–15 days post-hatch) with number of precipitation events that occurred during brood-rearing for Merriam's wild turkeys in the southern Black Hills, South Dakota, 2001–2003.

age of poults (positive), precipitation events (negative), and the interaction of age with the cold-wet index (Table 2). The interaction of age with the cold-wet index indicated younger poults were more susceptible to death by cold and wet events than older aged poults (Fig. 2). The covariates age of poults and precipitation events occurred in three of the models considered having support and the cold-wet index was included in four of the models. Due to model-selection uncertainty the parameter estimates for covariates from the top six models were averaged (Table 2).

Additionally, we found 11 dead poults while locating broods with radio-telemetry. Necropsies revealed poults died from hypothermia and we provide the weather data associated with the day the mortality occurred (Table 3). Mean 24-hr precipitation during the 11 weather related mortalities was 1.4 cm (SE = 0.7) and mean 24-hr minimum temperature was 1.5 °C (SE = 3.2).

Relationship of Weather to Poult:hen Ratios

Poult:hen ratios (1971-2006) were not correlated with number of days with precipitation during June ($\beta = -0.17$; $F_{1,35} = 1.04$, $P = 0.32$), nor number of days with precipitation events where average temperature was < 11 °C ($\beta = -0.28$; $F_{1,35} = 3.12$, $P = 0.09$). However, poult:hen ratios were correlated with the June cold-wet index ($Y = 5.48 - 0.15$ [Jun cold-wet index], $\beta = -0.60$; $F_{1,35} = 19.40$, $P < 0.01$) (Fig. 3). Cold-wet index values ≥ 10 for the month of June typically had ratios with fewer poults/female (≤ 3), whereas index values that were < 5 indicated ratios with more poults per female (≥ 5).

DISCUSSION

Poult survival and recruitment are of major importance to maintaining wild turkey populations (Vangilder 1992); however, information on survival of Merriam's turkey

Table 2. General estimate equation models predicting poult survival through 15 days of age for Merriam's turkeys in the southern Black Hills, South Dakota, 2001–2003. Number of parameters (K), Quasilikelihood under the Independence model Criterion with variance inflation factor (QIC_u), Kullback-Leibler distances rescaled as simple differences (ΔQIC_u), Akaike weights (w_i), and evidence ratios (ER). Only the top six models are presented due to their weight of evidence ($\leq 2\ \Delta QIC_u$) and model averaged coefficients with variance are presented at the bottom.

Poult survival models	**K**	**QIC_u**	**ΔQIC_u**	**w_i**	**ER**
$\hat{S}$ = 0.19 + 0.23 (Age) – 0.37 (Precipitation events)	3	59.93	0.00	0.23	1.00
$\hat{S}$ = 0.17 + 0.23 (Age) – 0.34 (Precipitation events) – 0.002 (Age x Cold-wet index a)	4	60.77	0.84	0.15	1.52
$\hat{S}$ = 0.37 + 0.21 (Age) – 0.30 (Precipitation events) – 0.04 (Cold-wet index a)	4	61.00	1.07	0.13	1.71
$\hat{S}$ = – 0.26 + 0.24 (Age) – 0.01 (Age x Cold-wet index a)	3	61.33	1.40	0.11	2.01
$\hat{S}$ = 1.51 – 0.08 (Cold-wet index a)	2	61.60	1.67	0.10	2.30
$\hat{S}$ = 0.16 + 0.23 (Age) – 0.38 (Precipitation events) + 0.04 (HDD b)	4	61.62	1.69	0.10	2.33
Average $\hat{S}$ = 0.26 + 0.16 (Age) – 0.21 (Precipitation events) – 0.001 (Age x Cold-wet index a) – 0.01 (Cold-wet index a) + 0.004 (HDD b) (variance [$\hat{S}$] = 0.04)					

a – the cold-wet index was calculated as 11°C – the minimum temperature on the coldest day during the interval multiplied by the precipitation that occurred that day

b – heating degree days (HDD) is calculated on the Celsius scale as HDD = 11°C – average temperature if average temperature < 11°C, or HDD = 0 if average temperature ≥ 11°C, where average temperature is the mean of daily minimum and maximum temperatures

