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TITLE: Cause Specific Mortality of Mountain Plover (*Charadrius montanus*) Chicks in Eastern Colorado: Phase III. A Pilot Field Study

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ABSTRACT

The mountain plover (*Charadrius montanus*) is a species of special concern in Colorado with >50% of the continental population believed to breed in the eastern half of the state. In eastern Colorado breeding plovers primarily use short-grass prairie habitats consisting of grasslands with and without black-tailed prairie dogs (*Cynomys ludovicianus*) and agricultural fields. The nesting ecology of mountain plovers has been well-studied across the species' breeding range and nest success is similar among the eastern Colorado short grass habitats (Dreitz and Knopf 2007). However, chick survival and brood movement patterns were found to differ between habitats and were not related to differences in prey resource availability among habitats (Dreitz 2009). Further information on cause-specific mortality of chicks is needed to understand differences in brood-rearing behavior and success among different habitats.

Technological advances in radio transmitters have resulted in small (≤ 0.35 g) radio transmitters that can be used in field investigations of cause-specific mortality of mountain plover chicks (~10 g at hatch). During 2007 and 2008 we conducted captive studies evaluating transmitter attachment methods and concluded that a leg harness attachment is a suitable method, with minimal to no observed impacts on survival, physiology, growth and behavior of chicks (Dreitz 2007, 2008). Using this attachment method, we field tested the use of transmitters to address future biological questions on the mortality (or survival) of mountain plover chicks in 2009. The results of this study suggest that telemetry is a feasible technique for investigating cause-specific chick mortality. We were able to determine distance range in which we could locate transmitters, feasibility of finding below-ground transmitters, ability and distance to locate transmitters via aircraft, longevity of transmitters and/or needed adjustments in the leg harness attachment, and determine mortality causes including distinguishing between avian and mammalian predators. Predation (45%) and weather conditions (13%) were the main contributors to mortality in our study. Premature failure of transmitter battery and precipitation led to unknown fates of 42% of chicks. Body mass in wild plover chicks was found to be significantly lower than chicks reared in captivity at equivalent ages (Dreitz 2008). This finding suggests modifications to the size of the loops of the leg harness or using transmitters with longer battery longevity are needed for future field investigations.

Cause Specific Mortality of Mountain Plover (*Charadrius montanus)* Chicks in Eastern Colorado: Phase III. A Pilot Field Study

PROJECT OBJECTIVES

The objective of this study was to develop and test field techniques to determine the feasibility of using transmitters attached by the leg harness method on mountain plover chicks for future studies investigating cause-specific mortality.

SEGMENT OBJECTIVES

1. To address various field technique questions on the applicability of using transmitters attached by the leg harness method on mountain plover (*Charadrius montanus*) chicks from hatch to fledging or conclusion to their fate.
    a. Assess the feasibility of locating, capturing, and placing a transmitters on ≤1 d old 'wild' mountain plover chicks.
    b. Evaluate the loop size of leg harness transmitter attachment method on 'wild' mountain plover chicks.
    c. Determine distances in locating transmitters in a vehicle or on foot both above- and below-ground (buried or in a burrow), and by an aircraft.
    d. Determine the feasibility of distinguishing cause of mountain plover chick mortality as predation (avian versus mammalian), starvation, weather conditions or transmitter technique failure.
2. Summarize and analyze data, publish information as a Progress Report. Publish previous captive studies (Dreitz 2007, 2008) and these findings in a peer-reviewed manuscript.

INTRODUCTION

The mountain plover (*Charadrius montanus*) is a neotropical, upland shorebird found on the xeric tablelands from Mexico to northern Montana (Knopf and Wunder 2006). Steep, constant declines in population size have been reported for mountain plovers across their range since 1966. In 1999, the USFWS petitioned for 'threatened' status of the mountain plover, but the listing decision was found not warranted in 2003 (USFWS 2003). Nevertheless, consistent population declines have prompted conservation agencies to assess the spatial extent and potential factors contributing to declines.

Historically, mountain plovers were present across western prairies in areas of intensive grazing by bison (*Bison bison*) or prairie dogs (*Cynomys* spp.). Today, mountain plovers are still observed on areas grazed by prairie dogs, along with areas grazed by domestic cattle and sheep, and on agricultural fields (Knopf and Wunder 2006). The eastern plains of Colorado provide breeding habitat for more than half of the continental population of mountain plovers (Kuenning and Kingery 1998). Smaller, more isolated breeding areas occur throughout the western Great Plains region including Montana (Knowles et al. 1982, Olson-Edge and Edge 1987) and South Park, Colorado (Wunder et al. 2003).

