J. Field Ornithol., 64(4):500–506

GROWTH AND SURVIVAL OF MOUNTAIN PLOVERS

BRIAN J. MILLER[1] AND FRITZ L. KNOPF

NATIONAL BIOLOGICAL SURVEY
4512 McMurry Avenue
Fort Collins, Colorado 80525-3400 USA

Abstract.—Growth and survival rates of Mountain Plovers (*Charadrius montanus*) were monitored using radiotelemetry from hatching until birds left the breeding grounds on the Pawnee National Grassland, Weld County, Colorado. Chick weights increased logarithmically ($r = 0.961$) and tarsus length linearly ($r = 0.948$) with age. Using the average fledging weight of 69.8 g and an age/weight regression we predicted that the average age at fledging was 36 d.

Fourteen Mountain Plover nests each had three eggs; an average of 2.6 eggs hatched in seven nests, whereas remaining nests were lost to predation, storms, or trampling by a cow. Twenty-four adult Mountain Plovers were monitored for 275 telemetry days with no mortalities. Twenty flightless chicks had a calculated daily survival rate of 0.979 for 233 telemetry-days. Mortalities of flightless chicks were due to predation or unknown causes. The daily survival rate predicted that 1.2 of the 2.6 chicks hatched per nest lived to fly. Eight fledged chicks were monitored for 74 telemetry-days, with a daily survival rate of 0.974. Mortalities of fledglings were all attributed to predation. The combined survival rates predicted that 0.7 of the 2.6 hatched chicks lived to leave the nesting area. Survival rates of flightless chicks were similar to those reported 20 yr ago, implying that recent declines in Mountain Plover numbers on the continent are not attributable to either longer-term declines in nesting productivity or phenomena occurring at non-breeding locales.

CRECIMIENTO Y SUPERVIVENCIA DE *CHARADRIUS MONTANUS*

Sinopsis.—El crecimiento y la tasa de supervivencia de individuos de *Charadrius montanus* fue monitoreado mediante el uso de radiotransmisores desde la etapa de polluelos hasta que éstos dejaron sus áreas reproductivas. El estudio se llevó a cabo en Pawnee National Grassland, del condado de Weld, Colorado. Se encontró que el peso de los polluelos incrementó logarítmicamente ($r = 0.961$) y el largo del tarso linealmente ($r = 0.948$) a tono con el incremento en edad. Utilizando como referencia el peso promedio de los volantones (69.8 g) y una regresión de edad/peso, se predijo que las aves dejaban el nido a la edad de 36 días. Catorce nidos de estos playeros contenían una camada de tres huevos; un promedio de 2.6 huevos eclosionaron en siete nidos, mientras que los huevos restantes se perdieron por tormentas, algunos los pisaron reses y otros fueron depredados. No hubo mortalidad en 24 de los playeros adultos que fueron monitoreados con radiotransmisores por 275 días de monitoreo. La supervivencia diaria de 22 polluelos resultó ser de 0.979 en 233 días de monitoreo. La mortalidad de polluelos fue atribuida a depredación y a causas desconocidas. La supervivencia diaria permitió predecir que de 2.6 polluelos nacidos/nido 1.2 llegarían a volantones. Ocho volantones se monitorearon telemétricamente por 74 días y resultaron con una tasa de supervivencia de 0.974. La mortalidad de volantones fue atribuida en su totalidad a depredadores. La tasa de supervivencia de polluelos resultó similar a la informada hace 20 años. Esto implica, al menos en al área de estudio, que la disminución poblacional de la especie se atribuye o a descensos de más largo plazo de productividad de anidamiento o a fenómenos que ocurren en áreas no reproductivas.

Northeastern Colorado is the breeding stronghold of the Mountain Plover (*Charadrius montanus*). A Candidate Species under the Endangered

[1] *Current address: Centro de Ecología, Universidad Nacional Autónoma de México, Apartado Postal 70-275, México D.F., 04510 México.*

Species Act, Mountain Plover populations have declined 63% continent-wide since 1966 (Knopf 1993). Information on juvenile growth rates and survival during the various stages of development is vital to identifying causes of declines of the species. Such data are scarce for the Charadriidae, in part because the precocial, cryptic young are difficult to locate and relocate after they leave the nest.

In this study, we developed a growth curve to age Mountain Plover chicks. Although Wilcox (1959) reported mean weights ($n = 6$) of flightless Piping Plovers (*C. melodus*), no statistically valid growth curve exists for any plover.

