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Diet of nesting Killdeer in North Dakota.—The Killdeer (*Charadrius vociferous*) is one of the most widespread of all North American shorebirds and, unlike other shorebirds, tolerates a wide variety of open inland habitats in addition to the shores of coastal and inland water. Given its common status, there is surprisingly little information on the Killdeer diet. The only study is an unpublished report by Baldwin (1971) on their diet during the breeding season (June 16 to July 28) on the shortgrass prairie of eastern Colorado. Henderson (1927), Bent (1929), and Martin et al. (1951) also provide qualitative summaries of the Killdeer diet. Rundle (1982) compared esophageal and gizzard analysis in four species of shorebirds including Killdeer and found the three main taxonomic groups eaten by Killdeer were Coleoptera adults (40% occurrence), Diptera larvae (40%), and Coleoptera larvae (20%). No diet preference studies have been done on the Killdeer.

Because of concern for the impacts of pesticides on upland shorebirds, we conducted a study investigating the direct and indirect effects of carbaryl grasshopper control on Killdeer nesting on the U.S.D.A., Animal Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ), Grasshopper Integrated Pest Management (GHIPM) demonstration site in western North Dakota. Killdeer gizzard analyses were performed to investigate a possible functional response in the Killdeer as a result of a reduction in arthropod availability caused by range grasshopper control. Killdeer were collected from areas sprayed with carbaryl Sevin-4 oil formulation and from similar unsprayed habitat. Each Killdeer was analyzed for brain acetylcholinesterase activity, pesticide residues (including organochlorines), whole body % lipids, and gizzard contents. Relative arthropod abundance was also estimated on the sprayed areas. Here, we report the gizzard contents of the Killdeer collected for this research and compare these data with the Killdeer diet reported by Baldwin (1971) which was also based on an analysis of gizzard contents. We also contrast the diet data with the arthropod abundance data to see if Killdeer exhibit any dietary preferences.

This study was conducted on two locations treated for grasshopper control by USDA, APHIS, during the summer of 1992. The first area (Towner area) was primarily on privately owned rangeland, located northwest of Towner in McHenry County, North Dakota. The mixed prairie vegetation of this area is dominated by needle-and-thread grass (*Stipa comata*) and western wheatgrass (*Agropyron smithii*). Small woodlands on the area included green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), quaking aspen (*Populus*

tremuloides), narrowleaf cottonwood (*P. angustifolia*), and wild rose (*Rosa acicularis*). Annual cereal grain production characterizes the interspersed cropland, with a small percentage devoted to hay production. The second area (Medora area) was approximately 240 km southwest of the Towner area and was primarily on the Little Missouri National Grassland (LMNG) south of Medora in Billings County. The vegetation is a mixed-grass prairie dominated by blue grama (*Bouteloua gracilis*), western wheatgrass, needle-and-thread grass, prairie junegrass (*Koeleria pyramidata*), and threadleaf sedge (*Carex filifolia*). The grasslands are dissected by woody draws that support some shrubs such as silver buffaloberry (*Shepherdia argentea*) and chokecherry (*Prunus virginiana*), and the principle trees are green ash, Rocky Mountain juniper (*Juniperus scopulorum*), and cottonwood (*Populus deltoides*) (Fowler et al. 1991). The LMNG is managed for multiple use, including grazing, and a significant percentage of the area is developed for oil and gas extraction, as nearly all of the region is underlaid by lignite coal. One untreated control area was located 10–17 km from each treatment area.

Killdeer were collected on treatment and control areas by shotgun June 22–July 29 1992, under the U.S. Dept. of the Interior, Fish and Wildlife Service Permit PRT-719665 and North Dakota State Permit 0125 (this research was approved by Colorado State Univ.'s Animal Care and Use Committee Protocol No. 92-150A-01). Most Killdeer were located around windmills and water holes, in grazed pastures, or in level short-grass habitat. Birds were sexed by internal examination and aged either to adult or juvenile by feather growth. Gizzard and esophagus contents were separated on foil and frozen in the field for analysis later in the laboratory. This facilitated prey item identification and minimized post-mortem digestion of food items which may occur in birds. Collected specimens were transported on dry ice from the field and then stored at −80°C. Wet weight of the gizzard contents was also measured while still frozen. Voucher prey items were collected from the field and various sources were used to aid the identification process (Borror and White 1970, White 1983, Chapman and Rosenberg 1991). Numbers of individuals within a sample could be counted based on the number of body parts (e.g., six beetle legs = one Coleoptera).