The nesting ecology of mountain plovers has been well-studied across the species' breeding range including areas in Colorado (Graul 1975, Knopf and Wunder 2006, Dreitz and Knopf 2007) and Montana (Knowles et al. 1982, Knowles and Knowles 1984, Dinsmore et al. 2002). Detailed information on brood-rearing ecology has been conducted in both Colorado and Montana. Knopf and Rupert (1996) estimated daily chick survival on grassland habitat in northeastern Colorado at 10-day intervals ranging from 0.951-0.977. Lukacs et al. (2004) found that chick survival was lowest immediately after hatching and quickly increased within 4 d post-hatch on prairie dog colonies in Colorado. Dinsmore and Knopf (2005) found that fledglings tended by females had higher survival than those tended by males on prairie dog colonies in Montana. Knopf and Rupert (1996), Lukacs et al. (2004), and Dinsmore and Knopf (2005) indicated that daily survival rates increased with age of the chick. In eastern Colorado, Dreitz

(2009) estimated chick survival from hatch to 30 d post-hatch to be higher on grassland with prairie dogs (0.75, CI = 0.54, 0.87), than grassland without prairie dogs (0.24, CI = 0.08, 0.45) and agricultural fields (0.23, CI = 0.14, 0.33) and the rate of brood movement off of prairie dog nest habitat was lower than grassland, but higher than agricultural fields for each year of the study. These patterns observed in chick survival and brood movements were not influenced by prey resources biomass or density (Dreitz 2009). None of the above studies determined causes of mortality in plover chicks but Knopf and Rupert (1996) speculated that on grassland the main cause is predation by swift foxes (*Vulpes velox*).

Multiple factors may influence the mortality of young birds. In general, young individuals lack experience with selective pressures such as predation, foraging efficiency, parasites, and extremes in environmental conditions which may be correlated with habitat quality. Further, these selective pressures differ spatially and temporally across the species' range. The distribution of individuals among habitats reflects their ability to discriminate between habitat types and to assess habitat quality. Thus, the landscape configuration and the proximity of resources provided by different habitat types of the western prairie may be critical to the reproductive output of mountain plovers. Information on the post-hatching stage is imperative for conservation efforts on mountain plovers because brood loss affects real reproductive output as well as the degree of subsequent recruitment and, in turn, the viability of the population.

Technological advances in radio transmitters have made it possible to determine the cause-specific mortality of mountain plover chicks. Average hatching mass of mountain plover chicks is 7-11 g (Graul 1975, Miller and Knopf 1993). Radios ($\leq$ 0.35 g) placed on the chicks follow established guidelines to not exceed 5% of body mass for small (<50 g) birds (Caccamise and Hedin 1985, Gaunt et al. 1999). Various attachment methods have been evaluated in captivity suggesting that a leg harness attachment is a suitable method with minimal to no observed impacts on survival, physiology, growth and behavior (Dreitz 2007, 2008). In the spring/summer of 2009 we conducted a field study to further understand the field applications of using radio telemetry to address biological questions, particularly cause-specific mortality, on mountain plover chicks.

METHODS

Study Area

This study was conducted on the Pawnee National Grasslands (PNG) in Weld County, Colorado. Vegetation, climate, and physiography of this grassland are described by Graul (1975). Nests were found and monitored on grasslands with and without black-tailed prairie dogs (hereafter prairie dog) in 13 PNG allotments. Radio telemetry on chicks was conducted from hatching to fledging ($\geq$32 d, Graul 1975, Miller and Knopf 1993) or until conclusion of fate.

Placement of Transmitters on Hatchlings

We located and identified ~1d old plover chicks by monitoring nests. We used egg flotation (Westerskov 1950) to age eggs and to estimate days until hatching. Estimating hatching date is difficult even when egg laying date is known because incubation (and chick development) may not start until a few days after all eggs are laid. Additionally, continuous checking of nests by observers can lead to nest abandonment or attract mammalian predators (from leaving olfactory cues) to nests. We visited nests $\leq$5 times to minimize these potential impacts. David Augustine (USDA-ARS) collaborated with this study by providing nest locations.

After hatching and when chicks were completely dry, chicks were captured by hand and received a radio transmitter. We attempted to place a $\leq$0.35 g transmitter (average battery life 20 d, pers obs.) on all hatched chicks within a brood at initial capture. Transmittered plover chicks were located almost daily and live status (alive or dead) was determined by visual observation. We attempted to recapture chicks when they were ~14 d old and $\geq$20.0 g to replace the 0.35 g transmitter (hereafter, small) with a 0.62 g transmitter (hereafter, large). This was necessary to keep transmitters attached; avoid transmitter attachment impacting growth, survival and behavior of the chicks; and to monitor the chicks until fledging, ≥30 d, given the battery life of the transmitters. If body mass of chicks were ≤20.0 g at ~14 d, chicks were recaptured ≤5 d later and transmitters were replaced when they were the appropriate weight. Chicks were recaptured and weighed ≤3 times during the study.

