Abstract: Researchers investigating survival of wild turkeys (*Meleagris gallopavo*) traditionally have assumed mortalities within the first 14 days may be capture-related, and have excluded those data from analyses. Few have explored ways to reduce mortality during this period. In 2000, we initiated a long-term radiotelemetry study of the ecology of Rio Grande wild turkeys (*M. g. intermedia*) in the southern Great Plains. During 2000–2002, we captured and outfitted 667 turkeys with backpack-style radio transmitters. We recaptured 123 previously transmittered birds for 790 14-day survival periods. Sixty-seven birds (8.5%) died \(14\) days post capture and were considered capture-related mortalities. Male mortality (13.4%) was greater than female (5.8%) mortality \((P = 0.001)\). Birds captured in the afternoon had higher \((P = 0.035)\) mortality rates (11.6%) versus morning (8.0%) or mid-day (7.1%) captures. We found no differences in mortality among study sites \((P = 0.14)\), years \((P = 0.27)\), age class for males \((P = 0.38)\) or females \((P = 0.99)\), or capture method \((P = 0.64)\). We found no relationship between weather conditions and 14-day postcapture survival of turkeys with the exception of precipitation 48
Managing Wild Turkey Populations

Trent and Rongstad (1974) recognized the value of radio transmitters in survival analyses. They used telemetry to study survival in eastern cottontail rabbits (*Sylvilagus floridanus*) and since that time, radio transmitters have proven to be a valuable tool in studying survival and mortality of wild animals (White and Garrott 1990, Millspaugh and Marzluff 2001). Stress resulting from capture and handling needed to attach radio transmitters may cause increased mortality post-capture in turkeys (McMahon and Johnson 1980, Spraker et al. 1987, Miller 1996, and Nicholson et al. 2000). Therefore, researchers generally exclude from analyses birds that die ≤14 days post-capture as capture-related mortalities (Hennen and Lutz 2001, Hohensee and Wallace 2001, Wakling et al. 2001, Wright and Vangilder 2001, Nguyen et al. 2003). Capture-related mortalities in wild turkeys have been documented (McMahon and Johnson 1980, Clark 1985, Spraker et al. 1987, and Nicholson et al. 2000) at both capture and relocation sites; however only Miller et al. (1996) addressed capture-related mortalities in turkeys (*M. g. silvestris*) released immediately at original capture sites. No studies have investigated capture-related mortalities in the Rio Grande subspecies.

In 1999, prompted by apparent widespread population declines and a lack of basic life-history information, we initiated a long-term study of the ecology of Rio Grande turkeys in the southern Great Plains. As part of this study, one of our objectives was to investigate factors that might contribute to capture-related mortality and determine methods that may reduce mortality following capture events in the future.

**STUDY AREAS**

We captured Rio Grande wild turkeys at 3 sites in the Texas Panhandle and one in southwestern Kansas. The Texas sites occurred along the intersection of the Rolling Plains and High Plains physiographic regions. Cattle production was the primary landuse. The southernmost site was centered on the Matador Wildlife Management Area near Paducah, Texas (Matador). The Pease River flowed west to east through the center of the study area. Dominant vegetation types included mesquite (*Proposis glandulosa*), grassland, prickly pear cactus (*Opuntia* sp.), and juniper (*Juniperus* sp.) shrubland in the uplands and western cottonwood (*Populus fremontii*) in the riparian areas, with mesquite covering the largest area. Elevations ranged from 488 to 610 m above sea level.

The Salt Fork site was composed of private ranches along the Salt Fork of the Red River northeast of Clarendon, Texas. The Salt Fork of the Red River flowed west to east through the center of the study area. Dominant vegetation types included mesquite, grassland, shinnery oak (*Quercus havardii*), and sand sage (*Artemisia filifolia*) in the uplands, and western cottonwood in the riparian areas. Mesquite covered the largest area. Elevations ranged from 632 to 995 m above sea level.

The northernmost Texas site was centered on the Gene Howe Wildlife Management Area east of Canadian, Texas (Gene Howe). The Canadian River flowed west to east through the center of the study area. Dominant vegetation types included sandsage, grassland, and mesquite in the upland areas, and salt cedar (*Tamarisk gallica*) and western cottonwoods in the riparian areas. Sandsage habitats covered the largest area.

