Western North American Naturalist 65(2), © 2005, pp. 223–228

HABITAT AND NESTING BIOLOGY OF MOUNTAIN PLOVERS IN WYOMING

Regan E. Plumb[1], Stanley H. Anderson[1], and Fritz L. Knopf[2]

ABSTRACT.—Although previous research has considered habitat associations and breeding biology of Mountain Plovers in Wyoming at discrete sites, no study has considered these attributes at a statewide scale. We located 55 Mountain Plover nests in 6 counties across Wyoming during 2002 and 2003. Nests occurred in 2 general habitat types: grassland and desert-shrub. Mean estimated hatch date was 26 June (n = 31) in 2002 and 21 June (n = 24) in 2003. Mean hatch date was not related to latitude or elevation. Hatch success of nests was inferred in 2003 by the presence of eggshell fragments in the nest scrape. Eggs in 14 of 22 (64%) known-fate nests hatched. All grassland sites and 90% of desert sites were host to ungulate grazers, although prairie dogs were absent at 64% of nest sites. Nest plots had less grass coverage and reduced grass height compared with random plots. More than 50% of nests occurred on elevated plateaus. The Mountain Plover's tendency to nest on arid, elevated plateaus further substantiates claims that the bird is also a disturbed-prairie species.

Key words: Mountain Plover, Charadrius montanus, *nest site, hatching success, Wyoming, shortgrass prairie.*

The Mountain Plover (*Charadrius montanus*) is endemic to the grasslands of North America, particularly the western Great Plains and Colorado Plateau. It nests in shortgrass prairie habitats historically used by large assemblages of herbivores, specifically bison (*Bison bison*), pronghorn (*Antelocapra americana)*, and prairie dogs (*Cynomys* spp.), and in more xeric, desert shrub zones to the west (Knopf 1996). However, this tendency for Mountain Plovers to select native habitats with substantial bare ground, coupled with its former cohabitation with large herds of bison, pronghorn, elk, and prairie dogs, has led some to argue that it is a disturbed-prairie or semidesert species rather than a shortgrass associate (Knopf and Miller 1994). Laun (1957) found the bird on the arid mixed-grass plains surrounding Laramie, where sheep and cattle grazing has occurred for over 100 years. In the southern portion of their range, Mountain Plovers also nest on recently plowed fields, often with comparable success to rangeland nesters (Dreitz et al. in press). Likewise, wintering birds in California make extensive use of cultivated farmlands, land that was once native prairie supporting tule elk (*Cervus elaphus*), pronghorn, and kangaroo rats (*Dipodomys* spp.; Knopf and Rupert 1995).

Knopf and Miller (1994) reported 32% bare ground at nest sites in Colorado and suggest that 30% bare ground is a minimum habitat requirement for nesting Mountain Plovers. Ellison et al. (2001) found reduced grass cover at nest sites in Utah, while Parrish et al. (1993) reported 72% bare ground at nest sites and 79% bare ground in Wyoming. Beauvais and Smith (2003) were able to correctly classify 87% of points in an independent data set using a model that predicted Mountain Plover presence as a function of cover and slope in western Wyoming. These studies indicate that bare ground or, conversely, lack of vegetative cover, may be one of the most influential predictors of Mountain Plover nesting habitat, particularly on the shrub-steppe.

Our study objectives were to (1) describe nesting phenology of breeding birds across the state, (2) report on hatching success of Mountain Plover nests in Wyoming relative to other regions, (3) describe major vegetative associations at nest sites, and (4) report on presence of grazing at nest sites.

STUDY AREAS

Nest searching was conducted throughout the state at locations where historic records of

[1]Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Dept. 3166, 1000 E. University Ave., Laramie, WY 82071-3166.
[2]U.S. Geological Survey, Fort Collins Science Center, 2150-C Centre Avenue, Fort Collins, CO 80526-8118.