Leg Harness Attachment Method

We determined if our leg harness attachment method was a feasible method to use in a field setting. Our leg harness follows the design of Rappole and Tipton (1991) having a 2-loop harness with the transmitter between the loops (Fig. 1) in which the loops are placed over the legs such that the transmitter sits over the synsacrum. The equal-sized loops are made with a 100% polyurethane clear elastic material (Stretchrite®, purchased at most fabric stores; hereafter elastic). The elastic material is commercially available in 6.35 mm (0.25 inch) width which is decreased to 1.5 mm width. Based on information obtained on captive mountain plovers (Dreitz 2008), we used 40 mm loops for the small transmitters and 50 mm for the large transmitters (Fig. 1). Cyanoacrylate glue (Loctite Easy Squeeze Super Glue Gel) was used to affix the transmitter to the elastic material. This created a rough surface in which a small piece of felt was placed at this connection such that the felt was between the bird and the transmitter. The weight of the elastic and felt add <0.03 g to the transmitters. The transmitter harnesses were made in advance to lessen handling time of the chicks.

Locating Transmitters

Transmittered chicks were located by vehicle and on foot with collapsible 3-element hand-held Yagi antennas that were held in hand or mounted to the box of pickup trucks. We also had the opportunity to test the use of a whip-it antenna mounted on a vehicle when borrowing another CDOW researcher's vehicle at the end of the field season (late June). The ability to detect transmittered chicks from an aircraft was also tested.

We determined the distance in locating transmitters by placing activated transmitters (not attached to chicks) in random locations within the study area. Small transmitters were mainly used in order to determine the minimum distance we needed to be near a transmitter to locate a signal. To test the distance in which we could obtain a transmitter signal above-ground, we recorded the farthest perpendicular distance in which a signal heard by vehicle and on foot. We used vacant prairie dog holes to test how far a signal could be picked up if the transmitter was below-ground. We attached a string marked at 0.9, 1.2, 1.5 m to transmitters and dropped the transmitters in the burrows. This did not allow us to account for perpendicular distance below-ground. However, our interest was to know if a predator carried the transmitter into a burrow at what distance into the burrow could we pick up the signal. We also randomly placed activated transmitters within our study area to determine the distance and elevation a signal could be received from an aircraft. We provided general locations of where the transmitters were located to the pilot. The pilot located the transmitters and we determined the distance and evaluation we were able to pick up a signal from our known transmitter location. Additionally we determined the distance and elevation of the initial signal when locating 'lost' chicks (chicks we were not able to locate on the ground) from the aircraft.

Evaluating Cause Specific Mortalities

For all known mortality events, we attempted to determine the cause of mortality as either: predation (avian and/or mammalian), weather events, transmitter technique failure, or unknown fates. We assumed a chick predation event when the transmitter was found with or without remnants of a chick or a chick was not with the adult but its sibling(s) where still present. Further, we determined an avian predation event through evidence such as location near either avian nesting area or plucking post; amount of feather remains (e.g., where all the feather plucked from the chick); condition of transmitter, especially the antennae (e.g., was the antennae twisted or straight). Mammalian predation was suggested when transmitters were cached, scat was found in the area, and/or other physical signs (e.g., teeth marks) of the carcass or transmitter (e.g. antennae still in good condition). Mortality by weather events were defined when entire carcasses of chicks were found with the transmitter. These chicks were collected and further evaluated by necropsy at a later date to confirm if the mortality was weather related or determine other cause (e.g., starvation). Transmitter technique failure is not a true mortality event but the loss of chicks as a result of our field techniques such as the transmitter attachment method or the transmitter. Lastly we defined a mortality event as unknown when there was not enough evidence to suggest one of the other 3 mortality categories.

RESULTS

Success in Attaching Transmitters

A total of 35 nests were located in 13 different allotments within the PNG. Failure occurred in 49% (n=17) of the nests by predation (n=13), abandonment (n=3), or flooding (n=1).
A total of 52 eggs successfully hatched (Table 1) with slightly higher apparent nest success (56.9%) on grassland with prairie dogs than grassland without prairie dogs (42.6%).

We placed small transmitters on 28 chicks (in 10 broods) from the nests we monitored and 3 additional chicks that were ≤ 5 days found opportunistically while doing telemetry on other chicks (Table 1, Appendix A). We were unable to place transmitters on 24 successfully hatched chicks (in 8 broods) because we completely missed hatching. Mountain plover chicks are precocial and leave the nest within hours of hatching (Knopf and Wunder 2006). Once they leave the nest it is difficult to locate them due to their mobility, size (≤ height of the vegetation), cryptic coloration, predatory behavioral defense (hunkering down), and adult behavior (e.g., fleeing area with chicks upon encroachment).

