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Chapter 18- Chick Survival of Greater Prairie-Chickens

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CHAPTER EIGHTEEN

Chick Survival of Greater Prairie-Chickens

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Abstract. Chick survival during the first three weeks of life is a critical stage in the demography of Greater Prairie-Chickens (*Tympanuchus cupido*), but little information is available. Biologists often estimate brood success using periodic flushes of radio-marked females, but it is impossible to determine mortality factors if chicks are not radio-marked. We used sutures to attach 0.5-g transmitters to 1- to 2-day-old chicks in Johnson County, Nebraska, during 2008. Our objectives were to (1) assess causes of mortality of 0- to 21-day-old chicks, (2) estimate daily survival probability for 0- to 21-day-old chicks, and (3) evaluate the effect of applying transmitters with suture attachment to chicks. We monitored a total of 221 prairie chicken chicks from 20 broods. We radio-marked 27 chicks from 10 broods of radio-marked females (one to five chicks per brood). The chicks were located twice per day to ensure that they were within a 10-m radius of the female. Our limited sample showed a weak effect of radio-marking on the survival of prairie-chicken chicks ($\beta = -0.54$; SE = 0.33). Forty-two (19%; 95% CI: ±5%) of the 221 chicks in our sample survived to day 21, confirming low rates of productivity observed in hunter wing surveys and brood flushes of radio-marked females in a concurrent study. All radio-marked chicks in our sample died (13% exposure; 87% predators) before 21 days of age. Survival of chicks increased with age, and survival decreased during periods with high precipitation. Daily and 21-day survival rate estimates for all chicks in our sample were 0.926 (95% CI: 0.915–0.937) and 0.193 (95% CI; 0.155–0.255), respectively. Predation appeared to be the most critical factor for chick survival, so management of landscapes to reduce risk from predators may have a positive effect on Greater Prairie-Chicken populations.

Key Words: brood, chick, Greater Prairie-Chicken, radiotelemetry, survival, *Tympanuchus cupido*.

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Chick survival is a critical phase for Greater Prairie-Chicken (*Tympanuchus cupido*; hereafter prairie chicken) population dynamics; Wisdom and Mills (1997) reported that finite rates of population growth of prairie chickens were highly sensitive to juvenile survival rates. No data on cause-specific chick survival exists for prairie chickens; such information is critical for species of conservation concern. Biologists often use periodic flushes of radio-marked females to estimate brood success for grouse species, but this method does not provide information about the cause of mortality of chicks. Radio-marked chicks can be used to efficiently identify mortality events, suitable brood rearing habitat, and movements (Burkepile et al. 2002). However, radio-marking chicks requires the proper size transmitter and an effective and unobtrusive attachment method to avoid increasing mortality (Millspaugh and Marzluff 2001).

Hunter wing surveys in southeast Nebraska have indicated low productivity (0.92 chicks/adult) during 2001–2007 compared with north-central Nebraska's Sandhills population of prairie chickens in the same period (1.77 chicks/adult; J. Lusk, unpubl. data). Empirical data from a sample of radio-marked females in southeast Nebraska during 2007–2008 suggested that brood survival was low ($S_{21\text{-day}} = 0.59$; Matthews et al., this volume, chapter 13). However, Matthews et al. (this volume, chapter 13) monitored unmarked broods and could not determine the cause of chick mortality. Our goal was to radio-mark chicks to more precisely assess variation in chick survival of prairie chickens in southeastern Nebraska. Our three objectives were to (1) assess the causes of mortality of 0- to 21-day-old chicks, (2) estimate daily survival probability of 0- to 21-day-old chicks, and (3) evaluate effects of handling and applying radio markers with suture transmitters on survival of chicks.

METHODS

Study Area

Johnson and Pawnee counties (average precipitation: 840 mm; University of Nebraska–Lincoln High Plains Climate Center) in Nebraska contain a population of Greater Prairie-Chickens, thought to be the northernmost extension of the Flint Hills population. The topography of these counties is rolling uplands, and the landscape of our study site was dominated by corn, soybean, and alfalfa production with significant areas of pasture and rangeland. In 2007, 163.3 km^2 (40,345 acres; ca. 17%) of Johnson County and 172.1 km^2 (42,533 acres; ca. 15%) of Pawnee County was enrolled in the Conservation Reserve Program (Farm Service Agency, USDA).