Mountain Plover sightings occurred. We focused search efforts at sites with high densities of records in Wyoming Game and Fish Department files. High-density sites include grassland landscapes in the Powder River, Shirley, and Laramie Basins, and desert-shrub zones in the Big Horn, Great Divide, and Washakie Basins. The Powder River basin study sites are located on Thunder Basin National Grassland. The Laramie and Shirley Basin sites include portions of the Laramie Plains extending north and west from Laramie to Medicine Bow and Foote Creek Rim, and the central portion of Shirley Basin, roughly delineated by the 2 intersections of Wyoming Highways 77 and 487 in northeastern Carbon County. These basins are characterized by interspersed short- and mixed-grass prairie. Shortgrass species that occur include blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*). Commonly occurring mixed-grass species include needle-and-thread grass (*Stipa comata*), western wheatgrass (*Agropyron smithii*), Sandberg bluegrass (*Poa sandbergii*), threadleaf sedge (*Carex filafolia*), Indian ricegrass (*Oryzopsis hymenoides*), and pricklypear cactus (*Opuntia polyacantha*). Shrub species including big sagebrush (*Artemisia tridentata*), budsage (*A. spinescens*), and fourwing saltbush (*Atriplex canescens*) are also present. Black-tailed prairie dog (*Cynomys ludovicianus*) colonies are common, and grazing by domestic cattle and pronghorn antelope is pervasive. Wind power development occurs in portions of the Laramie Basin.

Primary desert-shrub sites include the Mexican Flats, located west of the town of Dad between Wamsutter and Baggs in the Washakie Basin, a portion of the Great Divide Basin of the Red Desert located south of Cyclone Rim in northern Sweetwater County, and parts of the Big Horn Basin near Cody and Powell (Park County) and Greybull (Big Horn County), particularly Polecat and Chapman Benches. These shrubland areas are typified by saline soils and are dominated by greasewood (*Sarcobatus vermiculatus*), shadscale (*Atriplex confertifolia*), fourwing saltbush, and Gardner saltbush (*A. gardneri*), with winterfat (*Ceratoides lanata*), cushion plants, and pricklypear cactus interspersed. A mosaic is often formed with stands of big sagebrush, saltbush, and greasewood. Mixed-grass species are also present. Oil and gas development is common, particularly in the Mexican Flats study area. The landscape is grazed by domestic sheep and cattle, pronghorn antelope, and wild horses. White-tailed prairie dog (*Cynomys leucurus*) colonies are common throughout.

Nest searching also occurred in numerous low-density areas including lands managed by the Kemmerer Field Office of the Bureau of Land Management (Lincoln County), the desert landscape west of Flaming Gorge Reservoir (Sweetwater County), and Hannah Basin in central Wyoming (Carbon County). Few breeding birds and no nests were located in low-density areas. For this reason, low-density sites are not described in detail.

METHODS

Nest Searches

Nest searches in 2002 were conducted in areas with historic Mountain Plover sightings, and in 2003 in areas previously established as concentration areas for breeding plovers (Plumb 2004; breeding concentration areas were sites that averaged >30 Mountain Plover detections in 2002). Survey protocol was modeled after Mountain Plover guidelines (U.S. Fish and Wildlife Service 2002). Driving transects were conducted along an established paved or dirt road. Stops were made at 0.25-mile intervals for visual scans. Scans were conducted outside the vehicle and lasted long enough for a 360° panorama. Nest searching occurred on sites where plovers showed signs of breeding activity upon detection (e.g., head bobbing, seated position, courtship displays, or unwillingness to leave immediate area; U.S. Fish and Wildlife Service 2002).

Data Collection at Nest

At least 2 eggs from each clutch were floated in water to estimate clutch age and to approximate hatch date (Alberico 1995, Mabee 1997). We revisited nests soon after projected hatch date to verify hatch. The relationship of projected hatch date to nest elevation and latitude was evaluated using linear regression.

Hatch success of at least 1 egg was inferred by the presence of small eggshell fragments in the nest scrape (Mabee 1997). Adult Mountain Plovers remove large shell parts from the nest as eggs hatch, but chicks breaking through the eggshell leave small pipped fragments. We collected addled or abandoned eggs at this time for embryo aging.