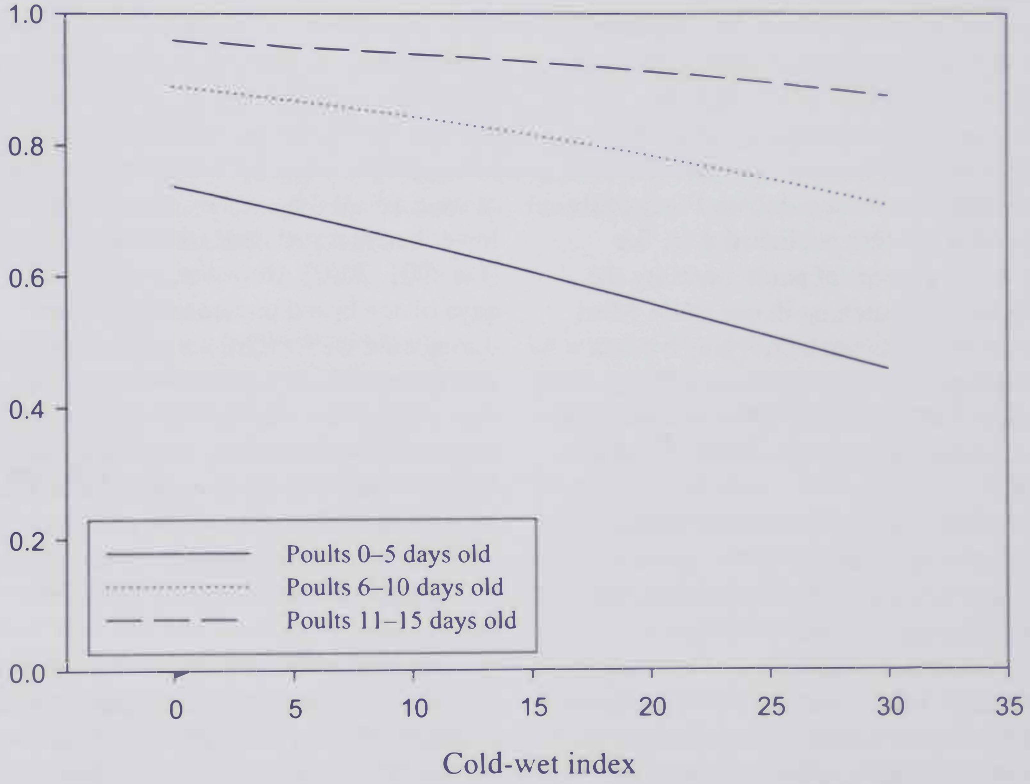

Fig. 2. Predicted survival of poults during 3 intervals (0–5, 6–10, 11–15 days post-hatch) with a cold-wet index during brood-rearing for Merriam's wild turkeys in the southern Black Hills, South Dakota, 2001–2003. The cold-wet index was calculated as 11°C – the minimum temperature on the coldest day during the interval multiplied by the precipitation that occurred that day.

Table 3. Relationship of weather data and Merriam's turkey poult mortalities investigators found dead from weather related death in the southern Black Hills, South Dakota, 2001–2003.

Date	Poult mortality events							
	n [a]	Age in Days	Prec. events [b]	Precip. [c]	Minimum temp. [d]	Cold-wet index [e]	HDD [f]	Predicted survival [g]
3 Jun 2001	2	1	2	1.93	–2	25.09	13	–0.22
4 Jun 2002	2	1	2	1.90	5	11.40	6	–0.10
4 Jun 2002	2	2	2	1.90	5	11.40	6	0.05
6 Jun 2003	1	1	2	0.50	–1	6.00	12	–0.02
6 Jun 2003	3	3	5	0.50	–1	6.00	12	–0.34
7 Jun 2003	1	1	2	1.90	3	15.20	8	–0.14