The Kansas-Colorado site was located in the southwestern corner of Kansas and the southeastern corner of Colorado, and was centered on the Cimmaron National Grassland (Kansas). The Cimmaron River flowed west to east through the center of the study area. Cattle production and oil-gas production were the only land uses on the grassland, but privately owned portions of the study area included dry cropland and irrigated cropland. Dominant vegetation types were western cottonwood woodland dominating the riparian areas and sandsage dominating the uplands.

**METHODS**

**Capture**

We captured Rio Grande wild turkeys at the 3 Texas sites during January–March, 2000–2002, and at the Kansas site during January–March, 2000–2001. We captured birds using drop nets (Davis and DiMonte 1986), rocket nets (Bailey et al. 1980, Wunz 1984) and walk-in traps (Davis 1994). Once captured, we removed birds from the nets and placed them in transport boxes (76.2 × 35.6 × 61.0 cm) provided by the National Wild Turkey Federation (Edgefield, South Carolina, USA) until processing. Boxes were placed together a short distance away from where the birds were captured. Birds were moved to our temporary processing site, where they were held for 14 days post-capture (P = 0.01). We recommend minimizing handling of males and avoiding afternoon captures to reduce capture-related mortalities.

**Key words:** capture-related mortality, Great Plains, Kansas, *Meleagris gallopavo intermedia*, Rio Grande wild turkey, survival, Texas.

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were processed to minimize disturbance. Once removed from the box for processing, birds were hooded and restrained. Handling time once the bird was removed from the box averaged approximately 5 minutes per bird. We classified turkeys as male or female and adult (≥1.5 years old) or sub-adult (approx. 0.5 years old; Williams and Austin 1988), then fitted each turkey with a 110-g backpack transmitter equipped with an 8-hour mortality switch (Model A1155, Advanced Telemetry Systems, Insanti, Minnesota, USA). We measured body temperature using digital thermometers inserted in the cloaca. Thermometers were cleaned between each use using rubbing alcohol. We collected a 10 ml blood sample from the brachial vein of the wing. All captured birds were weighed and received a uniquely numbered aluminum leg band. The general condition of the bird was recorded immediately prior to release. Condition was classified as “poor” if the bird had lost most or all tail feathers and a significant portion of contour feathers leaving bare patches, “fair” if some tail feathers and a small amount of contour feathers were lost, or “good” if the bird had almost no feather loss. Time of release was recorded to calculate total handling time (from capture to release). We released previously transmittered turkeys that we captured immediately after assessment, with no temperature or blood samples taken. We obtained the following weather data from the nearest weather station to each site: high and low ambient temperature the night prior to capture, and precipitation 24 and 48 hours post-capture (National Oceanic and Atmospheric Administration). We obtained a 10 ml blood sample from the brachial vein of the wing. All captured birds were weighed and received a uniquely numbered aluminum leg band. The general condition of the bird was recorded immediately prior to release. Condition was classified as “poor” if the bird had lost most or all tail feathers and a significant portion of contour feathers leaving bare patches, “fair” if some tail feathers and a small amount of contour feathers were lost, or “good” if the bird had almost no feather loss. Time of release was recorded to calculate total handling time (from capture to release). We released previously transmittered turkeys that we captured immediately after assessment, with no temperature or blood samples taken. We obtained the following weather data from the nearest weather station to each site: high and low ambient temperature the night prior to capture, and precipitation 24 and 48 hours post-capture (National Oceanic and Atmospheric Administration). We obtained a 10 ml blood sample from the brachial vein of the wing. All captured birds were weighed and received a uniquely numbered aluminum leg band. The general condition of the bird was recorded immediately prior to release. Condition was classified as “poor” if the bird had lost most or all tail feathers and a significant portion of contour feathers leaving bare patches, “fair” if some tail feathers and a small amount of contour feathers were lost, or “good” if the bird had almost no feather loss. Time of release was recorded to calculate total handling time (from capture to release). We released previously transmittered turkeys that we captured immediately after assessment, with no temperature or blood samples taken. We obtained the following weather data from the nearest weather station to each site: high and low ambient temperature the night prior to capture, and precipitation 24 and 48 hours post-capture (National Oceanic and Atmospheric Administration).

We attempted to maintain 75 transmittered turkeys at each site: 35–45 adult females, 15 adult males, and 15–25 sub-adults (both male and female). Birds that died before the end of the trapping season were replaced in the final capture at each site. Most turkeys that died within the 14-day period were killed by predators or scavenged immediately after death. Of the mortalities, only 1 turkey was found intact, thus eliminating the possibility of doing necropsies.