Field Methods

We randomly selected broods from radio-marked females in a concurrent study (Matthews et al., this volume, chapter 13) during 2008. Depending on brood size, one to five chicks in each brood were fitted with a 0.5-g (<3% chick mass) transmitter (Advanced Telemetry Systems, Isanti, MN, model A2415). We radio-marked 27 chicks from ten broods with a suture attachment method (Burkepile et al. 2002). The suture method was used for attachment because minimal training was needed, the transmitters could be attached at the nest site, and it was less invasive than prong-and-suture attachment (Mauser and Jarvis 1991) or subcutaneous implants (Korshgen et al. 1996).

We monitored female movements to ascertain nest hatch date, and we located each brood 1–2 days post-hatch to capture and mark chicks. The brood was caught by hand shortly after sunset using spotlights to maximize the chance of capturing the entire brood; potential brood numbers were determined by comparing number captured with number of eggshells when chicks departed the nest. We placed the chicks in an insulated box containing a warm bottle of water to maintain the chicks' body heat during transmitter application. We randomly selected chicks for radio-marking, and followed methods of Burkepile et al. (2002) for suture attachment. We inserted monofilament suture into a 12-ga syringe needle. The transmitters were sutured in the mid-dorsal region directly between the wings with the transmitter antennae positioned toward the tail. We inserted the needle subcutaneously, ensuring about 5 mm of skin was between the insertion and exit hole. We pushed the monofilament suture through the needle and removed the needle, leaving the monofilament in the epidermal tissue. We positioned both free ends of the monofilament through the transmitter's anterior backpack attachment once and tied a square knot. We repeated the same process for the posterior attachment of the transmitter. To ensure room for tissue growth the transmitters were sutured to leave a ca.

TABLE 18.1

Comparison of competing models to explain variation in survival of radio-marked Greater Prairie-Chicken chicks in southeast Nebraska, 2008.

Model	DIC	ΔDIC	w_{DIC}	K
Handled + marked + age + precipitation	567.9	0.00	1.0	5
Handled + precipitation	592.0	24.1	0.0	3
Handled + marked + age	808.1	240.2	0.0	4
Handled + age	916.1	348.2	0.0	3
Handled + age + precipitation	917.9	350.0	0.0	4
Handle + marked	922.1	354.2	0.0	3
Handled + marked + precipitation	922.8	354.9	0.0	4
Age	1,012.8	444.9	0.0	2
Precipitation + age	1,013.1	445.2	0.0	3
Handled	1,211.2	643.3	0.0	2
Precipitation	1,270.2	702.3	0.0	2
Null	1,273.3	705.4	0.0	1

NOTE: Models are ranked by Deviance Information Criterion (DIC) score. Differences between the top model and all other models are shown by ΔDIC; K is the number of model parameters. The model weight (w_{DIC}) is the certainty that each model is the best model of the models compared.

2-mm suture gap (Burkepile et al. 2002). We placed the entire brood, consisting of radio-marked and handled-only chicks, at the capture location to allow the female to relocate them.

Following marking, we determined location of chicks twice each day to ensure chicks were alive and within a 10-m radius of the female. If the radio-marked chick was not within 10-m of the female, we conducted an immediate, extensive search for the transmitter to determine chick fate. We performed brood flushes at 10 and 21 days post-hatch to determine chick survival of unmarked young in the same brood.

We randomly selected 10 broods from the 2008 sample of the concurrent study on the same site by Matthews et al. (this volume, chapter 13) to serve as a control group to compare survival with the handled-only and radio-marked chicks in our 10 study broods. Control chicks were never captured and never handled. Like the handled-only chicks, the control broods were flushed at 10 and 21 days post-hatch to determine brood size. Animal capture and handling protocols were approved by the University of Nebraska–Lincoln Institutional Animal Care and Use Committee (Protocol #05-02-007).

Statistical Methods

We developed an *a priori* set of 12 models, which included main effects models of chick age, precipitation, and handling, a global model with all effects, and six other additive models with biologically reasonable combinations of the effects (Table 18.1). We compared all models to a null model, with constant survival through time and space. Our age model allowed survival to vary in a linear fashion as a function of the number of days since hatch. We used the average daily precipitation as a covariate for each monitoring interval in our precipitation model. Our final models incorporated the type of handling and marking each chick received. First, a "handled" model assessed the effect of handling chicks during capture; chicks that were handled, as well as radio-marked chicks, were considered handled; chicks in broods without captures were used as controls. Second, we used an additional model to assess the effect of radio-marking and included the nested effects of handling and radio-marking in a two-factor, additive model of handling and radio-marking, which allowed us to separate the effects of radio-marking from handling.