The relative abundance of ground-dwelling and flying arthropods on the two treated areas were estimated concurrently using pitfall traps. Pitfall traps were placed in a trapping web (Anderson et al. 1983). Each trapping web consisted of eight lines radiating out from a central point and each line had 10 traps each separated by 1.5 m (N = 80). This results in trap densities declining from 1.13 traps/m^2 at the center, to 0.01 traps/m^2 at the edge. Each trap consisted of three plastic cups (Baars 1979, Quinn et al. 1990). Traps were checked two days after installation and invertebrates were collected for identification.

Gizzard content variables were compared using two-way analysis of variance (ANOVA; PROC GLM) and significance for all analyses was inferred at the $P < 0.05$ level. (SAS Institute Inc. 1987). To evaluate diet preference, the proportions of Orthoptera, Coleoptera, and other arthropods (all remaining orders pooled together) in Killdeer diets and the proportions of the same three categories of arthropods caught in the pitfall traps were compared using a Chi-square goodness-of-fit test with a Bonferroni 95% confidence interval (Ott 1988).

A total of 72 Killdeer were collected (59 adults [38 males, 21 females], 13 juveniles). A total of 1501 prey items were identified; 96% of these items were identified to the family level (Table 1). The mean wet weight for the adult gizzard contents was 0.679 g ± 0.062 SE and 0.643 g ± 0.143 SE for juveniles. There was no difference in the gizzard weight between age classes ($F = 0.06$, $P = 0.809$). There was also no difference in the number of different prey families taken by adults and juveniles ($F = 0.04$, $P = 0.849$). Males and females did not differ in their gizzard content weight ($F = 3.58$, $P = 0.06$) or in the number of families consumed ($F = 0.03$, $P = 0.863$). Coleoptera were the predominant prey taken

TABLE 1

DIET (MEAN NUMBER OF INDIVIDUALS PER GUT AND PERCENT OF TOTAL GUT CONTENTS) OF KILLDEER FROM NORTH DAKOTA[a] (THIS STUDY 1992) AND COLORADO (BALDWIN 1971)

Taxonomic group	$\bar{x}$ ± SE	Percent of total[b]	Baldwin (1971) percent of total
Acrididae (short-horn grasshoppers)	5.97 ± 0.77	25.6	0
Gryllidae (crickets)	0.01 ± 0.04	0.1	5.0
Carabidae (ground beetles)	8.40 ± 0.34	26.2	33.0
Tenebrionidae (darkling beetles)	2.71 ± 0.53	8.5	26.3
Curculionidae (weevils)	2.35 ± 0.71	7.1	8.3
Scarabaeidae (scarabs)	2.21 ± 0.31	6.8	7.8
Hydrophilidae (water scavengers)	0.43 ± 0.20	1.3	13.3
Chrysomelidae (leaf beetles)	0.36 ± 0.19	1.1	0.3
Histeridae (hister beetles)	0.23 ± 0.23	0.7	0.9
Melyridae (soft-winged flower beetles)	0.03	<0.1	0
Ptinidae (spider beetles)	0.01	<0.1	0
Unidentified coleoptera larvae	3.1 ± 0.34	9.7	0
Dermestidae (dermestid beetles)[c]	0.13	<0.1	0
Dytiscidae (predaceous diving beetles)[c]	0.04	<0.1	0.3
Syrphidae (rat-tail maggots)	0.77 ± 0.91	3.3	0
Sarcophagidae (flesh flies)[c]	0.43 ± 0.85	1.9	0
Ptychopteridae (phantom flies)[c]	0.40 ± 0.76	1.7	0
Muscidae (muscid flies)[c]	0.06	0.2	0
Stratiomyidae (soldier flies)[c]	0.01	<0.1	0
Asilidae (robber flies)[c]	0.01	<0.1	0
Bombyliidae (bee flies)[c]	0.01	<0.1	0
Tabanidae (deer flies)	0.01	<0.1	0
Lepidoptera larvae	0.11	0.5	1.5
Hemiptera (unidentified)	0.03	<0.1	0
Corixidae (water boatman)	0.01	<0.1	0
Notonectidae (back swimmers)	0.01	<0.1	0
Hymenoptera (unidentified)	0.0	0.0	0.3
Halictidae (Halictid bees)	0.03	<0.1	0
Formicidae (ants)	0.56 ± 0.32	2.4	1.4
Aphididae (aphids)	0.03	<0.1	0
Trichoptera (caddisflies)	0.17 ± 0.10	0.7	0
Acarina (mites)	0.04	<0.1	<0.1
Hirudinea (leeches)	0.01	<0.1	0
Mollusca	0.0	0.0	0.4
Gastropoda (snails)	0.08	0.4	0
Bivalvia (clams)	0.01	<0.1	0
Plant material (seeds)	—	0.2	0.3