We were able to place transmitters on the 3 chicks in the brood when they were still in the nest cup for only 1 brood out of 10 broods. Mountain plover eggs hatch asynchronously usually within 10 hr (Graul 1975) but could be as long at 41 hr (Knopf and Wunder 2006). We found that if we were able to place a transmitter on ≥1 chick during hatching, we were able to place transmitters on the rest of the chicks within a brood. That is, during hatching we disturbed the nest area only to place transmitters on dried chicks. We re-checked these hatching nests > 10 hr later and placed transmitters on the remaining chicks. These remaining non-transmittered chicks were no longer in the nest cup but we were successful in capturing these chicks on our next visit except for 1 chick which took 5 attempts (over 5 d, mainly due to cold, wet weather) to capture.

We placed large transmitters on 6 chicks in 5 broods. These chicks were 13-18 d old and easy to recapture when necessary by locating them through telemetry. Of these 6 chicks, 4 chicks experienced a mortality event (all due to predation). We suspect battery failure of the transmitter for the remaining 2 chicks. The transmitter was activated for >18 d and we noted differences in the signal strength a few days prior to losing these 2 chicks.

Leg Harness Attachment Method

We designed and used the leg harness size based on the results of Dreitz's (2008) captive study. The body mass of the hatchings (0-1 d old) in the wild were comparable to those in captivity (Fig. 3). We found no evidence of transmitters falling off or hindering mobility at this age group.

Body mass of the wild chicks (n=7) when replacing transmitters, ~14 d old, was ≤20.0 g except for 1 chick. We abstained from placing the large transmitter on 6 chicks until they were ≥20.0 g. In 5 of the 6 chicks this occurred by day 18. We were unable to replace the transmitter on 1 chick because we were unable to locate the chick after day 14, likely the result of battery failure. On average wild chicks were ~ 10 g less than captive chicks at the time of transmitter replacement (Fig. 3). We still used the 50 mm size leg-loops on the leg harness (Fig. 1) for wild chicks ≥20.0 g which appeared to keep the transmitter attached and did not hinder mobility. However, if our criteria would have been only age, we would of needed to adjust the size of leg-loops on the leg harness to get the desired fit on the chicks.

Locating Transmitters

We evaluated the above- and below-ground distances in which we could locate a transmitter signal by randomly placing transmitters within our study and noting distances when locating chicks. We determined the minimum distance in which we could locate transmitters by foot was 0.5 km. This was particularly the case in areas with some terrain (e.g., rolling hills). The maximum distance we could locate a signal by foot was ~1.5 km. This was with ideal condition with transmitters placed aboveground (on a fence post) and very little change in the terrain. Using the vehicle we determined the distance in which we could pick up transmitter signal ranging between 1.0-1.5 km using both the Yagi-antennas mounted to the box of the pickup truck or the whip-it antenna. The advantage of the mounted Yagi-antennas is it allowed us to determine which side of the truck the chick was located. The whip-it antenna is logistically easier to set up and can be used on other types of vehicles, such as Sport Utility Vehicles, and all-terrain vehicles.

For the below-ground distances we only determine the distance from the vehicle and used both small and large transmitters. We only assessed by vehicle recognizing that we would like first locate the transmitter by vehicle prior to on foot if it was located below-ground. We located small transmitters that were placed 1.5 m below-ground at a distance of ~0.03 km from the vehicle, ~0.04 km at 1.2 m below-ground, and ~0.07 km at 0.9m below-ground. For the large transmitters the distances were ~0.02 km at 1.5 m below-ground, ~0.03 km at 1.2 m below-ground, and 0.24 km below-ground at ~0.9 m below ground.

We also determined the feasibility and distance and elevation of locating transmitters from the air. We flew a total of 3 times during the field season. On our initial flight we determined that small transmitters could be locate at a distance of ~3 km at an elevation of ~0.3 km. In addition, we noted the distance and elevation when we obtained a signal for lost chicks on subsequent flights. We located 2 predated chicks by air exploration 1.16 km and 2.19 km from their location the preceding day. The initial signal for these 2 chicks was obtained at the distance and elevation equivalent to other transmitter findings, ~3 km at an elevation of ~0.3 km from the aircraft.

Evaluating Cause Specific Mortalities

Most chicks were monitored daily. Periodically weather conditions prevented daily monitoring resulting in lapses in monitoring averaging 2 d and ranging 1-6 d.