TABLE 18.2

Parameter estimates of slope coefficients (SE and 95% confidence interval) from the best model (Table 18.1) for effects of handling, radio-marking, age, and precipitation on survival of Greater Prairie-Chicken chicks in southeast Nebraska, 2008.

Parameter	β(SE)	95% Confidence Interval
Intercept	1.30 (0.22)	$0.88 < \beta < 1.72$
Handling	0.15 (0.21)	$-0.24 < \beta < 0.54$
Radio-marking	−0.54 (0.33)	$-1.18 < \beta < 0.10$
Age	0.12 (0.02)	$0.08 < \beta < 0.16$
Precipitation	−0.54 (0.04)	$-0.62 < \beta < -0.46$

NOTE: Control young not handled or radio-marked serve as the baseline ($\beta = 0.00$) for the comparison with discrete effects of handling and radio-marking.

We used a logistic exposure structure to estimate daily chick survival ($\hat{S}_D$; Shaffer 2004). We combined two known fate data structures in the same model; radio-marked chicks had monitoring intervals corresponding with telemetry observations, while non–radio-marked chicks had 10- or 11-day monitoring intervals corresponding with flush counts at 10 and 21 days after hatch. The logistic exposure structure allowed us to include data with unequal intervals (Shaffer 2004). We encountered convergence difficulties with standard methods based on iterated weighted least squared method because of the survival patterns in control birds. Thus, we used a Markov Chain Monte Carlo (MCMC) framework using WinBUGS (version 1.4.2) and program R with R2WinBUGS package (R package version 2.1-8). We used three replicated chains with 100,000 iterations, each sampling with a starting value from a normal distribution with a mean of 0 and a standard error of 0.2. We had a burn-in of the first 50,000 samples and set our thinning at 150 for the subsequent samples. We then calculated a Deviance Information Criterion (DIC) score for each model (Spiegelhalter et al. 2002). DIC is used in the MCMC framework and is similar to Akaike's Information Criterion, so we selected the model with the lowest DIC score as the best model (Burnham and Anderson 2002). We used the 95% confidence interval (CI) surrounding the covariate estimate (β) to evaluate the strength of the parameter's effect on chick survival (Table 18.2). We calculated a mean daily survival rate using our top model (Table 18.1), setting parameters at their mean. We estimated a 21-day success rate ($\hat{S}_{21}$) as $\hat{S}_{21} = (\hat{S}_D)^{21}$, and we used the delta method to approximate the variance of $\hat{S}_{21}$ and calculate the 95% CIs (Powell 2007).

RESULTS

We monitored 221 chicks from 20 broods; 27 chicks from 10 broods were radio-marked, and 56 chicks from the same broods were handled but not radio-marked. Our control sample consisted of 138 chicks (not handled or radio-marked) from 10 broods. The suture procedure for each chick took approximately 3 minutes, with brood handling time <20 minutes. No chicks died during the suture process. We did not observe infection or inflammation of the area of suture attachment on recaptured chicks, nor did we observe abnormal movement of radio-marked chicks relative to their unmarked brood-mates. Female abandonment of broods after radio-marking did not occur, and females usually remained <20 m from us while we attached chick transmitters.

Data from three of 27 (11%) radio-marked chicks were censored when the sutures failed prior to 21 days post-hatch; two failed at day 7, one at day 9. When we recovered these transmitters, we believed the chicks were still alive because the brood was still in the vicinity, in contrast to broods which left the vicinity after partial losses due to predators. In addition, our subsequent flushes of these broods showed no mortality of young. Because we lost radio contact with these chicks before our 21-day monitoring interval ended, we were only able to assess the fate of 24 chicks.

Three of 24 (13%) radio-marked chicks died from apparent exposure. The intact remains of one chick were found shortly after a heavy rain, which

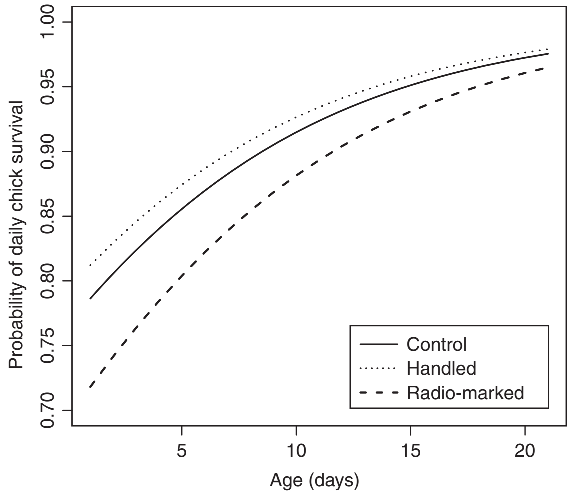

Figure 18.1. Relationship between daily chick survival and age of young (0–21 days) for control (not handled or radio-marked), handled, and radio-marked Greater Prairie-Chicken chicks in southeast Nebraska, 2008. Confidence intervals overlapped and are omitted for clarity.