We also documented nest success, survival rates for flightless and fledged chicks, and causes of mortalities of the Mountain Plover. In the Charadriidae, researchers have reported Piping Plover nest success and fledging rates (Haig and Oring 1988, Prindiville Gaines and Ryan 1988, Wiens and Cuthbert 1984), Dotterel (*C. morinellus*) nest success (Byrkjedal 1987), Snowy Plover (*C. alexandrinus*) nest success (Grover and Knopf 1982, Hill and Talent 1990, Page et al. 1983) and fledging rate (Page et al. 1983), and Mountain Plover nest success (Graul 1975, McCafferey et al. 1984) and fledging rate (Graul 1975). Flightless chick survival rates for Mountain Plovers have not been documented since Graul (1975), and data on survival rates and causes of mortality of fledged chicks and adults are not available.

METHODS

We studied Mountain Plovers on the Pawnee National Grassland, a 780-km^2 shortgrass prairie located in Weld County, Colorado, from 14 May to 28 Jul. 1992. Graul (1973a) summarized the physiography, vegetation and climate of this region. Adult birds were captured on the nest with a fishing line snare. Juveniles were chased on foot until they could be captured by hand.

All captured birds were banded with a U.S. Fish and Wildlife Service numbered metal band on the left leg and two colored plastic bands on the right leg. Forty-four birds (24 adults, 20 chicks) were fitted with either a 3-g (adults only, 90-d-life-span) or a 1.5-g (adults and chicks, 45-d-life-span) back-mount-style transmitter (Holohil Ltd., Woodlawn, Ontario, Canada. Mention of commercial products does not constitute endorsement by the U.S. Government). The radios were fixed by clipping a 1.5-cm-diameter patch of feathers high on the back, and using an adhesive (Titan Corp., Lynnwood, Washington) to attach the transmitter to the bases of those clipped feathers. We located birds at distances up to 1000 m with a TRX-1000 Wildlife Materials Inc. (Carbondale, Illinois) receiver and a hand-held, three-element yagi antenna.

Nest failure due to storms or predation was documented using the methods of Graul (1975). Nests were checked by driving a vehicle near the nest to avoid spreading human scent around the nest.

Growth.—Chicks were located by radiotelemetry, positively identified by leg band numbers, then weighed and measured. The tarsus was mea-

sured to the nearest millimeter from the inside of the knee to the inside of the ankle (terminology after Hayman et al. 1988:18). The middle toe was measured from the intertoe webbing to the end of the nail.

Data from the first 2 wk of age were recorded on three chicks from three different broods. Data from the age of 2 wk to fledging came from two chicks from two different broods. Coincidentally, we measured both chicks at 29 and 32 d of age, and their measures were averaged before entering into regression analyses.

Survival.—Daily survival of chicks <2 wk of age was monitored by locating a telemetered adult, and then capturing and individually identifying accompanying chicks. Thus, many data points on chick survival came from untelemetered chicks. Twenty chicks >2 wk of age were fitted with transmitters. Chicks monitored for survival were considered to be independent within the same brood because all disappearances occurred individually and not as a brood.

We applied the Heisey and Fuller (1985) survival rate estimate to both flightless and fledged chicks hatched from mid-May to mid-June. Survival rates were compared between groups with a Z test for comparing two proportions at $P \geq 0.95$ (Jones and Witham 1990, Zar 1984). Causes of mortality were determined by location of the remains and evidence at the recovery site. Inconclusive causes of mortality were recorded as such.

RESULTS

Growth.—Log_{10} body weights of chicks were an excellent ($r^2 = 0.925$), and tarsus length a slightly poorer ($r^2 = 0.899$), predictor of chick age (Fig. 1). The middle toe was comparatively well developed at hatching; mean length changed from 17 ± 0.1 [SE] mm ($n = 5$) at hatching to 21 ± 0.6 mm ($n = 6$) at fledging.

Chicks fledged (first capable of any flight) at an average weight of 69.8 ± 4.9 g ($n = 7$), or about 70% of adult weight. Mean tarsus length at fledging was 34.1 ± 1.36 mm, which is comparable to adult lengths (Graul 1973b).

One known-age chick fledged at 39 d and weighed 71 g. A second known-age chick weighed 58 g at 34 d of age, when the radio malfunctioned. Using the average fledging weight of 69.8 g with the weight regression formula, we predicted an average age at fledging of 36 d. The tarsus length regression also predicted an average age at fledging of 36 d.