Predation—A chick was assumed predated if its transmitter was found no longer attached to the chick (n=5 chicks), if its sibling was found with the parent and it could not be found (n=4 chicks), remnants of the chick were found (n=3 chicks), or if the transmitter was activated <12 d prior to receiving no signal (n=2 chicks). A total of 14 chicks were predated (Table 1, Appendix A). Potential predators that were observed include Swainson's hawk (*Buteo swainsoni*), golden eagle (*Aquila chysaetos*), burrowing owl (*Athene cunicularia*), swift fox (*Vulpes Velox*), western rattlesnake (*Crotalus viridis*), and ferruginous hawk (*Buteo regalis*). We were able to confirm predation by a mammalian predator for 4 chicks and avian predators for 2 chicks. One of the mammalian predation events was a cached chick ~ 0.2 m below ground (Fig. 2). Avian predation was from raptors including a burrowing owl in which a transmitter and leg bands were located <0.5 m from an owl burrow along with pellets. There was not enough evidence at the remaining suspect predation events (n=8) to determine mammalian or avian predation.

Weather Events— We collected whole carcasses of 4 chicks for further evaluation of cause of mortality by necropsy. The carcasses were collected in zip-loc plastic bags and placed in coolers containing frozen water bottles to keep the carcasses cool during transport, then placed in a storage freezer until necropsies could be preformed. The necropsy results concluded that 3 out of 4 chicks died due to trauma related incidents, the remaining carcass was too desiccated for a necropsy to be preformed. We believe that the trauma observed in necropsies may have been due to our transport method verses natural causes. While we tried to secure the carcasses in the coolers and the coolers in the vehicle, substantial movement (i.e., bouncing across the terrain) throughout the rest of the field day may have caused additional trauma to the chicks. These 4 carcasses were collected shortly (<48 hr) after substantial thunderstorm which may of caused the trauma (e.g., pelting rain or hail) or mortality (hypothermia) to these individuals.

Battery Failure— Initially we intended to recapture chicks at day 14 to attach the larger (0.62 g) transmitter. The battery life of the 0.35 g transmitter proved to be shorter than observed in a previous study (Dreitz unpublished data). Battery failure was discovered while observing chicks (n=2) whose frequencies were not being received. It was assumed that the battery failed when we could not receive a signal and the age of the chick was > 12 d (guaranteed life expectancy from Holohil Systems Ltd.). We estimate that the battery failure occurred in > 6 chicks.

Unknown Fates— We were unable to account for the fates of 7 mountain plover chicks because there was insufficient evidence to draw a conclusion. Through the duration of this study there were days telemetry was unable to transpire due to large amounts of precipitation. In these instances, chicks were not observed on subsequent days due to 1) signal location on private land in which we did not have access permission (≥ 3 transmitter chicks), 2) the possibility of predation, or 3) transmitter battery failure.

DISCUSSION

The results of this study suggest that it is possible to monitor mountain plover chicks by means of attaching radio transmitters at hatching. We were able to determine cause-specific mortalities for 58% of the chicks. However, we were not able to confirm survival of any chick to fledging age. Although we were unable to address many biological questions, this study paved the way for future work by answering necessary field questions.

Of the successful nests we monitored, 33.3% (6 out of 18 successful nests) of the chicks hatched and moved before we were able to place transmitters on them. Placing a transmitter on the tending adult 2-3 d prior to the estimated hatch date would help ensure location of the brood even if hatch day is missed. Previous studies have attached transmitters to upper back feathers of adult plovers using an adhesive, allowing the birds to rid themselves of the transmitter during molting (Miller and Knopf 1993, Knopf and Rupert 1996, Dreitz et al. 2005, Dreitz 2009). Leg harness attachment has not been attempted on adult plovers, but might be feasible and warrants further study.

The results from this field study suggest there are substantial differences in the development of captive versus wild plover chicks warranting modification to the leg harness attachment. Coupling factors of shorter battery life of transmitter and smaller body mass of wild chick at 13-18 d requires adjustment to transmitter harness size, timing of transmitter replacement, and/or the use of transmitters with longer battery life. Although minimal amount of handling is desired, it may be necessary to change transmitters more frequently to monitor chicks to >30 d post-hatch if transmitters with similar battery life are used. In this instance, we suggest replacing the transmitter at day 11 with harness loops ~43 mm (± 2 mm), and again at day 22 with ~50 mm (±2 mm) harness loops. Secondly, there may be other companies manufacturing small transmitters with longer battery life. If so, the timing of the transmitter replacement could be similar; however body size at ~14 d would necessitate a 46 mm size loops (± 2 mm) instead of 50 mm given the differences in body mass compared to captive reared chicks (Fig. 3).

