EVALUATION OF A METHOD FOR SURGICALLY IMPLANTING RADIOTRANSMITTERS IN RIO GRANDE TURKEY POULTS

by

STEPHANIE LYNN MCKENZIE, B.S.

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Approved

Mark C. Wallace
Co-Chairperson of the Committee

Warren B. Ballard
Co-Chairperson of the Committee

C. Brad Dabbert

Donald C. Ruthven III

Accepted

Fred Hartmeister
Dean of the Graduate School

DECEMBER, 2007

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TABLE OF CONTENTS

ABSTRACT

Wild turkey (*Meleagris gallopavo*) poult survival is fundamental to understanding wild turkey populations. However, current technology only allows managers to measure survival through the first 30 days of life. With the aid of suitable radiotransmitters, it would be possible to gain reliable poult survival estimates into their first winter. Various methods of attachment of radiotransmitters have been examined including harnesses, backpacks, gluing, suturing, collaring, and implants. New radiotransmitter and implant technology is necessary to assess poult survival between hatching and recruitment as juveniles the following spring.

We tested a new surgically implantable radiotransmitter (weighing 2.2 g [Advanced Telemetry Systems, Isanti, MN]) and implant procedure on Rio Grande turkey (*M. g. intermedia*) poults to assess survival to 8 months of age. We evaluated 4 treatment groups: (1) control (no radiotransmitter or surgery) (n = 22); (2) surgery without radiotransmitter (n = 26); (3) surgery with radiotransmitter (n = 35); and pre-treatment birds (n = 8). We monitored poult behavior and daily survival to determine effects of these procedures. Neither implants nor implant procedure had detectable effects on survival among treatment groups. However, immediately post-surgery we did notice a difference in the motor response of implanted poults. We also detected differences in weight, wing chord, and girth among the treatment groups. Signals from the implanted radiotransmitters could be detected at a range of 30 ± 10 m for 102-day period.

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The wild turkey (*Meleagris gallopavo*) is widely distributed throughout North America. Five subspecies inhabit the United States: Florida wild turkey (*M. g. osceola*), eastern wild turkey (*M. g. silvestris*), Merriam's wild turkey (*M. g. merriami*), Rio Grande wild turkey (*M. g. intermedia*), and Gould's wild turkey (*M. g. mexicana*) (Kennamer et al. 1992). Three subspecies are found in Texas, the Rio Grande, eastern, and Merriam's wild turkey.

Prior to European colonization, wild turkey populations existed in 39 of the contiguous states and Ontario, Canada. However, human disturbance, market hunting, and habitat loss caused wild turkey population declines, such that by the end of the 19^{th} century wild turkey populations were at their lowest historical levels (Kennamer et al. 1992). During the Great Depression, small farms were abandoned as farmers fled to the refuge of cities. The resulting plant succession of abandoned old fields improved wild turkey habitat and the stage was set for wild turkey restoration (Kennamer et al. 1992). The implementation of bag limits and creation of restoration programs directed by federal and state agencies led to wild turkey recovery. Bag limits of 25 wild turkeys were established in 1903 (Kennamer et al. 1992). Then, during the 1930s, the Cooperative Wildlife Research Unit Program and the Federal Aid in Wildlife Restoration Act, more commonly known as the Pittman-Robertson Act, were created. The Cooperative Unit program provided the means for the development and training of wildlife professionals and the Pittman-Robertson Act provided the money needed by state agencies to hire these newly trained "wildlifers" and put them in the field (Lewis 2001). Wild turkeys were also trapped and reintroduced into previously uninhabited areas. Currently, wild turkeys inhabit portions of all lower 48 states and Hawaii (Kennamer et al. 1992).

Population restoration efforts and successful implementation of federal programs marked the resurgence of the wild turkey in North America. However, there is some concern that Rio Grande wild turkey populations in some portions of the Panhandle and northcentral Texas are currently declining (Ballard et al. 2001, Hohensee and Wallace 2001). Reasons for these declines are unknown but speculation includes changing habitat due to increases in agricultural crops and alterations in rangeland brush control (Hohensee and Wallace 2001).

Though much is known about wild turkey life history, little is known regarding poult survival and habitat needs beyond 30 days of age. However, poult survival is a key parameter needed to understand wild turkey population dynamics (Hubbard et al. 1999). In order to effectively manage Rio Grande wild turkey populations, biologists must be able to estimate poult mortality and survival.

However, limited knowledge about this critical life stage has made it difficult to accurately evaluate annual variation in population numbers (Hurst 1992, Hubbard et al. 1999). Many radiotelemetry studies have been published that deal with adults of various subspecies but few studies have assessed poult survival in wild turkeys, especially during the first 8 weeks post-hatch (Hubbard et al. 1998). In order to correctly develop population models, offspring data must be included. Methods such as flush counts, brood surveys, and poult surveys have been used to estimate poult survival during the first few weeks post-hatch; however, each method has shown varying degrees of success (Hubbard et al. 1999). In the past, visual observations have been used to observe poult losses; however, these kinds of observations are difficult to perform (Spears 2002). Visual obstruction, escape, and hiding capabilities of wild turkey poults make visual observations difficult and unreliable (Spears 2002). Also, visual observation may negatively affect poults and hens by invoking unnecessary stress and can increase brood visibility causing predation and poult mortality (Spears 2002).

Reliable estimates of poult mortality can be obtained using radiotelemetry. For example, Speake et al. (1985), Hubbard et al. (1999), and Spears et al. (2005) have all conducted research on poult survival to approximately 4 weeks using various radiotransmitter attachment methods. However, data on poult mortality >4 weeks post-hatch does not exist due to limitations of radiotransmitter attachment methods. Previously, annual survival rates of wild turkey poults have been based on data pooled across years, study areas, or both (Vangilder 1992). With the aid of suitable poult radiotransmitters it would be possible to gain reliable survival estimates for poults surviving into their first winter. By this age wild turkey poults, referred to as juveniles, could be recaptured and equipped with a traditional radiotransmitter (Holdstock et al. 2006).

Radiotransmitters were first used in wild turkey research in 1965 (Wilson and Norman 1995). Forms of attachment have included harnesses, backpacks, gluing, suturing, collaring, and implanting. However, radiotransmitter attachment methods can affect behavior and survival (Murray and Fuller 2000), as well as the condition and reproduction of the individual (Whitney et al. 2001). For example, previous research on

Gray partridge (*Perdix perdix)* concluded that effects from backpack harnesses included reduced takeoff angle, flight speed, and climbing (Whitney et al. 2001).

In an attempt to minimize the deleterious effects of attaching radiotransmitters on birds, researchers have experimented with different types of implants (Murray and Fuller 2000). Partially implanted, as well as full implanted radiotransmitters have been used with some success, but such implants can result in short-term preening over the incision site and cause low rates of seroma and infection (Murray and Fuller 2000). Implanting radiotransmitters also reduces radio signal transmission distance when the antenna is within the abdominal cavity. To counter this affect, Korschgen et al. (1996) developed a technique allowing the antenna to extrude from the body, thereby augmenting transmission distance. For full implants to be successful, radiotransmitters must remain small, <2% of body mass (Murray and Fuller 2000), which has inherently limited battery size and longevity to <6 weeks.