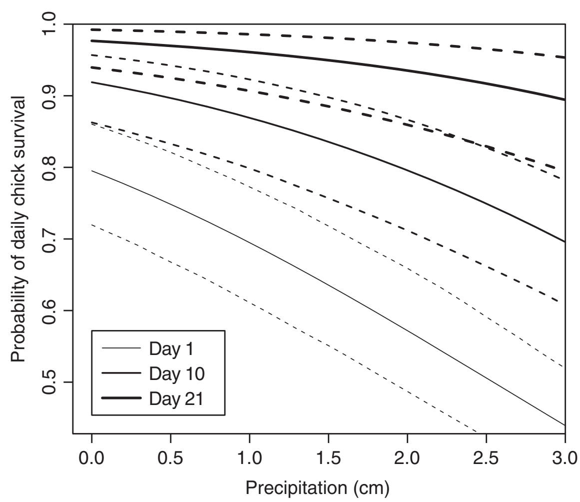

Figure 18.2. Daily survival probability for 1-, 10-, and 20-day-old Greater Prairie-Chicken chicks as a function of daily precipitation in southeast Nebraska, 2008.

suggested hypothermia as the cause of death. Two other dead chicks were found intact (day 2 and 4 post-hatch) with no visible signs of cause of disease or mortality, suggesting other exposure causes. Two of 24 (8%) radio-marked chicks died from known predation events. One chick's transmitter condition included a curled antenna and abrasions, which suggested predation by a raptor, and another transmitter was found in a pile of plucked chick and adult prairie chicken feathers, also suggesting raptor predation. Nineteen of 24 (79%) radio-marked chicks' fate was uncertain, as transmitters disappeared and were never recovered. We observed >300-m movements by radio-marked females immediately after disappearance of radio-marked young. Because the movement of broods during periods absent of chick mortality usually was localized, we believe the missing transmitters were ingested or destroyed by predators. Hence, we recorded these chicks' fates as mortalities caused by predation. On five occasions, >1 radio-tagged chick disappeared from the same brood simultaneously, also indicative of mortality rather than radio failure. All radio-marked chicks died before 21 days of age, and 84% (n = 24) of mortalities occurred 6–13 days after hatch, 4% (n = 24) occurred 1–5 days after hatch, and 12% (n = 24) occurred during days 14–21. Twenty-seven of 56 (48%) handled-only chicks died before the first flush at day 10, and 36 of 56 (64%) died before day 21. One hundred thirteen of 138 (83%) control chicks died before day 10 and 116 of 138 (84%) died before day 21. Forty-two (19%; 95% CI: ±5%) of the 221 chicks in our sample survived to day 21.

Daily chick survival varied with age (β = 0.12, SE = 0.02; Fig. 18.1) and precipitation (β = –0.54, SE = 0.04; Fig. 18.2). Our estimate of daily survival of chicks was 0.926 (95% CI: 0.915–0.937);

probability of survival to 21 days post-hatch was 0.193 (95% CI: 0.155–0.255). Our best model (w_{DIC} = 1.00) included effects of precipitation, age, handling, and radio-marking. However, the estimates indicated no negative effect of handling (β = 0.15, SE = 0.21) and weak evidence for an effect of radio-marking (β = –0.54, SE = 0.33) on chick survival (Table 18.2).