We were not able to confirm that weather events were the cause of mortality in mountain plover chicks. However, we believe it may have occurred. Precocial chicks, such as mountain plovers, use considerable amounts of energy for thermoregulation and locomotion, and they need to keep their energy in balance within narrow margins to survive (Schekkerman and Visser 2001). Extreme inclement weather may increase chick mortality due to hypothermia or direct mortality (e.g. hail, pelting rain). While necropsy results did not confirm that hypothermia occurred during our study, we believe we need to further evaluate how to detect hypothermia in young mountain plover chicks both by necropsies and laboratory diagnostics.

In the past predators have been reported as a major source of mortality (Knopf and Rupert 1996), and was not dissimilar to the findings in this study with 45.2% known predation events. Distinguishing avian from mammalian predations was possible when there was enough evidence left from the predator. For instance, we suspect the incident in which we found a cached chick that the predator was as a mammal, likely a swift fox because numerous swift foxes (both adults and kits) were observed in the general location during the study. When evidence is available distinguishing between avian and mammalian is rather straightforward. However, when there is little evidence, such as a transmitter with the elastic material of both loops on the leg harness torn, determining the cause of mortality is difficult. In this case, we presume the cause of mortality to be an avian predator. However, we are not confident in our assumption and categorized this cause of mortality as an unknown predator. Even stating the cause of mortality of a cached chick was a mammal predator is speculative because the chick could have died prior to being located by the mammal predator. Continuous monitoring of chicks or observation of mortality events are the only means to determine the exact cause of mortality, both are impractical for most wildlife studies. Therefore, studies investigating cause-specific mortality are constrained to evidence found at the location the transmitter was found. Even if we monitored the chicks more frequently than daily, we do not believe this would increase our ability to distinguish between avian and mammalian predators because it is unlikely the predators would leave more evidence at the mortality site.

This study allowed us to determine many aspects of the field logistics on the applicability of using transmitters attached by the leg harness method on mountain plover chicks. A discomforting result of our study was we did not observe any chicks surviving to fledging. Various reasons, some of them listed above, may have influenced this outcome. Another reason may be that the transmitters are impacting survival in these 'wild' chicks. Future field studies should examine this possibility. This could be accomplished by placing transmitters on only 1 or 2 chicks within a 3 chick brood. This would also need to be coupled with attachment of transmitter on the adult plover to assist in tracking and observing chicks without transmitters.

SUMMARY

Currently, radio telemetry is the principal approach to investigate various aspects of brood-rearing behavior of mountain plover chicks or chicks of other small species. In 2007 and 2008, we addressed questions of how to place a transmitter on chicks of small birds and if the transmitter impacts survival or behavior of the chicks in a captive setting (Dreitz 2007, 2008). The results from those studies suggested the leg harness technique had no to minimal impact on survival, physiology, growth and behavior (Dreitz 2007, 2008). Our field study suggests that telemetry is a potentially effective tool for exploring cause-specific mortality of chicks; however there are aspects that still need to be examined to insure this is a viable method.

In our study, we applied the leg harness attachment method for the 0.35 g transmitters used to track mountain plover chicks in the field. Transmitters were placed on the chicks upon hatching, and tracked from that day forth. Monitoring chicks allowed the determination of cause-specific mortalities and aided in understanding movement behavior. We were able to draw conclusions on 18 of the 31 chicks included in this study. As suspected, predation was the main cause of mortality. While our sample sizes were rather small, the information gathered paves the way to take this study to a larger scale and address biological questions.

In sum, we answered our original objectives and believe that radio telemetry on mountain chicks can be used to address large scale, biological questions. We found that:

- capturing and attaching transmitters to 0-1 d old chicks is feasible,
- difference in body mass between wild and captive chicks requires adjustments to the loop size of the leg harness and/or battery life of transmitters needs to be increased,.
- the range in distance for locating transmitters above ground is 0.5-1.5 km,
- transmitters can be located below-ground, either buried or carried into a burrow,
- transmitters can be located by aircraft,
- causes of mortality can be determined with the possibility of distinguishing predation between avian or mammalian species.

Additionally, we recommend the following for future studies on chick mortality of mountain plovers:

- place transmitters on tending adults prior to hatching to locate chicks in case hatching is missed,

- locate chicks every 24 hr to determine cause of mortality,
- attempt to locate 'lost' chicks by aircraft prior to transmitter battery failure,
- investigate predator behavior more thorough to distinguishing between different types of predators,
- refine laboratory methods to determine causes of mortality from whole carcasses,
- determine if transmitters do influence chick survival in the field.

As the use of radio telemetry in avian studies progresses there is a need for further studies on the effect of the transmitter and the attachment techniques on all aspects of a species. We encourage others to critically assess the ability of using transmitters on a species before embarking on large scale studies to address biological questions.