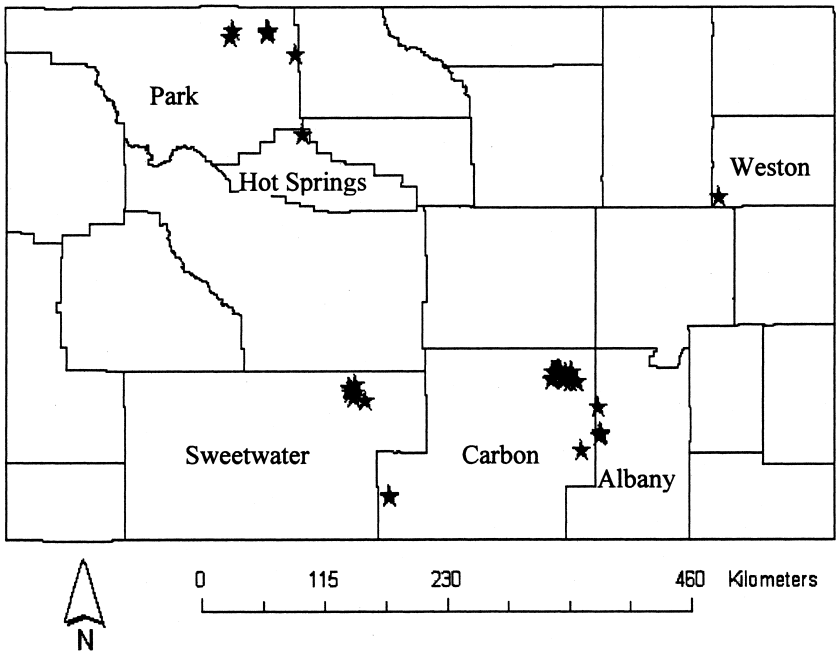

Fig. 1. Mountain Plover nest sites located in Wyoming in 2002 and 2003.

In 2002 vegetation was sampled at four 1.0-m^2 plots at each nest site. The 1st plot was centered on the nest, and consecutive plots were spaced at distances of 25, 50, and 100 m from the nest along a straight-line transect in a randomly selected cardinal direction determined by 2 coin tosses. We generated 4 random plots in the vicinity of each nest by traveling along the nearest road for an arbitrarily chosen distance of 1.6 km, randomly selecting a cardinal direction by coin tosses, and sampling 1.0-m^2 plots at 0-, 25-, 50-, and 100-m increments along a straight-line transect. Plots were delineated with a meter stick, and coverage by vegetation classes, including bare ground and grass, was estimated for all 1.0-m^2 plots. Nest plots were compared to respective random plots using Student's t test ($\alpha = 0.05$) for all nests.

Evidences of disturbance regimes, including grazing by wild or domestic ungulates, prairie dog activity, or industrial development visible within 400 m of nest sites, were described. We also considered general topography at the nest site (i.e., plateaus versus open plains or basins).

In 2002 we marked nests by placing a rock on the road shoulder immediately perpendicular to the nest. Distance from the road to the nest was paced and GPS coordinates were taken (Garmin 12). This method did not allow for relocation of nests. In 2003 we marked nests with 2 small stones labeled with Xs and placed them precisely 1 m to the north and south of the scrape. GPS locations and detailed descriptions of the immediate nest environment were taken.

RESULTS

Clutch Size and Breeding Phenology

Between 28 May and 10 July 2002, we located 31 Mountain Plover nests. An additional 24 nests were found between 22 May and 26 June 2003 (Fig. 1). Of 55 clutches, 51 (93%) had 3 eggs and 4 (7%) had 2 eggs. Projected hatch date ranged from 6 June to 24 July 2002 and from 7 June to 7 July 2003. Average projected hatch date was 26 June 2002 and 21 June 2003. Egg hatch date was influenced by neither nest elevation ($r^2 = 0.02$, $P = 0.36$, $n = 55$) nor latitude ($r^2 = 0.05$, $P = 0.18$, $n = 41$).