Survival Analyses

We monitored captured turkeys at least every other day during the 14-day post-capture period using either a truck-mounted omni-directional whip antenna or null-peak system. We chose a 14-day period because this is the point where most previous authors considered capture-related mortalities to occur, and our data seemed to support this (Figure 1) as mortality rates after 14 days were similar to winter mortality (Holdstock 2003, Phillips 2004). If a mortality signal was detected, we located the bird as soon as possible to determine if the bird died or had lost its transmitter.

We calculated survival rates using the Kaplan-Meier staggered entry design (Pollock et al. 1989).

RESULTS

During 2000–2003, we captured and outfitted 667 turkeys with backpack radio transmitters. Previously captured birds were recaptured 123 times. Of these recaptures, 97 birds were captured twice, 23 were captured 3 times, and 4 were captured 4 times. Total captures (n = 790) included 319 adult females, 194 sub-adult females, 136 adult males, and 141 sub-adult males. We had 42 capture events: 28 rocket net captures, 13 drop net captures, and 1 walk-in trap capture. Drop nets were used to capture 384 turkeys (mean group size = 43.9, range = 5–87), rocket nets were used to capture 403 turkeys (mean group size = 24.9, range = 2–74), a walk-in trap was used to capture 5 turkeys. Most captures were conducted in the morning (n = 25), followed by afternoon (n = 10), and midday (n = 7).

Total handling time of turkeys after removal from drop net or rocket net until release (including time-in-box and processing) ranged from 13 min to 315 min. Low ambient temperatures the night prior to capture...
avergaed $-3^\circ C$ (range $-12^\circ C$ to $9^\circ C$). High ambient temperatures the day of capture averaged $13^\circ C$ (range $-7^\circ C$ to $27^\circ C$). Low ambient temperatures the night after capture averaged $-2^\circ C$ (range $-12^\circ C$ to $9^\circ C$). Precipitation occurred within 24 hours following capture events 8 times and occurred within 48 hours following capture events 15 times.

Of 790 individual turkey captures, 67 (8.5%) died within 14 days of capture and were classified as capture-related mortalities. The mean number of days survived by those birds was 5.6 days. The Kaplan-Meyer survival rate for all birds was 92.4%.

The proportion of males dying from capture-related stress (37 of 277; 13.4%) was higher ($\chi^2 = 12.4, df = 1, P < 0.001$) than female turkeys (19 of 319; 5.8%). The proportion of sub-adult and adult females ($\chi^2 = 0.00, df = 1, P = 0.997$) and males ($\chi^2 = 0.78, df = 1, P = 0.378$) dying from capture-related stress did not differ; therefore, we pooled data from both age classes for both sexes in further analyses.

When considering each capture method, the proportion of turkeys dying did not differ ($\chi^2 = 0.22, df = 1, P = 0.637$) between rocket nets (7.94%) and drop nets (7.85%). The proportion of capture-related mortality was not different among study sites ($\chi^2 = 2.2, df = 1, P = 0.137$), nor among years ($\chi^2 = 1.2, df = 1, P = 0.266$). Differences did occur between capture periods ($\chi^2 = 6.4, df = 1, P = 0.035$). The afternoon period (11.6%) had a higher probability of mortality than mid-day (7.1%) and morning (8.1%) captures. A difference did not occur when comparing the survival probability to the number of recaptures a bird had experienced ($\chi^2 = 3.0, df = 1, P = 0.081$). The condition of the bird at release did impact survival ($\chi^2 = 5.8, df = 1, P = 0.016$). Turkeys released in Poor condition had a higher percentage of mortalities (28.6%, $n = 14$) than those in fair (11.9%, $n = 67$) or good (9.2%, $n = 578$) conditions.