Survival.—Each of 14 nests monitored in 1992 had three eggs; seven (50%) of those nests failed. Two nests were destroyed during storms, one was trampled by a cow and four were apparent victims of predation, assumed because weather was clear and we found egg fragments in the nest lining. In addition, three other nests were abandoned after trapping, but those abandonments were not included when calculating nest success. Two of the abandonments occurred after the adult was trapped a second time to reattach a radio.

An average of 2.6 of the three eggs hatched in the seven successful nests. Two broods hatched over several days. In one nest, one egg hatched

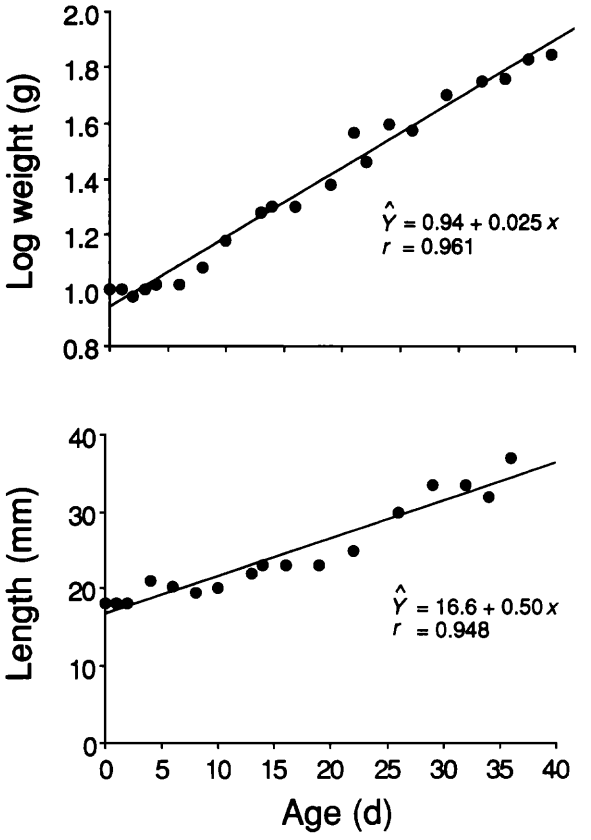

FIGURE 1. Changes in weight and tarsus length of Mountain Plover chicks from time of hatching until fledging.

each day for 3 d. In the second nest, one egg hatched on day 1 and two eggs on day 2. In two other nests all three eggs hatched in 1 d, with the eggs hatching in <30 min in one. We saw no telemetric evidence of two adults splitting a brood between them or of paired adults raising two broods.

Twenty-four adult Mountain Plovers were monitored during 275 telemetry-days with no mortalities. Twenty chicks were used in juvenile survival estimates; eight were known age (hatched between 11 and 16 June). The other 12 chicks were from broods telemetered within 15 d before fledging. We used weights and the regression equation to estimate hatching dates for these chicks between 18 May and 1 June.

We monitored the 20 flightless chicks for 233 telemetry-days, and the Heisey and Fuller (1985) daily survival rate was 0.979. The 74 telemetry-days that we monitored eight fledged chicks indicated a daily survival rate of 0.974. There was no significant difference ($P > 0.05$) between

the daily survival of flightless and fledged chicks. The combined survival rate was 0.977 for 307 telemetry-days.

Using the daily survival rate extended over the 36 d necessary to fledge (0.979^{36}), we calculated a 46.6% chance that chicks would survive to fly. Restated, 1.2 chicks fledged for every 2.6 eggs hatched per nest. In a separate calculation from a subset of the data, we visually confirmed that 11 chicks fledged from 10 broods, for a fledging rate of 1.1 chicks/brood. Mountain Plovers left the study site on 28 July. This data was an average of 18 ± 8.7 d after the known fledging date for nine chicks. Extending the post-fledging daily survival rate over 18 d (0.974^{18}), there was a 62% chance that a fledged chick would survive to leave the natal area. When the combined daily survival rate of 0.977 is extended over 54 d, we calculated a 28.5% chance of survival from hatching until leaving the area. Thus, of 2.6 chicks hatched/nest, 0.7 lived to migrate.

Five chicks died before fledging. Remains of two were located within 10 m of different swift fox (*Vulpes velox*) dens. A third radio was located on the top of a small crest and was badly damaged from being chewed (probably by a canid). The causes of the fourth and fifth pre-fledging mortalities were unknown. Two mortalities occurred post-fledging. Radios from both of those chicks were excavated from different swift fox dens.