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Table 1. Summary of mountain plover (*Charadius montanus)* chicks monitored in the spring-summer of 2009 on the Pawnee National Grassland.

	Grassland with prairie dog colonies	Grassland without prairie dog colonies
Nesting Information		
Total number of nests	17	18
Hatched (≥ 1 egg)	10	8
Failed	7	10
Egg Information		
Total number of eggs	51	54
Hatched eggs	29	23
Chick Information		
Total number of transmitters put on	11	20
Fates		
Predated	3	11
Environmental Influence	0	4
Battery Failure	0	5
Unknown	0	7

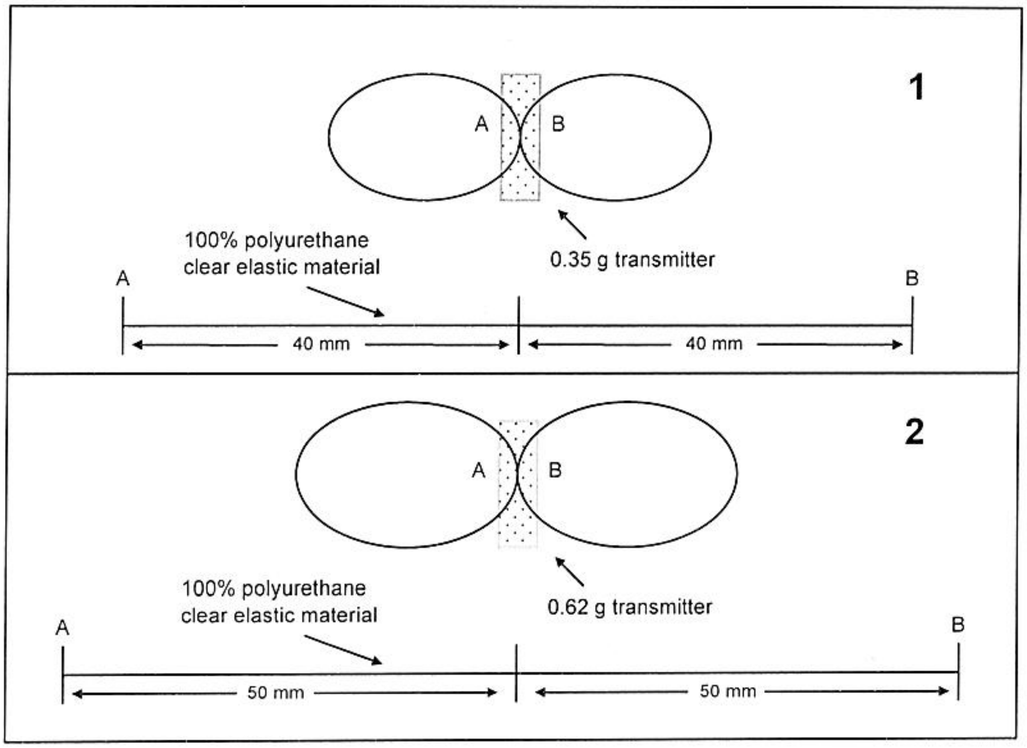

Figure 1. A modification of the leg harness attachment by Rappole and Tipton (1991). The design consists of 2-loops of equal size with the transmitter between the loops. Diagram 1 has a harness for a ≤1 d old mountain plover chick, diagram 2 is for a mountain plover chick >10 d and <20 d old.

Figure 2. Photograph showing chick dug up after being cached by a mammalian predator, such as a swift fox (*Vulpes velox*).