[a] Pooled from individuals collected at all four sites (two treatment and two control sites).
[b] % of total from 1509 total prey items identified.
[c] Larvae.

by Killdeer, occurring in 100% of the gizzards and ranging from 4–19 individuals per gizzard. Major beetle families (>5% of diet) included, in order of occurrence, Carabidae, Tenebrionidae, Curculionidae, and Scarabaeidae. Other important arthropod groups included Orthoptera (Acrididae), Coleoptera larvae, and Diptera larvae. Orthoptera (Acrididae) occurred in 63% of the gizzards, and the number of Orthoptera found per gizzard ranged from zero to 14. Grit was found in only a few samples. One sample contained both glass and a piece of aluminum. Two chicks less than two-weeks-of-age also were collected and their mean gizzard content weight was 0.093 g. The majority of the Killdeer chick prey was weevils (Curculionidae) and small carabid beetles. No grasshoppers were consumed by the chicks.

The major difference between these results and Baldwin's (1971) findings (Table 1) is the importance of grasshoppers in the diet. No grasshoppers were taken by the Killdeer (N = 4) in the eastern Colorado study, whereas grasshoppers comprised 25.6% of the prey items identified in the North Dakota gizzards. These differences are probably due to differences in the habitats of the two study areas and in grasshopper availability. The Killdeer in North Dakota were collected from grasshopper outbreak areas with an average of 17 grasshoppers/m^2 pretreatment which declined to 2–3/m^2 posttreatment (Fair 1993). Bent (1929) reviewed published food habits of Killdeer and reported heavy use of grasshoppers when abundant. Another major difference between the two study areas was the abundance of Diptera larvae in the Killdeer diet. Diptera larvae in our study constituted 7.2% of the total Killdeer diet but were not consumed by the Colorado birds. Darkling beetles (Tenebrionidae) were important prey in both study areas (26.3% in Colorado; 8.5% in North Dakota). Conversely, water scavengers (Hydrophilidae) comprised 13.3% of the Colorado diet and only 1.3% of the North Dakota diet. A total of 16 arthropod families were identified in Colorado and 31 families in North Dakota. These taxa differences may be due to (1) a higher availability of aquatic habitat on the Colorado site and (2) differences in sample sizes between the two studies.

There was significant difference in the proportions of the three prey groups, Orthoptera, Coleoptera, and other arthropods in the diet of the Killdeer and the available arthropods caught in the pitfall traps ($\chi^2 = 6669$, $P < 0.001$). Orthoptera use fell within the Bonferroni 95% confidence interval for the expected proportion, Coleoptera was lower than the confidence interval, and other arthropods were above the interval. These results suggest the Killdeer exhibited a diet preference in this study. Preference, in this case, refers to a greater proportion of one of the three groups of prey used in a greater proportion of that group available on this study area. The major difference was the percentage of Coleoptera taken by the Killdeer (52%) which was greater than the percentage found in the pitfall traps (5%). The birds took Orthoptera in proportion to their availability. Due to the fact that both sampled locations were grasshopper outbreak areas and were selected for grasshopper control, Orthoptera can be considered an abundant resource. Hence, Killdeer were foraging opportunistically on a more available food resource.

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Unusual Marbled Murrelet nest.—Marbled Murrelets (*Brachyramphus marmoratus*) nest primarily in trees, except in treeless or nearly treeless areas of Alaska where they are known to nest on the ground (Mendenhall, Proc. West. Found. Vertebr. Zool. 5:5–16, 1992; Piatt and Ford, Condor 95:662–669, 1993). We observed a ground-level Marbled Murrelet nest in old-growth forest in July–August 1993. The nest was located in the Log Jam Creek drainage of northern Prince of Wales Island in southeastern Alaska (55°52′56″N, 132°57′53″W). Southeastern Alaska contains the greatest numbers of Marbled Murrelets in North America (Mendenhall 1992, Piatt and Ford 1993).

On 23 July, H. Lambert found a clifftop nest containing an egg. On 27 July this nest was occupied by an adult Marbled Murrelet incubating a single pipping egg. After approximately