DISCUSSION

Growth.—Both weight and tarsus length were strongly correlated with chick age, with weight showing the better relationship. In addition, weights appeared to be more easily and reliably measured among workers. Graul (1973b) provided tables of average body weights and tarsus measurements for juvenile Mountain Plovers which, when regressed against age, produced a weight slope (b_1) of 0.021, compared to 0.025 in this study, and a tarsus slope of 0.473, compared to 0.495.

Mountain Plovers fledge at 70% of adult weight, yet the tarsus and toe lengths at fledging are nearly adult-sized. Rapid leg development appears to be an adaptive predator-avoidance trait for this precocial ground-nesting bird that leaves the nest a day after hatching. Mountain Plover chicks rely on running and crypsis when approached by potential predators (Sordahl 1991). We observed four telemetered broods that moved 1.1–1.9 km between days 2 and 5 post-hatching. We observed that even though the flight feathers were fully formed at fledging (as expected), the head still contained some down and the rectrices were just beginning to emerge, as previously noted by Graul (1973b).

Survival.—Graul (1975) reported 65% success for 80 nests and 48% success for 21 nests in two different years, with predators destroying about 16% each year. McCaffery et al. (1984) reported 45% success for 20 nests with 45% of the losses to predation. Both of those studies occurred in different regions of the Pawnee National Grassland.

In this study, located near the McCaffery et al. (1984) research area, we found 50% nest success with 28.6% of the nests falling to predators. Lack (1954) analyzed nest success in 24 species of precocial ground-

nesting birds and listed a 56% rate of nest success. The 2.6 hatched eggs/nest reported in this study agrees with Graul's (1975) reported 2.7 eggs/nest, but is a higher rate than the 2.1 eggs/nest reported by McCaffery et al. (1984).

As previously reported (Graul 1975, McCaffery et al. 1984) all mortalities were of chicks. We saw no mortalities among 24 adults that were monitored a total of 275 telemetry-days. Chick mortality was not concentrated in the first few days but spread over the developmental period, which departs from data reported by Graul (1975) and agrees with the observations of McCaffery et al. (1984). Indeed, the nearly identical daily survival rate for flightless and fledged chicks in 1992 suggests that fledged chicks are equally vulnerable to predators.

In 1992, Mountain Plovers fledged 1.2 chicks/nest. For comparisons to fledging rates of other Charadriidae, the Piping Plover (which usually lays 4 eggs/nest) fledged 0.3–1.5 chicks (Haig and Oring 1988) or 1.0–1.5 chicks/pair (Prindiville Gaines and Ryan 1988), and the Snowy Plover fledged 0.5–0.7 chicks/female (Page et al. 1983). Page et al. (1983) estimated a fledging rate of 0.8 chicks/female was necessary for a stable population of Snowy Plovers. Mountain Plover post-fledging survival indicated that 0.7 of the 2.6 chicks hatched lived to depart the nesting area, although population recruitment may be higher as at least some females lay more than one clutch in this species (Graul 1973a).

Graul (1975) reported 1.4 Mountain Plover chicks fledging for every 2.7 chicks hatched from a nest. He speculated that the 1.4 estimate may be slightly high because he could not include broods that had lost all chicks in the 16 broods that he watched. Using radiotelemetry in 1992, we recorded two of 10 nests from which all chicks died before fledging. If we recalculate our data for visual confirmation of chicks fledged (i.e., exclude those latter two nesting efforts) following Graul's method, we calculate an identical, inflated value of 1.4 chicks fledged/nest.

Mountain Plover populations have declined drastically in the last century, and the species no longer breeds in North Dakota and South Dakota and only rarely in Nebraska (FLK, pers. obs.). Yet, fledging rates for the Pawnee National Grassland from this study were comparable to Graul's (1975) data 20 yr earlier. Our data indicate that recent population declines of Mountain Plovers are attributed to either longer-term declines in reproductive success or phenomena occurring at nonbreeding locales.

ACKNOWLEGMENTS

We thank the U.S. Forest Service for financial assistance, and personnel of the Rocky Mountain Region, Arapaho-Roosevelt National Forest and the Pawnee National Grassland District for technical assistance. We are especially grateful for the administrative support of Larry Mullen and to Bryce Bowman for permission to track birds that moved onto his land. B. Houston, J. Godbey, R. Hill, S. Brech and K. Ayers provided field assistance, and W. Graul, S. Olson-Edge and T. Sordahl provided helpful comments on the manuscript.

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Received 30 Oct. 1992; accepted 22 Feb. 1993.