Hatch Success and Condition of Unhatched Eggs

Eggs successfully hatched in 14 of 22 (64%) revisited nests in 2003 as indicated by the

TABLE 1. Comparison of mean grass and mean bare ground coverage ($\% \pm s_{\bar{x}}$) of 1.0-m² grassland and desert nest plots and 1.0-m² random plots at 4 distances from nest or random start point. Plots sampled in 2002.

	GRASS COVERAGE				
	Grassland sites (n = 18)		Desert sites (n = 13)		
	Nest plot	Random plot	Nest plot	Random plot	t[a] (P)[b]
0 m	13.9 ± 3.3	20.3 ± 3.0	8.5 ± 1.4	23.5 ± 7.3	–2.50 (0.02)
25 m	20.0 ± 2.4	19.7 ± 1.8	13.5 ± 3.3	19.2 ± 3.3	–0.86 (0.40)
50 m	19.0 ± 3.0	17.8 ± 1.7	15.8 ± 4.5	18.5 ± 4.1	0.27 (0.79)
100 m	19.4 ± 3.8	19.7 ± 4.6	16.5 ± 4.4	16.5 ± 3.8	0.20 (0.84)
	BARE GROUND COVERAGE				
	Grassland sites (n = 18)		Desert sites (n = 13)		
	Nest plot	Random plot	Nest plot	Random plot	t[a] (P)[b]
0 m	47.2 ± 4.5	35.3 ± 4.4	61.2 ± 5.6	56.2 ± 8.3	1.53 (0.13)
25 m	42.2 ± 4.6	44.2 ± 3.3	60.0 ± 6.6	51.9 ± 3.7	1.10 (0.28)
50 m	56.9 ± 4.3	46.4 ± 3.8	63.9 ± 7.0	56.9 ± 6.8	1.09 (0.28)
100 m	48.9 ± 4.6	41.9 ± 5.4	56.9 ± 5.9	53.1 ± 6.7	0.36 (0.72)

[a]Degrees of freedom range from 48 to 59.
[b]Reported t tests are for grassland and desert samples combined.

TABLE 2. Comparison of mean grass height ($\pm s_{\bar{x}}$) in centimeters of 1.0-m² grassland and desert nest plots and 1.0-m² random plots at 4 distances from nest or random start point. Plots sampled in 2002.

	GRASS HEIGHT				
	Grassland sites (n = 18)		Desert sites (n = 13)		
	Nest plot	Random plot	Nest plot	Random plot	t[a] (P)[b]
0 m	5.88 ± 0.57	7.39 ± 1.26	4.09 ± 0.58	7.00 ± 0.92	–2.14 (0.04)
25 m	6.67 ± 0.49	6.94 ± 0.60	6.00 ± 0.75	7.17 ± 0.51	–1.02 (0.31)
50 m	7.78 ± 0.61	6.61 ± 0.55	6.40 ± 0.82	6.75 ± 0.90	0.90 (0.37)
100 m	9.47 ± 1.67	6.47 ± 0.83	7.27 ± 1.57	8.80 ± 0.63	0.96 (0.34)

[a]Degrees of freedom range from 40 to 55.
[b]Reported t tests are for grassland and desert samples combined.

presence of shell fragments in the nest cup. Of the remaining 8 clutches, 5 were devoid of eggshell fragments although predation could be confirmed in only 1 case. The remaining 3 clutches had been abandoned, and all eggs were collected. Also, 4 eggs were collected from otherwise successful clutches. Nests were not revisited in 2002. In total, 13 eggs were collected from 6 nests and their contents examined. Shell thickness was not quantified, but 9 eggs had shells that appeared thinner than others and were noticeably fragile. Eight of the 13 were either infertile or had minimally developed embryos (<3 days). The remaining 5 were moderately developed (≈8–17 days).