There was no relationship between body temperature and the probability of mortality ($\chi^2 = 0.05, df = 1, P = 0.818$) in turkeys. Mean body temperature for turkeys at release was similar ($t = 0.356, df = 1, P = 0.63$) in males ($x = 41.2^\circ C$) and females ($x = 41.12^\circ C$), and body temperature did not impact survival within the 14-day period ($\chi^2 = 0.50, df = 1, P = 0.478$). Body mass influenced the probability of survival in turkeys ($\chi^2 = 15.3, df = 1, P < 0.001$) as a whole. Body mass did impact the probability of mortality for male ($\chi^2 = 28.5, df = 1, P < 0.001$) turkeys but did not impact the probability of survival of female ($\chi^2 = 1.1, df = 1, P = 0.300$) turkeys. Handling time had no relationship with probability of mortality ($\chi^2 = 0.37, df = 1, P = 0.543$). Low ambient temperature the morning of capture ($\chi^2 = 0.02, df = 1, P = 0.888$), high ambient temperature the day of capture ($\chi^2 = 0.05, df = 1, P = 0.819$), low ambient temperature the night after capture ($\chi^2 = 0.69, df = 1, P = 0.407$), rainfall 24 hours after capture ($\chi^2 = 2.7, df = 1, P = 0.102$), handling time ($\chi^2 = 0.37, df = 1, P = 0.406$) and number of birds captured ($\chi^2 = 2.9, df = 1, P = 0.543$) all did not show relationships with probability of mortality. Only rain 48 hours following capture ($\chi^2 = 10.27, df = 1, P = 0.001$) had a positive relationship with probability of mortality.

**DISCUSSION**

The use of radio transmitters is invaluable to wildlife research; capture stress and associated mortality is an unfortunate side effect of these captures (Spraker et al. 1987, Miller et al. 1996, Nicholson et al. 2000). Our results suggested that several factors initially suspected of increasing mortality risk were not associated with greater mortality. However, sex, capture period, and precipitation post-capture were associated with increased risk.

Our observation of increased capture-related mortality in male Rio Grande wild turkeys is different from the findings of Spraker et al. (1986) who found no differences in capture myopathy between male and female eastern wild turkeys. In Mississippi, Miller et al. (1996) observed that females were less likely to survive the 14-day post-capture period. They hypothesized that the greater body mass of males allowed them to better tolerate the physical stress of capture and handling. However, we found no relationship between body mass and mortality for either sex during the post-capture period. Although we found no relationship between handling time and mortality, male turkeys were captured in small groups, which reduced handling time. The body temperature at release was not higher in males than females. Nor did body temperature at release differ in males that died within the 14-day period compared to those that survived. We believe a behavioral issue may be responsible for these differences, rather than body mass. The smaller winter flock size of male (approx. 4–15 birds; personal observation), compared to female Rio Grande wild turkeys (approx. 25–250 birds; personal observation) in this region, may increase susceptibility to predators. Male mule deer (*Odocoileus hemionus*) that tended to remain solitary much of the year suffered higher mortality from mountain lions (*Puma concolor*) than females in groups (Geist 1981). Our survival data also indicated male Rio Grande wild turkeys had lower winter survival rates (77.8%) than females (94.6%), with most identifiable deaths (33.7%) of males being attributed to coyotes (*Canis latrans*) and bobcats (*Lynx rufus*) (J. Brunjes, Texas Tech University, unpublished report).

Previous studies found juvenile or sub-adult turkeys were more susceptible to capture-related mortality than adults (Spraker et al. 1887, Miller et al. 1996). In Mississippi, 21% of sub-adult female eastern wild turkeys and 7% of adult females died ≤14 days post-capture (Miller et al. 1996). Sub-adult and adult eastern wild turkeys in Oklahoma survived the post-capture period at similar rates (21% and 14%, respectively; Nicholson et al. 2000). We found no differences between the probability of mortality of adult (6.0%) and sub-adult (5.7%) female turkeys or between adult (14.7%) and sub-adult (12.1%) male Rio Grande wild turkeys.
Although others have suggested ambient temperatures may impact survival of birds post-capture, there is scant data to support this supposition. Bailey et al. (1980) recommended that turkeys not be trapped in temperatures \( >21.6^\circ C \); however, they did not confirm increased mortality when captures were conducted in warmer conditions. Miller et al. (1996) also recommended not trapping during periods of high temperature, but did not specify an upper limit. They further recommended only trapping in temperatures \( >15^\circ C \). This recommendation could have been influenced by the fact they were using alpha-chloralose, which reduces the thermoregulatory ability of birds, in some of their capture events. In contrast, Nicholson et al. (2000) found that mortality in the post-capture period decreased with decreasing temperatures. They recommended not trapping in conditions where temperatures exceeded 10\(^\circ\)C. Temperature did not impact post-capture survival in our birds, with temperature ranging from \(-12^\circ\)C to \(18^\circ\)C. We did not observe any adverse effects from low temperatures. In our coldest capture (\(-12^\circ\)C), 31 of 31 (100\%) birds survived \(\geq 14\) days. We do not believe low temperatures, as experienced in this region, negatively impact mortality rates in the post-capture period. The lowest temperatures we recorded the night after capture did not impact survival, but extreme low temperatures combined with wet conditions immediately following capture may increase post-capture mortality.