Few studies have assessed the effects of implanted radiotransmitters. Hubbard et al. (1998) noted implanted radiotransmitters reduced wing length growth but did not affect body mass. They concluded that implants worked better on wild turkey poults than backpack harnesses. Pen studies and the use of captive turkey poults can be used to estimate survival and behavior effects from radiotransmitter implant techniques. Bowman et al. (2002) found the mean retention time for glued backpacks was 27.6 days and 30.5 days for interscapular implants. They also concluded there were no detectable effects on poult growth between the 2 methods. However, balance and mobility presented some difficulty for poults immediately following surgery (<1 hour) (Bowman et al. 2002). Bowman et al. (2002) concluded implanted radiotransmitters offered greater potential for increased retention times, but they were concerned about the training needed to successfully implant radiotransmitters and the time needed to apply radiotransmitters. Spears et al. (2005) evaluated retention times of glued radiotransmitters on Rio Grande wild turkey poults in the field. They found that mean retention time for poults was 20.4 ± 8.3 days (n = 34). Poults were able to balance and maneuver immediately following the application of the radiotransmitters (Spears 2002). There is a need for turkey poult survival data >4 weeks of age. We evaluated the use of a new radiotransmitter that was implanted in 3–5-day old turkey poults.

Chapter II examines the effects of implanting the radiotransmitter into 3–5-day old Rio Grande turkey poults. We documented the effects of survival, behavior, and poult growth throughout the study period. Chapter II is formatted for submission to the *Journal of Wildlife Management* and includes co-authors that made substantial contributions to the study. Authorship is as follows:

Chapter II. Stephanie L. McKenzie, Mark C. Wallace, Warren B. Ballard, Matthew J. Butler, C. Brad Dabbert, Donald C. Ruthven III, P. Ole Alcumbrac, and Christopher O. Kochanny.

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CHAPTER II

SURVIVAL, BEHAVIOR, AND PHYSICAL EFFECTS OF SURGICALLY IMPLANTED RADIOTRANSMITTERS ON 3–5-DAY OLD RIO GRANDE TURKEY POULTS

Abstract

We conducted a study on captive Rio Grande turkey (*Meleagris gallopavo intermedia*) poults to evaluate the effects of implanting a 2.2 g radiotransmitter using an intra-abdominal surgical procedure. Neither implants nor implant procedure had detectable effects on survival among treatment groups. However, immediate impairment (post-surgery) of motor response on implanted poults was observed. Behavior differences between treatment groups were found in various weeks. Growth differences were detected among treatment groups. Signals from implanted radiotransmitters could be detected at a range of 30 ± 10 m for a 102-day period. Future research should be conducted on wild turkey poults in a field setting.

Introduction

Understanding wild turkey poult survival is imperative to understanding wild turkey population dynamics (Hubbard et al. 1999). However, accurate population models are rare because poult survival rates are non-existent. Effective monitoring of young, growing wild turkey poults without affecting survival and growth presents a daunting task. Flush counts, brood surveys, and visual observations have been used in the past with varying degrees of success (Hubbard et al. 1999).

Radiotransmitters have been used on wild turkeys since 1965 (Wilson and Norman 1995). Forms of radiotransmitter attachment for young birds have included harnesses, tail clips, implants (Hubbard et al. 1999), and most recently glue expected to last 2–28 days (Bowman et al. 2002, Spears et al. 2005). Recently, researchers have begun experimenting with implants to minimize deleterious effects of radiotransmitter attachment (Murray and Fuller 2000).

Korschgen et al. (1984) first surgically implanted radiotransmitters into the abdomens of diving ducks (Anatidae) and extended the radio antenna from the body, thereby augmenting transmission distance (Korschgen et al. 1996). For abdominal implants to be successful radiotransmitters must remain small, <2% of body mass (Murray and Fuller 2000), which has inherently limited longevity to <6 weeks because of limitations in battery technology. Ideally, size and attachment method of radiotransmitters should have a minimal effect on physical and behavioral development of rapidly growing wild turkey poults (Hubbard et al. 1998).

Few studies have assessed survival, behavior, or physical effects of radiotransmitter implants. Hubbard et al. (1998) assessed the effects of implanted radiotransmitters on wild turkey poults and reported reduced wing growth but did not detect effects on body mass. They concluded that implants worked better than backpack mounted radiotransmitters. Bowman et al. (2002) conducted a pen study on captive turkey poults. They compared glued (backpack style) and interscapular implants and concluded there were no detectable effects on growth between the 2 treatments. However, Bowman et al. (2002) found that for an interval of 2–4 hours, implanted poults showed an impaired motor response, including decreased balance and mobility. Hubbard et al. (1998) preferred the implant technique whereas Bowman et al. (2002) questioned the practicality of the technique in the field. Implants offered potentially greater retention times, but post-surgical impairment would produce more problems for poults released immediately post-surgery (Bowman et al. 2002).

Our objectives were to test an intra-abdominal implant technique on survival, behavior, and growth of Rio Grande turkey poults over an 8-month period, and to test the effective range and longevity of implanted radiotransmitters.

Study Area

The Reese Center Aviary, Lubbock, Texas, provided both an outdoor aviary and an enclosed building which housed 2 commercial brooders. The outdoor aviary was comprised of wire mesh pens (8 2.1 × 2.4 m) with enclosed roof and washable concrete flooring. We split each into 4 equal sub-pens measuring 1.1 × 1.2 m to reduce movement and facilitate turkey poult identification. Each sub-pen contained ≤6 poults.

Our preliminary signal distance tests were performed on private lands in Collingsworth County, Texas, in grassland habitat and brush habitat (primarily sand sagebrush [*Artmisia filifolia*] and shinnery oak [*Quercus havardii*]). Further tests were conducted at the Texas Tech University Native Rangeland facility which was dominated by plains yucca (*Yucca glauca*), mesquite (*Prosopis glandulosa*), blue grama (*Bouteloua gracilis*), and prairie three awn (*Aristida oligantha*) which was representative of Texas Rolling Plains rangelands.

Methods

We purchased captive bred, <3-day old Rio Grande turkey poults from Privett Hatchery (Portales, NM) and received them on 26 April 2006. Captive birds can be used to provide accurate estimates of growth and survival effects for various radiotransmitter attachment techniques (Bowman et al. 2002). When turkey poults arrived at the Reese facility, we placed them in a brooder for 2 days and provided feed and water ad libitum prior to being selected for treatments. Poults were fed Purina® Show Chow Turkey Starter for the first 3 weeks (bacitracin methylene disalicylate = 50.0 g/T, crude protein = 30% [Purina Mills, LLC, St. Louis, MO]). After the third week, we fed them Tatum Gamebird Starter (chlortetracycline = 50 g/T, crude protein = 27% [Economy Mills, LTD, Lubbock, TX]).

Pre-surgery

We randomly selected turkey poults from the brooder and placed them into one of the following treatment groups: (1) control (no radiotransmitter or surgery) (C); (2) surgery without radiotransmitter (S W/O); and (3) surgery with radiotransmitter (S W). We then weighed the poults to the nearest 0.1 g and banded them with an individual color-coded leg band identifying treatment group and individual. The turkey poults assigned to the C group were weighed, banded and then placed back into the appropriate brooder location. The S W/O poults were weighed and banded and then underwent surgical procedure but received no radiotransmitter implant. The S W poults were weighed and banded and then had a dummy radiotransmitter (Advanced Telemetry Systems, Isanti, MN) surgically implanted into the caudal air sac. The dummy radiotransmitter was 8 × 13 mm and weighed 2.2 g. Two turkey poults were implanted with active radiotransmitters and were used to determine effective radiotransmitter range.