a – number of poults investigators found dead from weather related mortality
b – number of precipitation events that occurred from hatch to death
c – precipitation (cm) that occurred 24 hours before poults were found dead
d – minimum temperature (°C) that occurred 24 hours before poults were found dead
e – the cold-wet index was calculated as 11°C – the minimum temperature on the coldest day during the interval multiplied by the precipitation that occurred that day
f – heating degree days (HDD) is calculated on the Celsius scale as HDD = 11°C – average temperature if average temperature < 11°C, or HDD = 0 if average temperature ≥ 11°C, where average temperature is the mean of daily minimum and maximum temperatures
g – predicted survival using model averaged coefficients (= 0.26 + 0.16 [Age] – 0.21 [Precipitation events] – 0.001 [Age x Cold-wet index] – 0.01 [Cold-wet index] + 0.004 [HDD]) and variables associated with mortality

poults is limited to a few studies (Rumble et al. 2003). Survival of Merriam's poults to 4 wks of age ranged from 36–59 percent (36% in Wyoming [Hengel 1990], 36–59% in Arizona [Wakeling 1991], 43% in southcentral South Dakota [Flake and Day 1996]). We consider poult survival (33%) at 4 wks posthatch in the southern Black Hills low relative to other published data. We observed 54 percent of poult mortality the first week after hatching in our study. Most poult mortality occurs before poults reach 2 wks of age (Glidden and Austin 1975, Vangilder and Kurzejeski 1995, Roberts and Porter 1998a, Lehman et al. 2001, Spears et al. 2007).

Precipitation events in combination with cold temperatures < 11 °C reduced survival of Merriam's turkey poults in the 15-day posthatch period. We found 11 dead poults during the course of locating broods with radio telemetry following cold and wet weather events; eight of which were 1–2 days old and found near nests. Three other poults ~ 3 days old were found dead at sites where we observed broods foraging. Necropsy did not reveal wounds or injuries that suggested predation, so we concluded these mortalities likely resulted from weather conditions. Precocial young of galliform birds in the first week after hatch have poorer insulation, poorer thermal regulation, and relatively high surface area to volume ratio than older young (Schmidt-Nielsen 1997). On the other hand, precocial young of two other galliform species seem to have adapted to cold by maintaining lower body temperatures than older young (Pis 2001, 2002). However, poults < 10 days of age brood underneath females during cold wet conditions and may be less susceptible to cold and wet weather than older poults that have become too large to brood under females (Healy and Nenno 1985). Our observations and model predictions indicated poults < 5 days of age were susceptible to mortality from cold and wet conditions despite protection by the brood hen.

Accumulation of body mass from 1 to 7 days posthatch is significantly less than during 8–14 days posthatch (Healy and Nenno 1980). Thus, poults ≤ 1 wk of age may be hindered energetically in being able to survive cold and wet weather events even though they have a reserve supply of yolk available the first few days after hatch. Survival of eastern turkey poults to