The effect of precipitation on wild turkeys following capture events has not been previously investigated. We found a significant effect of rainfall within 48 hours post-capture while rainfall 24 hours post-capture did not impact survival within the post-capture period. We believe this observation was due likely to a 9.1-cm freezing rain event which followed 1 capture event in which 4 of 8 birds captured (50\%) died \(\leq 14\)-days post capture. We, therefore, recommend avoiding captures when heavy or freezing rain is forecasted within 48 hours following the capture event. When this event was removed from analyses, light rain and snowfall 48 hours post capture did not appear to impact survival. Bailey (1980) recommended wet or snow-covered nets not be fired because the net could malfunction and injure birds during capture, not because of concern that precipitation immediately before or during capture might decrease survival after release.

The increased mortality rates associated with afternoon captures versus morning (8.1\%) or mid-day (7.1\%) captures has not been reported previously. Other studies have reported post-capture related mortalities (Spraker et al. 1987, Nicholson et al. 2000). Birds in those studies, however, were being relocated and thus were held for extended periods before release, which likely impacted survival differently than immediate on-site release. Miller et al. (1996) suggested trapping early in the morning in the summer months to avoid heat, but did not report capture times or associated mortality rates. Because we observed no relationship between temperature and mortality, the reason for increased mortality in birds captured after 1400 hours is unclear. Many birds, after being outfitted with transmitters and losing tail feathers during capture, had difficulty flying after release. Possibly, turkeys require a time to adjust to the transmitter or sudden feather loss to become comfortable flying. Birds released late in the day may have had difficulty flying into the roost or otherwise avoiding predators.

Potential differences between birds captured with rocket nets versus drop nets have not been investigated. Miller et al. (1996) found no differences in survival when comparing alpha-chloralose and cannon nets. We found similar capture-related mortality rates for drop nets (7.8\%) and rocket nets (7.9\%). Although low sample size precluded comparison with nets, all 5 turkeys captured in walk-in traps survived \(\geq 14\) days. We used rocket nets on 28 capture events and drop nets for 13 events. We used the rocket nets more frequently because they were simpler to set up, required less acclimation time for the birds, the number of birds captured per event was smaller, and fewer personnel were required. During our first season we perceived that drop nets had increased mortality; however, data did not confirm this. One drop net that had been dipped in a rubber coating to protect it from the elements caused unacceptably high amounts of feather loss in most of the captured turkeys and thus was used only once. We recommend avoiding using nets that have been weather-coated.

Eastern wild turkeys subjected to handling time \(\geq 180\) min suffered mortality rates of nearly 50\% (Nicholson et al. 2000). In our study, 56 turkeys with handling times between 180 and 315 minutes had a post-capture mortality rate of 7.1\%, which was similar to the overall mortality rate of 8.5\%.

No previous studies have addressed the impact of recaptures on survival. The post-capture mortality of recaptured birds in this study (4.1\%) was lower \((P = 0.003)\) than that of birds captured only once (10.1\%). This suggested that capture-related stress was temporary.

**MANAGEMENT IMPLICATIONS**

Our data suggested that male Rio Grande wild turkeys were more susceptible to capture-related mortalities than females. We suggest processing and releasing male turkeys first when both sexes are captured to reduce possible stress. We also recommend using experienced and additional personnel when males are the goal of capture efforts. Based on our data, we feel trapping in late afternoon should be avoided. Although we found no relationship between temperature and survival, we also recommend avoiding captures when temperatures exceed 10\(^\circ\)C, as we observed that turkeys captured on warmer days overheated in the boxes awaiting processing (J. Brunjes, Texas Tech University, personal observation). At 1 capture event, birds appeared so heat stressed (i.e., rapid panting, decreased alertness) that we released the remaining birds \((n = 4)\) without workup or transmitters in an effort to decrease post-capture mortality. We also recommend avoiding captures in which heavy or freezing rains are predicted.
within 48 hours post-capture. Drop nets and rocket nets did not differ in their capture-related deaths; however, larger potential captures may occur with drop nets, thus we suggest more personnel be present during drop net captures. We found that a minimum of 5 experienced personnel were required for rocket net captures, and suggest a minimum of 7 people when using a drop net.

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