Surgical procedure

We established a surgical station (sterile field on table) adjacent to the brooder. We began by sterilizing dummy radiotransmitters in 12.9% benzalkonium chloride (Noida Chemicals, New Delhi, India) and rinsed with 60 cc of 0.9% sodium chloride (NaCl). We then placed turkey poults in left lateral recumbency and anaesthetized the turkey poults using a facemask (made from ventilator tubing covered by small portion of latex glove with a slit in the middle for the head) emitting 5% isoflourane gas (Vedco Inc., St. Joseph, MO). Once a turkey poult was anaesthetized we reduced isoflourane gas concentration to 4%. Next, we aseptically prepared the right flank by plucking the feathers between the femur and the last rib and then applied a disinfectant. A 1 cm skin incision was made in the paralumbar fossa. We then used blunt dissection to probe to the caudal air sac. Then, we inserted a sterilized radiotransmitter into the caudal air sac and the myotonic incision was sutured using 3-0 monocryl suture (Johnson & Johnson, New Brunswick, NJ). We reduced isoflourane gas to 3% during suturing stages. When the incision site was completely sutured we detached the facemask and closed the skin with 3M™ Vetbond tissue adhesive (3M™, St. Paul, MN). At the completion of the procedure we gave turkey poults an intramuscular injection of 0.5 mg enrofloxacin, an antibiotic, (Bayer Corp., Pittsburgh, PA) and 0.5 mg of butorphanol tartrate, an analgesic, (Fort Dodge Animal Health, Fort Dodge, IA) (control poults did not receive injections) and placed poults in the brooder at 37° C. We used an antibiotic as a precautionary measure, because we operated in a less than ideal environment and the analgesic was required by the Texas Tech University Animal Care and Use Committee (Protocol # 06007-02). Poults in the surgery without radiotransmitter group were subjected to the same surgical and suture procedure; however the radiotransmitter was not inserted. We used blunt dissection to probe to the caudal air sac to simulate the placement of the radiotransmitter implant.

Post-surgery observation

We observed post-operative recovery of all turkey poults until they regained normal balance and mobility. During this time we recorded any abnormal behavior or complications. We conducted scan sampling (i.e., rapidly censused behavior of individuals in a group; Martin and Bateson 1993) and focal sampling (i.e., continuous sampling of randomly selected individuals; Martin and Bateson 1993). We conducted scan samples (Altmann 1974) of all poults every 30 minutes during daylight hours (0800–1900) for 4 days post-surgery. Focal observations (Martin and Bateson 1993) were collected for 3 minutes on randomly selected individuals stratified among groups at 30 minute intervals. Behaviors recorded included: walking, lying down, standing, feeding, and drinking. Walking, feeding, and drinking were classified as “active” behaviors, the remaining were “inactive” behaviors (Table 2.1).

Poults remained in the brooder for 9 days at which time they were moved to the outdoor aviary pens at Reese Center Aviary. In the Reese Aviary, poults were placed randomly in groups of ≤6 poults/sub-pen. Poults were fed and watered ad libitum. We provided heat lamps for 21 days to provide necessary heat sources for brooding turkey poults. Active radiotransmitter birds were housed in a separate sub-pen because they were handled weekly for signal distance tests.

Behavior observation and data collection

We conducted scan samples on all poults and focal observations on randomly selected turkey poults (≤6 poults) daily. We conducted scan samples by counting how many birds in each treatment were active. During focal observations we entered the pen, but not the particular sub-pen, of a randomly selected poult. We then quietly sat and located the poult, then began a 3 minute continual observation of that poult. During this time we recorded behaviors observed (Table 2.1). We rotated the order of the poults observed weekly, so that poults observed during morning hours of 1 week were observed during the evening hours of the following week. We continued the daily observation process until the poults were moved to the Erskine facility at 3 months of age.

When poults reached 3 months of age we euthanized 18 poults (5 C, 8 S W/O, 5 S W) to ensure we met TTU ACUC provisions on space requirements per turkey. Turkey poults that were moved to the Erskine aviary were transported in turkey travel boxes approved by the National Wild Turkey Federation (NWTF).

Growth

We measured weight, wing chord length, and girth at the keel weekly to bi-weekly, when pens were being cleaned. We recorded weight to the nearest 0.1 g using a digital scale or vertical hanging scale. We measured wing chord (Gilliland and Ankney 1992) and girth (Latshaw and Bishop 2001) to the nearest 0.1 cm using a cloth tape.

Signal distance testing

Prior to this study, we performed preliminary signal tests with a commercially available frozen Cornish game hen carcass (*Gallus gallus domesticus*) in both open grass field and brush habitat. At each site we randomly placed the Cornish game hen carcass, with a radiotransmitter placed in abdominal cavity, in a field representative of previously mentioned habitats. We then walked in the 4 cardinal directions until we could no longer hear the radiotransmitter signal. Testing was performed on the live poults in the same manner, but was conducted at the TTU Native Rangeland facility. One modification included the use of a transport box provided by NWTF. The poults were placed in separate boxes and set out in the field.

Necropsies

Necropsies were performed on all turkey poults, whether they died during the experiment or were euthanized. We began by removing the skin where the incision site was located. We made note of any scar tissue, lesions, or other abnormalities. We then removed the skin to examine the incision in the muscle tissue. Finally, we made an incision into the abdomen and noted any abnormalities that may have been caused by the implant or surgical procedure. We investigated the gastrointestinal tract (GI) of each bird to determine whether food or water had been consumed immediately prior to death or euthanasia.

Statistical methods

We used Cox proportional hazards (Allison 1995) on 5 models to assess poult survival in relation to initial weight and treatment. We used AIC_c (Akaike's Information Criterion corrected for small sample size; Burnham and Anderson 2002) to assess which factors should be included in the best model explaining poult survival (Table 2.2). We compared percent of time spent in "active" behaviors for our focal data measured by daily observations using a repeated measures Analysis of Variance (ANOVA) (SAS Institute 2006 [PROC GLIMMIX]). We compared our scan samples by week and treatment, measured by daily observations, using *t*-tests (Zar 1999). We compared growth as measured by weekly weights, length of wing chord, and girth among treatment groups using a repeated measure ANOVA (SAS Institute 2004 [PROC MIXED]).

Results

We received 91 ≤3-day old Rio Grande turkey poults. We evaluated 4 treatment groups: (1) control (no radiotransmitter or surgery [C]) (n = 22); (2) surgery without radiotransmitter (n = 26) (S W/O); (3) surgery with radiotransmitter (n = 35) (S W); and (4) pre-treatment birds (n = 8). At the initiation of the surgical procedures the poults age ranged from 3–5-days old. The surgical procedure lasted approximately 7 minutes ($\bar{X}$ = 7.2, SD = 1.2) per individual from the time anesthesia tube was placed over the poults head to the time of the final antibiotic injections.