DISCUSSION

Our data suggested that 80% of chicks on our study site in 2008 died prior to 21 days after hatch. The high rate of chick mortality we observed may explain the low juvenile-to-adult ratios observed by NGPC in hunter wing surveys from 2001–07 in southeast Nebraska. Matthews et al. (this volume, chapter 13) reported 21-day success rates of 7.4% for non–radio-marked broods. Our study confirms that the brood survival estimates of Matthews et al. (this volume, chapter 13) were not negatively biased because chicks were missed during flushes; our combined results suggest that a well-designed effort to monitor broods using radio-marked females can provide unbiased estimates of brood survival. Chick mortality events were highest within 14 days of hatch, similar to research reviewed by Hannon and Martin (2006). Our daily survival rate was very similar to the rate from the Flint Hills reported by McNew et al. (this volume, chapter 19). The majority of mortalities (88%) were apparently due to predation, which was similar to other grouse studies (Riley et al. 1998, Gregg et al. 2006, Manzer and Hannon 2008). Our study site has a complex predator community, so chicks could have been depredated by mammals, raptors, or reptiles. Riley and Schulz (2001) suggested that the majority of Ring-necked Pheasant (*Phasianus colchicus*) chick mortalities in the central U.S. were caused by mammals.

Precipitation decreased brood survival of Lesser Prairie-Chickens (*Tympanuchus pallidicinctus*; Fields et al. 1998), and our data suggested the same trend for Greater Prairie-Chicken chicks. Precipitation reduces arthropod numbers during above normal rainfall (Riley et al. 1998), and chicks that ingested large amounts of arthropods had 50% higher survival than chicks that ingested a diet lower in arthropods (Hill 1985). Cool, wet weather also reduces chicks' ability to thermoregulate (Flanders-Wanner et al. 2004), and most exposure mortalities of chicks occur when precipitation is >109% above average (Riley et al. 1998).

Fields et al. (1998) also documented the effect of age on chick survival of Lesser Prairie-Chickens. As chicks age, their mobility improves, which may allow them to more effectively catch arthropods and avoid predators. The primary food source during early development for grouse chicks is insects (Hannon and Martin 2006); Hill (1985) reported that Ring-necked Pheasant chicks increased in body weight as arthropod food intake increased.

The transmitter attachment method worked well, but three (11%) of our transmitters were known to have fallen off prematurely. Burkepile et al. (2002) reported that 11% of posterior sutures on Greater Sage-Grouse chicks failed, and they suggested that suture failure was caused when the anterior suture failed as a result of the sutures restricting tissue growth and expansion. By using suture attachment, we reduced the risk of infection associated with subcutaneous implanted transmitters (Gaunt et al. 1997). The application process required little training and minimal brood handling, and could be performed in the field, reducing risk of female abandonment due to chick translocation off site.

Our highest-ranked chick survival model was well supported (w_{DIC} = 1.00) and included effects of handling and radio-marking, which provides some evidence that radio-marking with a suture method and handling accounted for variation in survival of our sample of prairie chicken chicks (Burnham and Anderson 2002). The direction of the effect for radio-marking was negative, although the CI suggested there was, at best, a weak effect of radio-marking on survival. Burkepile et al. (2002) suggested that Greater Sage-Grouse chick survival was not affected by 1-g suture-attached radio transmitters. Our study does not provide strong evidence that chick survival is negatively affected by radio-marking, but it is possible that our sample size was inadequate to make definitive conclusions. For this reason, we encourage future field research to test for effects of transmitters on chicks. Our simultaneous assessment of radio-marked, handled, and control chicks may serve as a useful framework for future investigations.

Transmitter size is a critical consideration for effective radiotelemetry studies. We often found that our 0.5-g transmitters could be not located from our truck-mounted antenna system at distances >300 m, which made it impossible to find 19 (90%) of 21 predated chicks. We were thus unable to determine the factors responsible for mortality. We selected the 0.5-g transmitters to minimize the potential negative effects of transmitters on chicks, but at a trade-off of transmitter performance versus radio mass. Burkepile et al. (2002) lost contact with <10% of 1-g transmitters in a similar study, and radio transmitters weighing 7% of the chick body weight did not reduce survival or weight gain in Ring-necked Pheasant chicks (Ewing et al. 1994) or Wood Duck (*Axis sponsa*) ducklings (Davis et al. 1999). Based on results with gamebirds, biologists may want to consider using 1-g transmitters on prairie chicken chicks when study objectives require relocation of chicks from long distances.

Our radiotelemetry study of Greater Prairie-Chicken chicks provided valuable information on survival rates, and we continue to investigate the unique population dynamics of this stable population with low rates of productivity. Predation was apparently the largest cause of chick mortality, but management of predators is complex (Riley and Schulz 2001). Previous management plans for prairie chickens in agricultural landscapes have focused on providing suitable nesting cover for females. Our data suggest that predation of broods may be a limiting factor for prairie chicken populations, and we encourage landscape-level research efforts to evaluate factors that may contribute to high predation rates of prairie chicken chicks (Schmitz and Clark 1999).

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