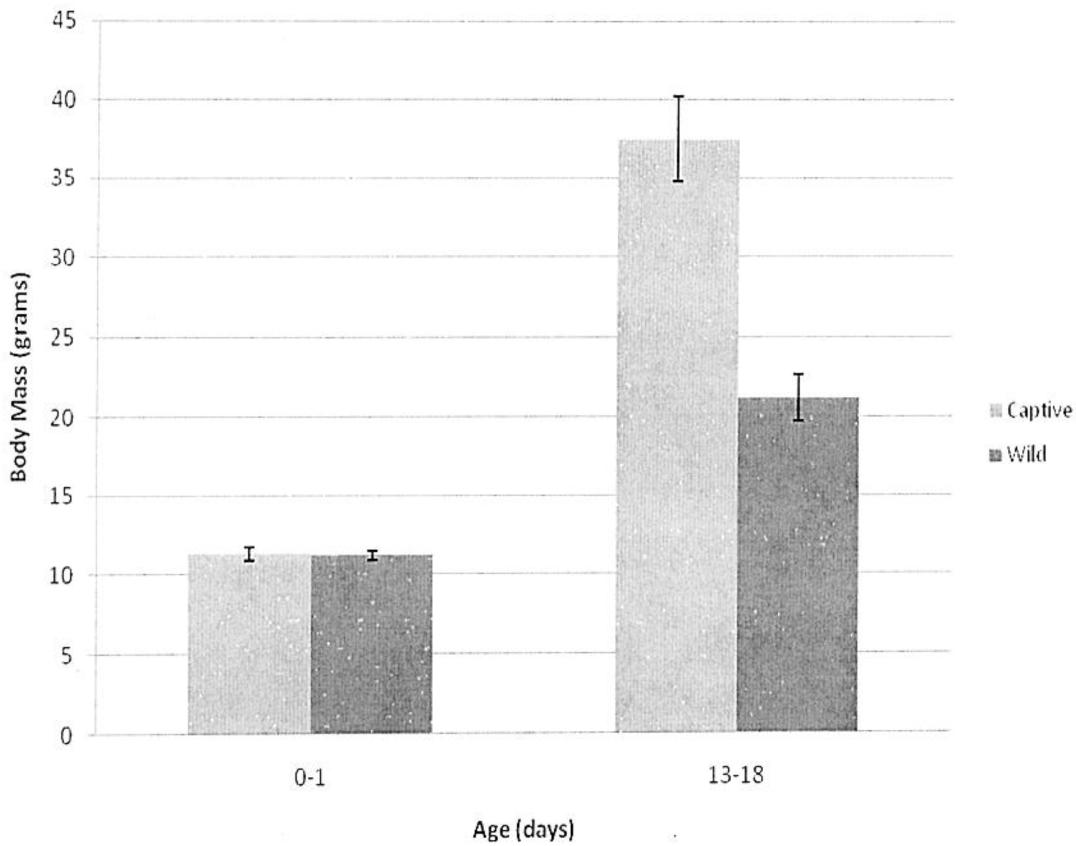

Figure 3. Graph of the body mass (g) of captive reared mountain plovers (Captive; n=10 body mass measurements for 0-1 d, and n=18 body mass measurements for 13-18 d) from Dreitz (2008) compared to mountain plovers in their natural habitat (Wild; n= 28 body mass measurements for 0-1 d, and n=7 body mass measurements for 13-18 d) from this study.

Appendix A. Summary of concluding fates of radio marked mountain plover (*Charadius montanus*) chicks in the spring- summer of 2009 on the Pawnee National Grassland.

Nest	Frequency	Age[1]	Habitat[2]	Fate	State[3]
403	092	14	GR-GR	Battery Failure	
	204	6	GR-GR	Death[4]	Chick on ground- bad weather preceding days
	636	18	GR-GR	Predation- Unknown	Transmitter on ground fully intact
406	054	17	GR-GR	Predation- Unknown	
	405	5	GR-GR	Predation- Unknown	
	678	4	GR-GR	Predation- Unknown	
432	116	23	GR-GR	Predation- Mammalian	Broken harness and auxillary bands
	367	7	GR-GR	Battery Failure	
	421	21	GR-GR	Predation- Unknown	
438	103	10	GR-GR	Predation- Mammalian	Lower half remains of chick
	154	2	GR-GR	Predation- Unknown	
439	167	8	GR-GR	Predation- Unknown	
	320	15	GR-GR	Battery Failure	
	517	15	GR-GR	Unknown	
443	444	17	PD-PD	Predation- Mammalian	
	492	12	PD-GR	Battery Failure	
	554	3	PD-PD	Predation- Unknown	Transmitter without harness material attached
448	477	4	GR-GR	Death[4]	Chick on ground- bad weather preceding days
	193	2	GR-GR	Death[4]	Chick on ground, still warm
	462	19	GR-GR	Battery Failure	
450	080	5	GR-GR	Unknown	
	217	5	GR-GR	Unknown	
	229	5	GR-GR	Unknown	
455	595	8	GR-GR	Battery Failure	
	529	12	GR-GR	Predation- Avian	Intact harness near fence post by avian pellets
457	243	9	PD-GR	Death	Desiccated corpse
	392	10	PD-C	Unknown	
	661	1	PD-PD	Predation- Avian	Antenna curled up, next to owl burrow
Unknown 1	281	10	GR-GR	Predation- Mammalian	Found buried under 6 inches of mud
Unknown 2	305	4	GR-GR	Unknown	
Unknown 3	343	1	GR-GR	Unknown	

[1] Age at mortality, or when last observed.
[2] Habitat at hatching - habitat at last observation. Grassland with prairie dogs (PD), Grassland (GR), or Crop field (C).
[3] Condition of chick or transmitter at final location.
[4] Necropsy performed and concluded a trauma related death.