Survival

Many, 50.5% (46 of 91), poults died within the first week of this study (Table 2.3 and Figures 2.1–2.2). Eight were not affiliated with any treatment (i.e., pre-treatment), 9 were in the C group (40.9%), 10 were in the S W/O group (38.5%), and 19 were in the S W group (54.3%). Interestingly, 17 of 30 (56.7%) poults that did not undergo any sort of treatment died; and 29 of 61 (47.5%) of those that underwent surgery or surgery with implant died within the first 5 days. No poults were lost after the fifth day except those we euthanized. Three poults were euthanized between day 7 and day 80 due to circumstances unrelated to the treatment; these were censored from analyses. Two of those poults were smaller than the other poults and were pecked severely due to the hierarchy of the other poults. The poor body condition of those poults and the lack of defense prompted us to remove them from the study. The third suffered a broken leg in a roost rung; consequently this poult was also euthanized. We found no difference in the probability of survival among the treatments in our top 3 models (Table 2.4). All mortalities occurred in the first 5 days; however, we may have been unable to detect a difference in survival because of our small sample size. The baseline model accounted for 37.8% of our weight and the rest of the weight was distributed throughout the remaining models (treatment [TRT = C, S W/O, S W], treatment + initial weight [TRT + WT = 3 treatment groups and initial weight], initial weight [WT = initial weight], and combined treatment [combined treatment = control group and "surgery" groups combined]) (Table 2.2). However, our treatment model was competitive with 17.2% of the model weight. The effect of the combined treatment model weight proved to be spurious because we combined 2 groups that did not have comparable survival data. The effect of initial poult weight also proved to be a spurious effect because we had no change in fit (–2LL) between the weight model and our baseline model.

We did not observe radiotransmitter loss in any poults. Necropsies of poults revealed scar tissue at the incision site on 2 individuals. We also noted dehiscence of the incision in 15 poults. However, these signs gave no indication of possible causes of mortality, because necropsies performed on poults euthanized at the end of the study exhibited the same condition. Also, we noticed radiotransmitter movement. Most of the movement was within the abdominal cavity, but we observed 3 cases in which the radiotransmitter was wedged between the epidermis and the muscle tissue. This occurrence did not affect survival because 2 poults euthanized at the end of study exhibited this condition.

<u>Behavior</u>

Poults in both treatment groups exhibited difficulty maintaining balance, difficulty walking, falling, limp wings, shallow breathing, some vomiting, and the presence of air pockets at the incision site immediately post-surgery. At least 50% of the poults recovered from these conditions within 35 minutes from the time they were placed in the brooder; however, in 10 cases recovery was longer (longest recovery, 3 days). We made intensive observations of poults that had not fully recovered until normal function was regained.

Focal sampling data indicated no treatment effect ($P > 0.05$). However, we did detect a difference among weeks (week effect) ($F_{(9,705)} = 361.5$, $P = \leq 0.001$) and an interaction between week and treatment (interaction effect) ($F_{(18,705)} = 81.0$, $P = \leq 0.001$) (Table 2.5). To further understand our behavior analysis we looked at 4 prominent behaviors (feeding, standing, locomotion, and lying down) to examine differences among treatments (Figures 2.3–2.6). In week 3 the C group spent more time walking (P = 0.500) ($\bar{X}$ = 69.2, SE = 15.1) than the S W/O group ($\bar{X}$ = 32.9, SE = 7.9). But, during the same time period, focal observations of the S W/O group were consistently performed later in the evening, potentially biasing this result because poults were less active later in the evenings. In week 10 the S W/O group time spent less time standing (P = 0.100) ($\bar{X}$ = 41.4, SE = 8.9) than the S W group ($\bar{X}$ = 90.5, SE = 13.3). However, poults in the S W group were again consistently observed later in the evening that week than the S W/O group. Scan data indicated differences in mean activity in weeks 1 and 10. In week 1 the C group ($\bar{X}$ = 53.7, SE = 1.6) was more active (P = 0.011) than the S W group ($\bar{X}$ = 46.9, SE = 2.1) and in week 10 the C group ($\bar{X}$ = 68.8, SE = 2.9) was more active

($P = 0.014$) than the S W/O ($\bar{X} = 58.7$, SE = 2.7) group. However, activity presented no clear patterns.

Growth

Initial weights of turkey poults differed ($P < 0.05$) among treatment groups. The S W group ($\bar{X} = 45.4$, SE = 1.1) was heavier than the C group ($\bar{X} = 38.0$, SE = 1.6) and the S W/O group ($\bar{X} = 37.8$, SE = 1.6). When performing the surgeries, we began by randomly selecting poults for treatment groups. However, later in the day we began choosing larger poults so that we could have poults implanted with radiotransmitters. Despite being 8 g heavier at surgery, there was a treatment effect ($F_{(2, 45.8)} = 3.7$, $P = 0.032$) of poult weights over the next 4 months (Figure 2.7). The S W group ($\bar{X} = 1280.9$, SE = 40.3) gained less weight than the S W/O group ($\bar{X} = 1427.7$, SE = 40.5 ($P = 0.013$) but did not differ from the C group ($\bar{X} = 1402.0$, SE = 44.1). Poults in the S W/O group were 146.8 g (SE = 57.1) heavier by the end of the experiment than the S W group. However, neither surgery group differed from the control group.

Wing chord also differed ($F_{(2, 44.4)} = 5.8$, $P = 0.005$) by treatment. Poults in the S W/O group ($\bar{X} = 27.1$, SE = 0.3) had 2 ± 0.5 cm longer wing chords ($F_{(1, 45.3)} = 10.7$, $P = 0.002$) than both the C ($\bar{X} = 26.8$, SE = 0.3, $P = 0.022$) and the S W group ($\bar{X} = 25.8$, SE = 0.3) (Figure 2.8).

There was an interaction between week and treatment for girth ($F_{(20, 316)} = 2.4$, $P \leq 0.001$). Girth differed ($P = 0.016$) between treatments in week 2. The C group ($\bar{X} = 11.5$, SE = 1.4, $P = 0.021$) and the S W/O group ($\bar{X} = 11.6$, SE = 0. 8, $P = 0.006$) had smaller girths than the S W group ($\bar{X} = 12.7$, SE = 1.2) (Figure 2.9). This was likely due to the effect of the radiotransmitter itself and the presence of air pockets in S W poults in the week after surgery. However, as the poults grew in size, the presence of air pockets disappeared.

Signal distance testing

Preliminary results using a Cornish game hen carcass (n = 4) revealed a mean detection distance of 96.5 ± 68.1 m in the grassland habitat and a mean detection distance of 81.9 ± 33.4 m in the brush habitat. "Live" poults with radiotransmitters (n = 2) were only detectable at a maximum distance of 50 m ($\bar{X}$ = 30 ± 10 m [n = 20]). Battery life for transmitters lasted <102 days.