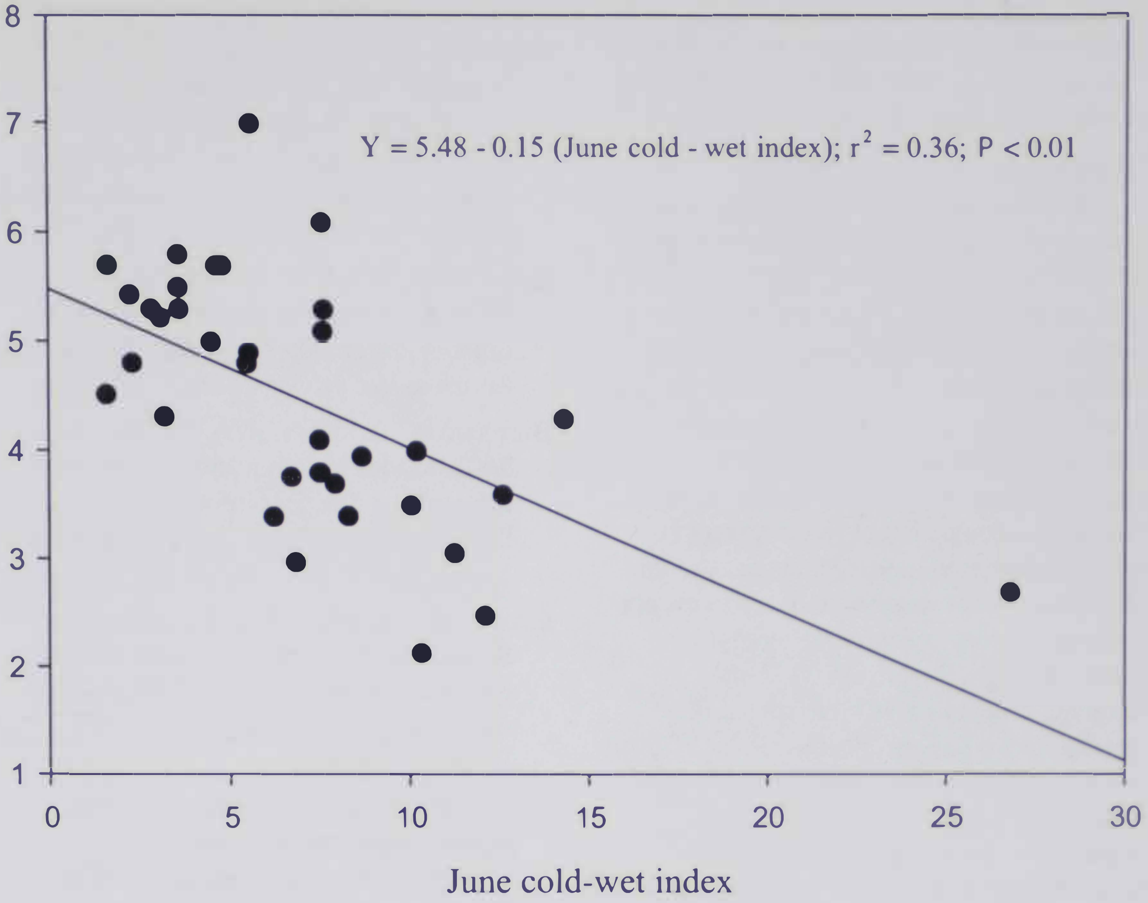

Fig. 3. Association of poult:hen ratio data and a June cold-wet index variable from 1971–2006 for Merriam's turkeys in the Black Hills, South Dakota. The June cold-wet index was calculated as follows: for days in June where the minimum temperature was < 11 °C and precipitation occurred that day, the difference between the minimum temperature and 11°C was multiplied by the precipitation on that day. June index values were correlated with poult:hen ratios using linear regression.

2 wks posthatch at the northern extent of their range was also negatively associated with colder temperatures and increased precipitation (Porter and Roberts 1998a).

The relationship between long-term poult:hen ratios and inclement weather does suggest a negative association between cold and wet weather and survival of poults. Extreme cold and wet weather coincided with years when poult:hen ratios were usually < 3. However, the strength of the relationship was marginal ($r^2 = 0.36$), which was most likely due to the scale at which weather variables were related to poult:hen ratios. Field staff opportunistically collected ratio data over a large area, and precipitation from convection storms are often patchy in the Black Hills. Such a coarse-scale evaluation of weather variables with poult:hen ratios does not provide as much information as a fine-scale approach.

Despite the effects of weather, we suspect that an appreciable portion of the unexplained variability in survival of poults was the result of predation. We observed a golden eagle (*Aquila chrysaetos*) prey on two poults that were 6 days of age hatched from a radio-marked female (Lehman and Thompson 2004). Mammals were the most common predators of turkey nests (Lehman et al. 2008), and predation on poults could be amplified during periods when poults are wet. Precipitation increases bacterial activity on the skin of turkeys and produces more odors during incubation possibly facilitating olfaction by predators (Syrotuck 1972, Roberts and Porter 1998b). During our study we continued to locate females with poults through 28 days posthatch but mortality was much reduced after 15 days of age.

Management Implications

Reduced nesting success during wet springs (Lehman et al. 2008), and reduced survival of poults resulting from cool and wet conditions during June will likely severely reduce recruitment in Merriam's turkey populations. Precipitation can be spotty over the Black Hills and a coarse-scale weather based index that tracks precipitation events over a large area may not be as valuable a tool for managers as a fine-scale based index. Managers should relate individual weather station parameters to specific areas occupied by turkeys and such a fine-scale approach will better estimate production of Merriam's turkey populations if survey or radio telemetry data are not available. Recruitment information will give managers more flexibility in adjusting season lengths and bag limits immediately after years of poor or good reproduction.

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