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DIET OF PIPING PLOVERS ON THE MAGDALEN ISLANDS, QUEBEC

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ABSTRACT.—Piping Plover (*Charadrius melodus*) droppings were sampled at four sites on Magdalen Islands beaches, Quebec, in order to assess diet during the breeding season. Fragments of organisms found in feces were used to identify the various prey consumed. Staphylinidae (43.8%), Curculionidae (31.5%), and Diptera (31.5%) were the most commonly found invertebrates in the feces. The Piping Plover's consumption of different prey items appears to reflect their availability in the habitat. *Received 10 Aug. 1993, accepted 15 Dec. 1993.*

The Piping Plover (*Charadrius melodus*) has been on the list of endangered species in Canada since 1985 (Haig 1985). In the United States, it is considered endangered in the Great Lakes area and threatened elsewhere (U.S. Fish and Wildlife Service 1985). Previous studies of the Piping Plover have focused on its population, biology, and habitat quality, but knowledge of the Piping Plover's diet remains scanty. The Piping Plover's precarious status precludes taking individual specimens for diet assessment based on analysis of stomach contents. In any event, this method yields only a small number of samples (Bent 1929). Also the organisms on which this bird feeds are small, and identifying prey consumed by direct visual observation is difficult (Cairns 1977). Examination of the abundance and diversity of organisms present in the habitat allows inferences to be drawn regarding the prey likely to be in the Piping Plover's diet (Whyte 1985, Nordstrom 1990).

Fecal analysis offers an alternative to the usual techniques in determining diets of Piping Plovers. This technique has been used for the Dunlin (*Calidris alpina*), the Black-bellied Plover (*Pluvialis squatarola*) (Le V. Dit Durell and Kelly 1990), and for a small sample (24 droppings) of the Piping Plover (Nicholls 1989).

METHODS

In the summers of 1990–1992 130 droppings were collected at four sites on the Magdalen Islands, Quebec, Canada (47°24′N; 61°48′W): on the lagoon beaches of the West Dune and Hospital Beach, which are situated on the shore of the Havre aux Basques and Havre aux Maisons lagoons, respectively, and on the ocean beaches of the West Dune and South Dune. The birds were observed by telescope (22×) to determine when they defecated. The droppings were then collected and preserved in 70% alcohol. At other times, droppings were found by following the bird's tracks, easily recognizable in the sand. Since plover families

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TABLE 1
INVERTEBRATES FOUND IN DROPPINGS OF PIPING PLOVERS

Organisms	Frequency (%)			
	West Dune		Hospital Beach	South Dune
	Lagoon side N = 44	Ocean side N = 53	Lagoon side N = 18	Ocean side N = 15
Gastropoda	20.5	1.9	5.6	0.0
Amphipoda	2.3	28.3	<0.1	<0.1
Cicindelidae	4.5	5.7	0.0	6.7
Carabidae	0.0	1.9	5.6	0.0
Staphylinidae	54.5	17.0	77.8	66.7
Curculionidae	6.8	45.3	94.4	33.3
Coleoptera (larvae)	52.3	0.0	5.6	13.3
Coleoptera (spp.)	6.8	67.9	22.2	20.0
Diptera	25.0	41.5	22.2	26.7
Diptera (larvae)	29.5	0.0	0.0	0.0
Hymenoptera	0.0	1.9	0.0	0.0

do not forage far afield, we assumed that the invertebrates found in the droppings were from the same habitat as where they were collected. The contents of the feces were identified using a stereoscopic microscope. Invertebrate fragments were identified as accurately as possible by comparison with a reference collection of whole specimens gathered on the feeding sites.

In order to build this reference collection and evaluate prey availability on the beaches, 140 soil samples were taken. A cylinder capable of holding a sample of 362 cm^3 was inserted to a depth of 5 cm. The material retrieved was screened on the spot (mesh: 500 μm), and the organisms obtained were preserved in 70% alcohol for identification in the laboratory. The sampling was done at sites that support the feeding of families of Piping Plover. The samples were taken a short time after the young fledged to avoid disturbing families and to obtain invertebrates representative of those they consumed.

RESULTS

Among the organisms found in the Piping Plover's droppings, insects were well represented, especially four different families in the order Coleoptera (Table 1). The hard body of the beetle is very resistant to damage in the bird's digestive tract, making identification in the feces easy. Nonetheless, this list is incomplete. Soft-bodied organisms leave no identifiable parts in the droppings, which probably explains the absence of worms from this list. Certain invertebrate fragments also remained unidentifiable.