Discussion

We detected no effects on poult survival of surgical implantation of radiotransmitters into caudal air sacs after day 5. All poult mortalities occurred within the first 5 days (no mortalities after day 5). Mortality prior to day 5 cannot be attributed to the surgical procedure. Even higher percentages of poults that received no surgery or implant were lost than those that did receive such treatments. We attributed these mortalities to the condition of the poults when they arrived from the hatchery and our own negligence. Poults were placed into the brooder without being shown food or water, a critical step in raising poults. Poults did eat and drink, but we cannot be sure that all poults were eating and drinking. Necropsies of the poults that died within 5 days revealed little evidence of food or water in the GI tract or crop. Evidence of the yolk sac was present in the youngest poults; no evidence remained in the older poults. Hatchery-related risk factors for flock mortality include: source of hatchery, age of poults, truck on which poults were shipped and truck temperature (Carver et al. 2002). Prior to receiving them for this study these poults had been exposed to a variety of aforementioned uncontrollable factors that have been proven to influence early poult mortality. When we began, many poults were in poor condition (not active, lying down, not feeding) due to shipping and handling factors that we could not control. These individuals were poor candidates for surgical procedures. We recommend that poults appear active, healthy, and apparently able to feed and drink prior to attempting this procedure. However, we were unable to identify specific weights or criteria for choosing which poults to exclude. Weight data from poults captured in the wild (Brian Spears, Texas Tech University, unpublished data) revealed that wild poults in the 1–3-day old range averaged 8 g heavier (48.6 ± 1.25 g) than the poults we received from the hatchery. Jeff Bowman (Texas Tech University, unpublished data), who received poults from Privett Hatchery, reported mean poult weights of 59.8 g (59.8 ± 8.2 g), almost 20 g heavier than initial poult weights from our study. Hubbard et al. (1998), Bowman et al. (2002), and Gregg et al. (2007) reported lower mortality rates when evaluating radiotransmitter implants and implant procedure in studies that implanted radiotransmitters subcutaneously.

None of the intra-abdominal radiotransmitter implants were lost, due to extrusion, by poults during this study. Garrettson and Rohwer (1996), Bowman et al. (2002), and Gregg et al. (2007) all experienced extrusion of subcutaneous implants. Retention of subcutaneous implants used by Bowman et al. (2002) on captive poults was only 31 days. Surgical implantation of the radiotransmitters used in this study provided retention of radiotransmitters for 8 months, the length of the study. This implant and surgical procedure offers much greater retention of the radiotransmitters which would allow biologists and researchers to obtain data for poults >4 weeks of age.

Behavioral differences among groups did not persist but there was a period of impairment in the "surgery" groups. Immediately post-surgery, poults exhibited difficulty maintaining their balance, walking, falling, limp wings, shallow breathing, some vomiting, and the presence of small air pockets at the incision site. Mauser and Jarvis (1991) and Bowman et al. (2002) also reported similar impairments immediately following surgery. More than half (>50%) of the poults experiencing impairment recovered within 35 minutes of the time they were placed in the brooder following surgery. The poor condition of the poults going into the surgery might explain why some of the poults did not recover within the 35 minute time period.

Behavior in 6 out of the 10 weeks of one or both surgery groups differed from the control group. In the first week, despite following such an invasive procedure, there were no detectable differences in the behavior of poults. The inconsistency of behavior over weeks may be due to small sample sizes. Scan sampling indicated differences in weeks 1 and 10 between the C group and the S W/O group. Again, this inconsistency was likely due to differences in sample size. We did not observe pecking or preening at the incision site during any of the focal observations. Our results did not indicate any life threatening behaviors such as inability to move or not being able to feed.

The S W group, which had initial weights 8 g more than the other 2 treatment groups, ended up being lighter and having shorter wing chord measures than other birds in the study indicating that poults with radiotransmitters grew at a slightly slower rate over the 8 month period.

Radiotransmitter signal distance tests in live turkey poults did not match the preliminary or manufacturer suggested distances. Inquiries of the manufacturer suggested that these live radiotransmitters actually used batteries that were up to 2 years old. Our data indicated that researchers could expect at least 30 m signal detection in field study conditions though preliminary test suggest further (96.5 m). Tests comparing signal transmission distance between a Cornish game placed on the ground in a bag (236.7 ± 18.7 m) and in a transport box (123.3 ± 10.7 m) revealed a significant difference ($P < 0.001$) in mean detection distance. So, the suggested distance given by the manufacturer would have been attainable had we not placed the live turkey poults in a transport box.

The surgical procedure performed on 3–5-day old poults proved to be a success. Though initial mortalities were prevalent, we observed that poults with this surgery and implant procedure can and do survive as well as poults without surgery. A period of impairment is inevitable when using implants (Mauser and Jarvis 1991, Bowman et al. 2002). This technique is easily learned by the untrained individual and can be transferred to the field. Also, this technique and implant offer much greater retention times than previously used techniques. Greater retention times, lasting up to 8 months, would provide survival data needed to accurately assess population models.

Management Implications

This new implant and surgical procedure offers greater retention time than the glued backpacks and subcutaneous implants used previously. This procedure is easily learned and can be transferred to the field. There are initial post-surgical effects ≤3 days, which may require censoring or a different handling strategy with surgically implanted poults. However, this technique could be used to obtain survival data on free-ranging wild turkey poults for >8 months. We know this technique works on captive turkey poults, but future researchers may want to focus on using this technique and implant on wild turkey poults in the field.

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Table 2.1. Defined captive Rio Grande turkey poult behaviors used for focal samples in Lubbock, Texas, 28 April 2006–11 July 2006.

Behavior[a]	Defined
Walking	Take 3 consecutive steps
Feeding	Eat ≥3 sec
Drinking	Drink ≥3 sec
Pecking poults	Pecking other poults ≥3 sec
Flying	Flutter wings and gain air
Preening	Preening ≥3 sec
Hopping	Hopping ≥3 sec
Laying	Laying ≥3 sec
Standing	Standing for ≥3 sec
Sleeping	Eyes closed for ≥3 sec
Roosting	Atop roost snag for ≥3 sec

[a] Active behaviors were walking, feeding, drinking, pecking poults, flying, preening, and hopping. Inactive behaviors were laying, standing, sleeping, and roosting.

Table 2.2. Candidate Cox proportional hazard models for captive Rio Grande turkey poults in Lubbock, Texas, 28 April 2006–15 December 2006. For each model, we give –2 × log-likelihood (–2LL), number of parameters (K), second-order Akaike's Information Crieterion (AIC_c), difference in AIC_c compared to lowest AIC_c of the model set (Δ_i). and AIC_c weight (w_i).

Model	–2LL	K	AIC_c	Δ_i	w_i
Baseline	320.610	0	320.610	0.000	0.378
Treatment[a]	318.035	2	322.185	1.575	0.172
Initial weight[b]	320.455	1	322.504	1.894	0.146
Treatment + initial weight[c]	316.436	3	322.740	2.130	0.130
Combined treatment[d]	320.011	1	322.159	1.549	0.174

[a] Survival between treatment groups (control group [C] [no radiotransmitter or surgery], surgery without radiotransmitter [S W/O] group, and surgery with radiotransmitter [S W] group).

[b] Survival using the initial weights of turkey poults.

[c] Survival between treatment groups ([C], [S W/O], and [S W]).

[d] Survival between the control group and the "surgery" groups (S W/O and S W groups combined into 1 group).

Table 2.3. Distribution of mortalities for captive Rio Grande turkey poults by treatment group (C = control [no radiotransmitter or surgery], S W/O = surgery without radiotransmitter, and S W = surgery with radiotransmitter, euth = euthanized), how the mortality occurred, and when the mortality occurred, Lubbock, Texas, 28 April–15 December 2006.