Nest Habitat Attributes

Bare ground was the largest component of 1.0-m² nest plots in both grassland and desert areas (Table 1). Nest plots at 0 m had less grass coverage (Table 1) and reduced grass height (Table 2) than corresponding random plots in all cases. There was no difference in grass coverage, bare ground coverage, or grass height between nest plots and corresponding random plots at distances ≥25 m.

All grassland nest sites and most desert nest sites showed evidence of grazing in 2002 and 2003, predominantly by domestic cattle and sheep. Pronghorn and wild horses were also present at some sites. Prairie dogs were

present on 17 of 32 grassland nest sites (53%; black-tailed) and 3 of 23 desert sites (13%; white-tailed). Thirty-four of 55 nests (62%) were located on plateaus elevated at least 100 m above surrounding terrain. The remaining 21 nests occurred in broad basins or on high plains.

DISCUSSION

Hatch Success and Condition of Unhatched Eggs

Our hatch rate across Wyoming was similar to Graul's (1975) findings on the Pawnee National Grassland, Weld County, Colorado, where at least 1 egg hatched in 65% of 80 nests, and was higher than those reported by Knopf and Rupert (1996; 26%–50%), also on the Pawnee National Grassland. Dinsmore et al. (2003) reported that at least 1 egg hatched in 58% of 600 monitored nests on the Charles M. Russell National Wildlife Refuge, Philips County, Montana. Mountain Plover nest failure is often attributed to predation or flooding (Miller and Knopf 1993, Knopf and Rupert 1996, Dinsmore et al. 2003), and these variable nest success rates might be expected as predator populations, habitat quality, and climatic conditions fluctuate.

Nest Habitat Attributes

Results from this study are in accordance with previous reports that Mountain Plover nesting habitat is typified by 27%–72% bare ground (Olson and Edge 1985, Parrish et al. 1993, Knopf and Miller 1994) and minimal grass coverage. Plovers have also been shown to use cultivated fields for nesting and brood-rearing (Knopf and Rupert 1999, Dreitz et al. in press). On average, our nest plots were 53% bare ground. This value is higher than results from Colorado and Montana (32%) and is likely due to the large number of Wyoming nest sites in xeric landscapes where bare ground accounts for >50% of coverage at random sites and >60% of coverage at nest sites.

Ungulate grazers were present at all grassland and most desert sites. Thus, open-range livestock grazing is compatible with Mountain Plover reproduction (Kantrud and Kologiski 1982, Knopf 1996). When correctly managed, open-range grazing emulates presettlement conditions much more effectively than do urban development and cultivation, both of which are more pervasive in surrounding states. Thus, Wyoming is of unique value to shortgrass and desert ground-nesters like the Mountain Plover because it boasts vast expanses of rangeland where habitat is kept open through grazing.

Although some studies have shown strong selection for black-tailed prairie dog colonies by Mountain Plovers breeding at mixed-grass prairie sites (Knowles et al. 1982, Olson and Edge 1985, Dinsmore et al. 2003), prairie dogs were absent at many of our Mountain Plover nest sites in Wyoming. Black-tailed prairie dogs were present at 53% of grassland sites and white-tailed prairie dogs at 13% of desert sites. Similarly, Parrish et al. (1993) reported that Mountain Plovers in the Powder River basin did not have a strong affinity for black-tailed prairie dog towns on Thunder Basin National Grassland, with only 1 of 15 nests occurring on a town. Pervasive livestock grazing may be adequate at Wyoming sites to attract breeding plovers in the absence of prairie dog colonies. Alternatively, soil quality, precipitation levels, and vegetative cover may be adequately low to curb the need for additional landscape disturbance.

It is notable that 62% of nests found were located on plateaus elevated at least 100 m above surrounding terrain, particularly since most surveys were *not* conducted on plateaus. Mountain Plovers also select plateaus for nesting in Philips County, Montana (Knopf personal communication 2003). Elevated plateaus may host a greater bare ground component than the surrounding landscape due to increased wind scour and precipitation runoff. The Mountain Plover's tendency to nest on arid, elevated plateaus further substantiates claims that the bird is also a disturbed-desert species rather than a strict associate of the shortgrass prairie.