No. Poults	Treatment	<5 days	Days 5–89	3 mos	4 mos	6 mos
8	None	died				
9	C	died				
10	S W/O	died				
19	S W	died				
1	S W/O		euth			
2	S W		euth			
5	C			euth		
8	S W/O			euth		
5	S W			euth		
1	C				euth	
1	S W/O				euth	
5	S W				euth	
7	C					euth
6	S W/O					euth
4	S W					euth

Table 2.4. Hazard ratios of captive Rio Grande turkey poults in Lubbock, Texas 28 April 2006–15 December 2006 using the Cox proportional hazards method on 4 models (treatment [TRT], treatment + initial weight [WT], initial weight, and combined surgery treatments.

Model	Variable	β[a]	SE[b]	Wald	*df*	*P*	Exp(β)[c]
Treatment	D 1[d]	0.511	0.406	1.582	1	0.208	1.667
	D 2[e]	-0.028	0.460	0.004	1	0.951	0.972
Treatment + Initial weight	D 1	0.728	0.446	2.668	1	0.102	2.071
	D 2	-0.042	0.460	0.008	1	0.927	0.959
	WT	-0.031	0.026	1.494	1	0.222	0.969
Initial weight	WT	-0.008	0.021	0.152	1	0.697	0.992
Combined treatment[f]	TRT	0.288	0.382	0.570	1	0.450	1.334

[a] Unstandardized regression coefficient.

[b] Standard error of β.

[c] Predicted change in the hazard for each unit increase in the covariate.

[d] D 1 = 0 when control, 0 when S W, and 1 when S W/O.

[e] D 2 = 0 when control, 0 when S W/O, and 1 when S W.

[f] S W/O and S W treatment groups combined into 1 treatment group for this model; TRT = 0 when control and 1 otherwise.

Table 2.5. Means and standard errors of percent of activity from focal samples of captive Rio Grande turkey poults during weeks 1–10 (C = control [no radiotransmitter or surgery], S W/O = surgery without radiotransmitter, S W = surgery with radiotransmitter, and "surgery" groups combined) with pairwise comparisons in significant weeks, Lubbock, Texas, 28 April 2006–11 July 2006.

	C		S W/O		S W		"Surgery"		
Week	$\bar{X}$ %	SE	$\bar{X}$ %	SE	$\bar{X}$ %	SE	$\bar{X}$ %	SE	*P*
1	18.3	3.5	26.3	4.3	26.1	4.1	26.2	3.0	0.263
2	8.2Aa	1.7	15.7b	3.0	7.6a	1.5	11.0A	1.5	0.023*
3	25.2Aa	4.4	15.8a	3.0	8.6b	1.7	11.7B	1.6	0.001*
4	12.7	2.6	16.7	3.2	14.4	2.7	15.5	2.1	0.616
5	20.7Aa	3.9	12.7ab	2.5	8.8bc	1.8	10.6B	1.5	0.013*
6	11.1Aa	2.3	12.1a	2.4	5.5b	1.1	8.2A	1.2	0.016*
7	12.7	2.6	7.6	1.6	11.7	2.3	9.5	1.4	0.176
8	14.1Aa	2.9	11.6a	2.3	5.8b	1.2	8.2B	1.2	0.009*
9	9.6	2.1	7.3	1.5	6.8	1.4	7.0	1.0	0.489
10	15.7Aa	3.1	8.5b	1.8	5.8b	1.2	7.1B	1.0	0.005*

[a] Estimates within week with the same letter combination are not different.

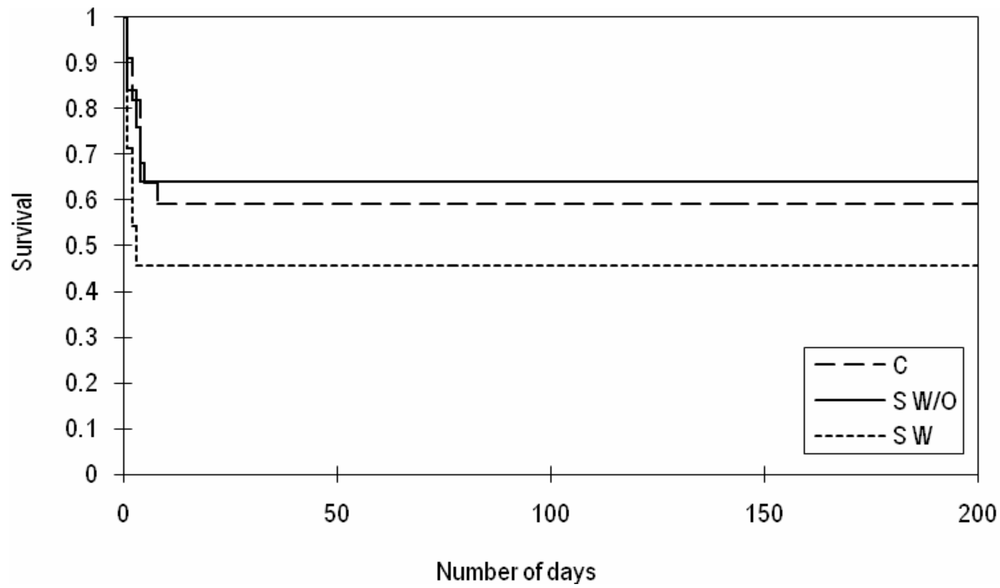

Figure 2.1. Survival of captive Rio Grande turkey poults from day 0–day 200 by treatment group (C = control [no radiotransmitter or surgery], S W/O = surgery without radiotransmitter, S W = surgery with radiotransmitter), Lubbock, Texas, 28 April 2006–15 December 2006.

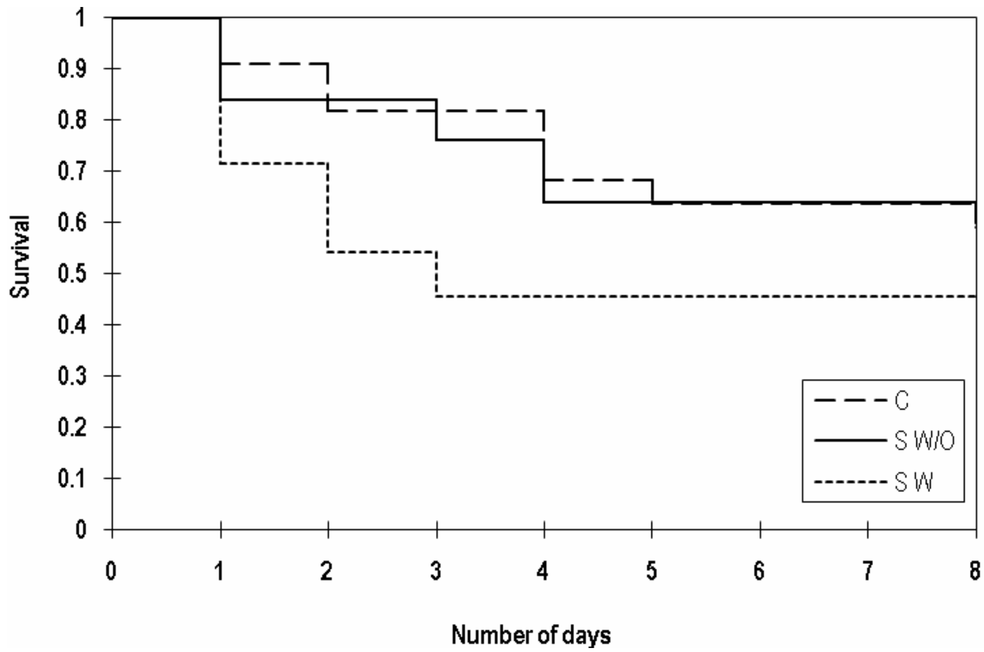

Figure 2.2. Survival of captive Rio Grande turkey poults from day 0–day 8 by treatment group (C = control [no radiotransmitter or surgery], S W/O = surgery without radiotransmitter, S W = surgery with radiotransmitter), Lubbock, Texas, 28 April 2006–9 May 2006.

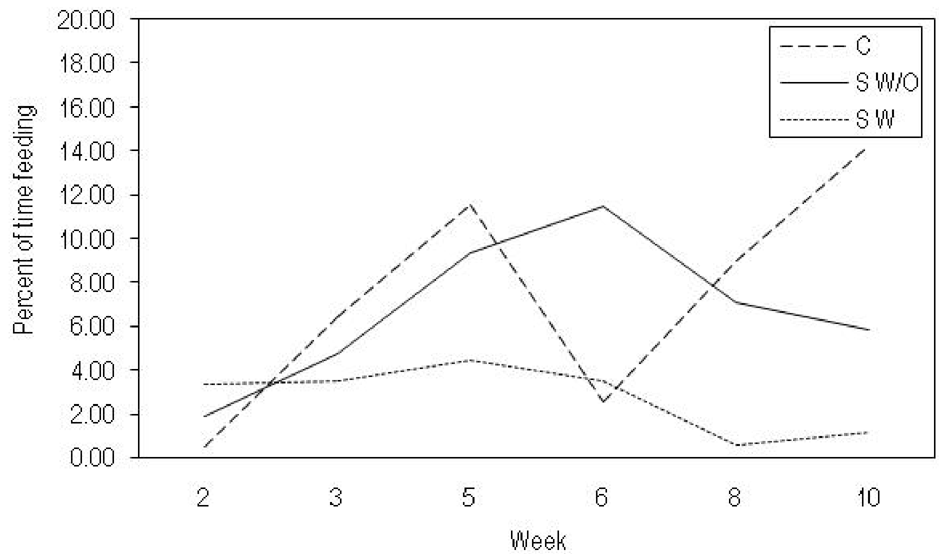

Figure 2.3. The percent of time captive Rio Grande turkey poults spent feeding in relation to week of study that was significantly different in corresponding week of the interaction effect for focal analyses by treatment group (C = control [no radiotransmitter or surgery], S W/O = surgery without radiotransmitter, S W = surgery with radiotransmitter), Lubbock, Texas, 28 April 2006–11 July 2006.

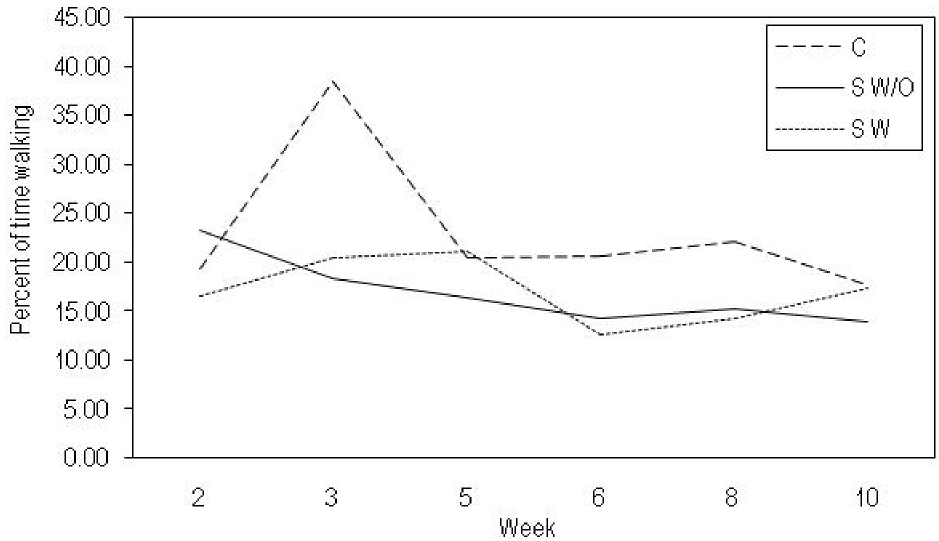

Figure 2.4. The percent of time captive Rio Grande turkey poults spent walking in relation to week of study that was significantly different in corresponding week of the interaction effect for focal analyses by treatment group (C = control [no radiotransmitter or surgery], S W/O = surgery without radiotransmitter, S W = surgery with radiotransmitter), Lubbock, Texas, 28 April 2006–11 July 2006.

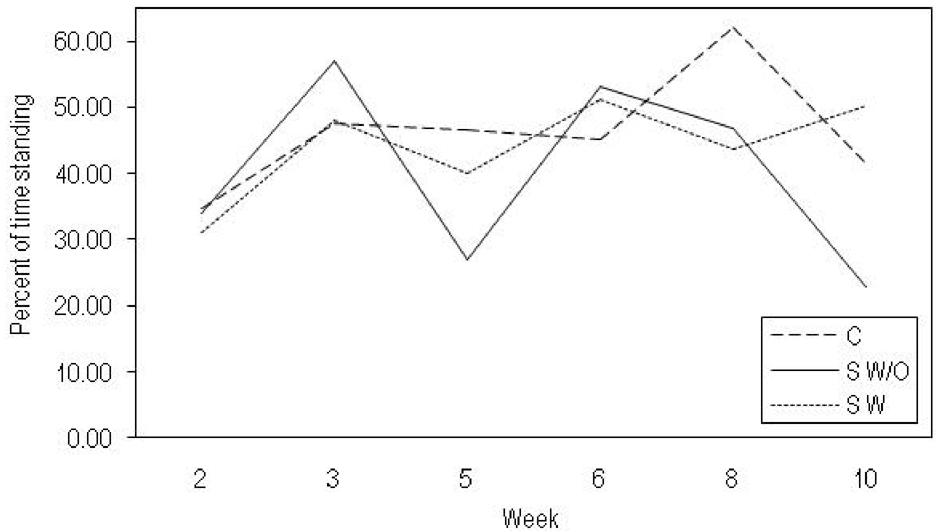

Figure 2.5. The percent of time captive Rio Grande turkey poults spent standing in relation to week of study that was significantly different in corresponding week of the interaction effect for focal analyses by treatment group (C = control [no radiotransmitter or surgery], S W/O = surgery without radiotransmitter, S W = surgery with radiotransmitter), Lubbock, Texas, 28 April 2006–11 July 2006.