LITERATURE CITED

ALBERICO, J.A.R. 1995. Floating eggs to estimate incubation stage does not affect hatchability. Wildlife Society Bulletin 23:212–216.

BEAUVAIS, G.P., AND R. SMITH. 2003. Model of breeding habitat of the Mountain Plover (*Charadrius montanus*) in western Wyoming. Western North American Naturalist 63:88–96.

DINSMORE, S.D, G.C. WHITE, AND F.L. KNOPF. 2003. Annual survival and population estimates of Mountain Plovers in southern Phillips County, Montana. Ecological Applications 13:1013–1026.

DREITZ, V.J., M.B. WUNDER, AND F.L. KNOPF. 2005. Movement and home ranges of Mountain Plovers raising broods in three Colorado landscapes. Wilson Bulletin: In press.

ELLISON MANNING, A.E., AND C.M. WHITE. 2001. Breeding biology of Mountain Plovers, *Charadrius montanus*, in the Uinta Basin. Western North American Naturalist 61:223–228.

GRAUL, W.D. 1975. Breeding biology of the Mountain Plover. Wilson Bulletin 87:6–31.

KANTRUD, H.A., AND R.L. KOLOGISKI. 1982. Effects of soils and grazing on breeding birds of uncultivated upland grasslands of the northern Great Plains. Unpublished report, United States Department of the Interior, Fish and Wildlife Service.

KNOPF, F.L. 1996. Mountain Plover (*Charadrius montanus*). *In:* A. Poole and F. Gill, editors, The Birds of North America, No. 211. The Academy of Natural Sciences, Philadelphia, PA, and The Ornithologists' Union, Washington, DC.

KNOPF, F.L., AND B.J. MILLER. 1994. *Charadrius montanus*—montane, grassland, or bare-ground plover? Auk 111:504–506.

KNOPF, F.L., AND J.R. RUPERT. 1995. Habits and habitats of Mountain Plovers in California. Condor 97:743–751.

_____. 1996. Reproduction and movements of Mountain Plovers breeding in Colorado. Wilson Bulletin 108: 28–35.

_____. 1999. Use of cultivated fields by breeding Mountain Plovers in Colorado. Studies in Avian Biology 19:81–86.

KNOWLES, C.J., C.J. STONER, AND S.P. GIEB. 1982. Selective use of black-tailed prairie dog towns by Mountain Plovers. Condor 84:71–74.

LAUN, H.C. 1957. A life history study of the Mountain Plover, *Eupoda montana townsend*, on the Laramie Plains, Albany County, Wyoming. Master's thesis, University of Wyoming, Laramie.

MABEE, T.J. 1997. Using eggshell evidence to determine nest fate of shorebirds. Wilson Bulletin 109:307–313.

MILLER, B.J., AND F.L. KNOPF. 1993. Growth and survival of Mountain Plovers. Journal of Field Ornithology 64:500–506.

OLSON, S.L., AND D. EDGE. 1985. Nest site selection by Mountain Plovers in north central Montana. Journal of Range Management 38:280–282.

PARRISH, T.L., S.H. ANDERSON, AND W.F. OELKLAUS. 1993. Mountain Plover habitat selection in the Powder River Basin, Wyoming. Prairie Naturalist 25:219–226.

PLUMB, R.E. 2004. Minimum population size and concentration areas of Mountain Plovers breeding in Wyoming. Master's thesis, University of Wyoming, Laramie.

U.S. FISH AND WILDLIFE SERVICE 2002. Mountain Plover survey guidelines. <http://montanafieldoffice.fws.gov/endangered_speciessurvey_guidelines/mountain_plover_survey_guidelines.pdf.>

Received 26 January 2004
Accepted 15 April 2004