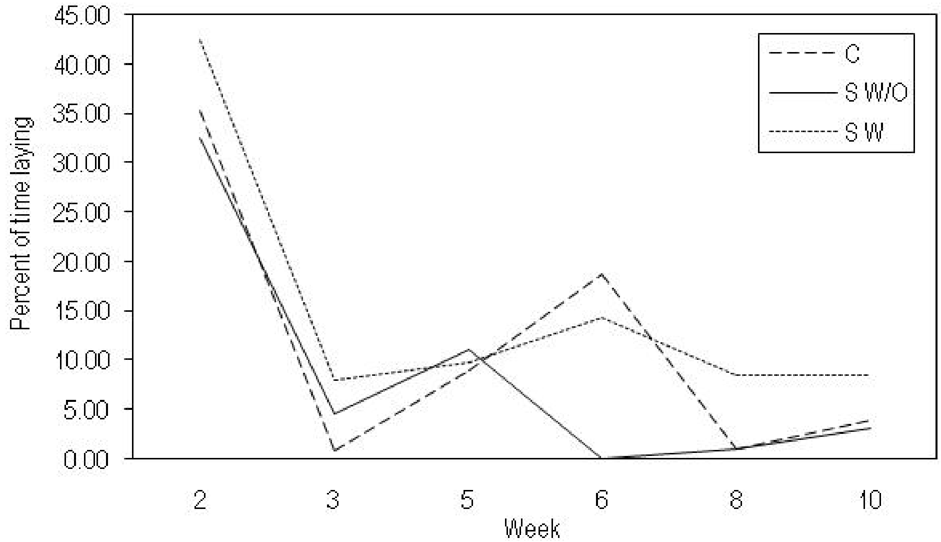

Figure 2.6. The percent of time captive Rio Grande turkey poults spent laying in relation to week of study that was significantly different in corresponding week of the interaction effect for focal analyses by treatment group (C = control [no radiotransmitter or surgery], S W/O = surgery without radiotransmitter, S W = surgery with radiotransmitter), Lubbock, Texas, 28 April 2006–11 July 2006.

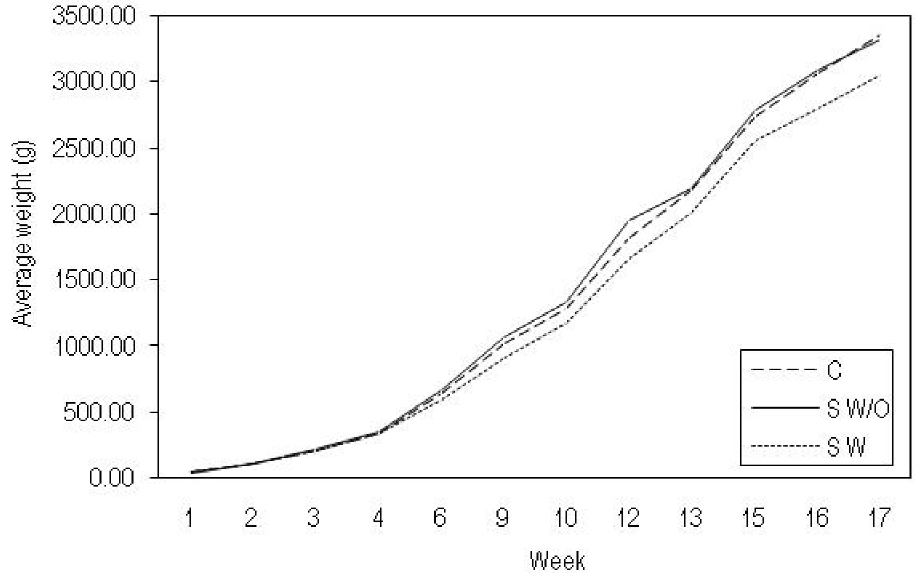

Figure 2.7. Mean weight gain of captive Rio Grande turkey poults from 28 April 2006–25 August 2006 by treatment group (C = control [no radiotransmitter or surgery], S W/O = surgery without radiotransmitter, S W = surgery with radiotransmitter), Lubbock, Texas.

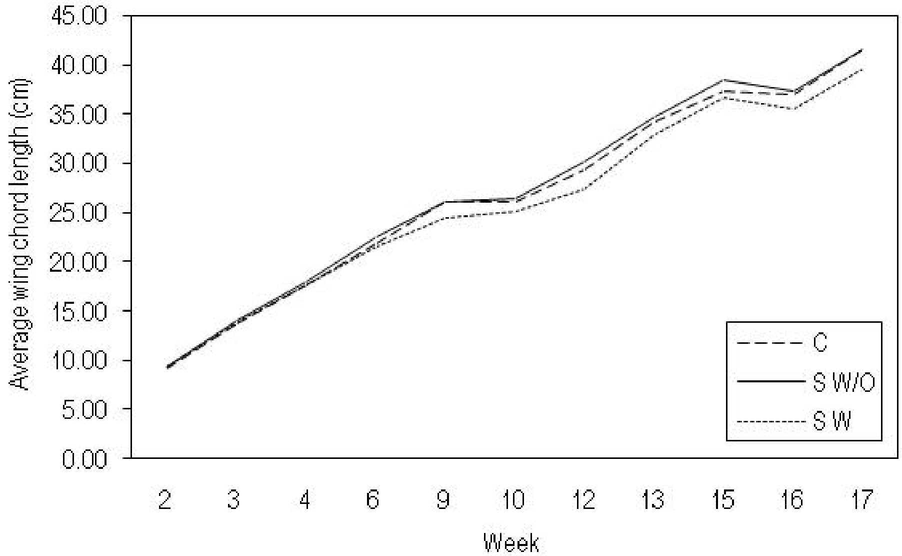

Figure 2.8. Mean wing chord growth of captive Rio Grande turkey poults from 28 April 2006–25 August 2006 by treatment group (C = control [no radiotransmitter or surgery], S W/O = surgery without radiotransmitter, S W = surgery with radiotransmitter), Lubbock, Texas.

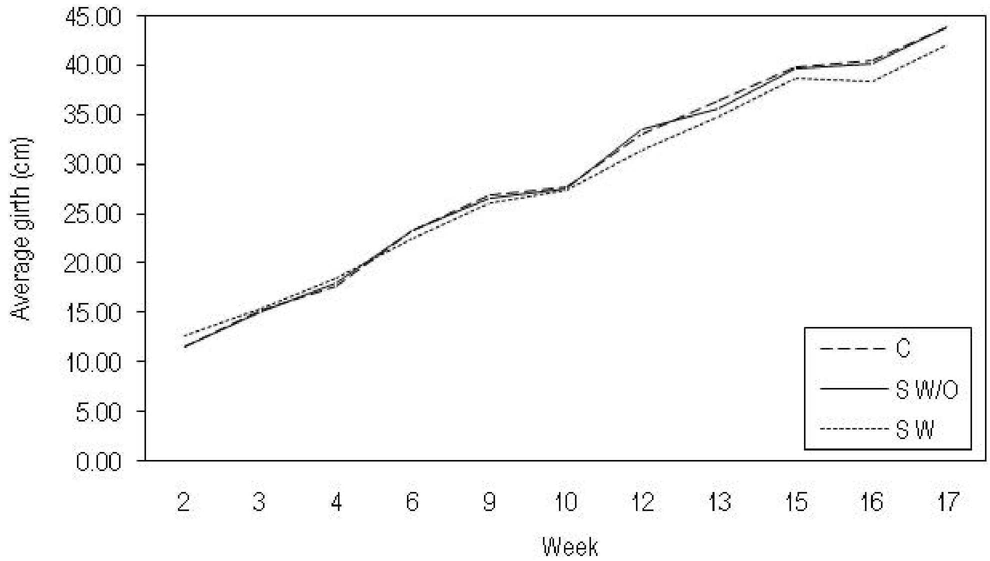

Figure 2.9. Mean growth of girth at keel of captive Rio Grande turkey poults from 28 April 2006–25 August 2006 by treatment group (C = control [no radiotransmitter or surgery], S W/O = surgery without radiotransmitter, S W = surgery with radiotransmitter), Lubbock, Texas.

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