Staphylinidae (43.8%), Curculionidae (31.5%), and Diptera (31.5%) were the invertebrates most often found in the feces of the Piping Plover (Table 2). Significant differences were found between the prey consumed, depending on the site used. There were more Coleoptera larvae (χ^2 = 11.8, df = 1, $P \leq 0.001$) and Diptera larvae (χ^2 = 6.7, df = 1, $P \leq$

TABLE 2
COMPARISON OF INVERTEBRATES FOUND IN DROPPINGS AND SOIL ON FEEDING GROUNDS OF THE PIPING PLOVER

Organisms	Frequency (%)	
	Feces N = 130	Soil N = 140
Gastropoda	8.5	4.2
Oligochaeta	0.0	5.7
Amphipoda	16.9	2.1
Collembola	0.0	2.1
Cicindelidae	4.6	0.0
Carabidae	1.5	0.0
Staphylinidae	43.8	37.1
Curculionidae	31.5	0.0
Coleoptera (larvae)	20.0	42.1
Coleoptera (spp.)	35.4	0.0
Trichoptera (larvae)	0.0	1.4
Diptera	31.5	0.7
Diptera (larvae)	10.0	20.0
Hymenoptera	0.8	0.7

0.001) in the feces found on the lagoon beaches of the West Dune than at Hospital Beach. Conversely, Curculionidae were more abundant in the feces gathered from Hospital Beach ($\chi^2 = 44.9$; df = 1, $P \leq 0.001$). This difference illustrates the diversity of organisms found in the lagoons of Havre aux Basques and Havre aux Maisons. A comparison of the organisms found in the droppings collected on the ocean beaches of the West Dune and the South Dune revealed that there were more Staphylinidae in the feces found at the South Dune ($\chi^2 = 14.3$, df = 1, $P \leq 0.001$). The differences between the other organisms either were insignificant or the samples were too small to apply a statistical test.

For the West Dune, we compared samples taken from the ocean side and the lagoon side of the same dune and found a significant difference between the frequency of Staphylinidae ($\chi^2 = 15.1$, df = 1, $P \leq 0.001$), Coleoptera larvae ($\chi^2 = 36.3$, df = 1, $P \leq 0.001$) and Diptera larvae ($\chi^2 = 18.1$, df = 1, $P \leq 0.001$) present in the feces collected from the lagoon side. In the feces from the ocean side of this dune, Amphipoda ($\chi^2 = 11.8$, df = 1, $P \leq 0.001$) and Curculionidae ($\chi^2 = 17.7$, df = 1, $P \leq 0.001$) were found most frequently.

Abundance of most prey items cannot be determined precisely by fecal analyses. An estimate of the quantities ingested is possible for some hard-bodied organisms. Elytra of Staphylinidae remain intact in

the feces, for example, and can be counted. The same is true for heads of Curculionidae and Coleoptera larvae. Counts based on droppings collected in 1992 (N = 60) revealed that an average of 14.9 Staphylinidae was present in each fecal sample. Staphylinidae were not only frequent in the droppings but also abundant in the diet. The Piping Plover eats relatively smaller quantities of Coleoptera larvae and Curculionidae since the average number of these specimens was 2.8 and 1.7 per sample, respectively.

Contents of 25 droppings from nestlings between 13 and 18 days of age included Staphylinidae (64%), Diptera (36%), and Curculionidae (32%). Nestlings also ate Coleoptera larvae (28%), Gastropoda (16%), Diptera larvae (12%), and Amphipoda (8%). Due to the small number of fecal samples of adult origin (N = 7), it was difficult to compare the diets of the young birds and adults.

Comparison of the frequency of prey in the droppings with the frequency of invertebrates present in the soil samples gives a picture of the Piping Plover's prey selection (Table 2). Oligochaeta and the larvae of Diptera and Coleoptera were more frequent in the soil samples than in the feces. On the other hand, Coleoptera, Amphipoda, Diptera, and Hymenoptera were most common in the fecal samples. These invertebrates, in contrast to the preceding group, inhabit the beach surface and thus are easier for the plover to find. Two biases should be kept in mind when analyzing this table. First, soft-bodied prey, such as Oligochaeta, which have a high degree of digestibility (Swanson and Bartonek 1970), leave no easily identifiable traces, which leads to an underestimation of the frequency of these organisms in the feces. Second, the technique used for taking soil samples does not permit adequate sampling of the most mobile organisms.

DISCUSSION

Use of feces as a method for analyzing diet of the Piping Plover gives a qualitative determination of the list of organisms collected in the habitat and, for several prey items, a quantitative analysis. Despite the difficulties in identifying certain invertebrate fragments and finding traces of soft-bodied invertebrates, fecal analyses made it possible to establish the presence of Gastropoda, Amphipoda, Coleoptera (Cicindelidae, Carabidae, Staphylinidae, Curculionidae), Diptera, and Hymenoptera in the Piping Plover's diet. Staphylinidae are an important group of organisms in this diet. These insects are specially adapted for life in a marine habitat; the adults and larvae can survive a long time buried in the sand when salt water covers the beach. When the water recedes, they come

out to feed on diatoms (Griffiths and Griffiths 1983). They are thus most often found on the lagoon side where the sand is more exposed.

There is no reason to believe that the diet of the young differs from that of the adults since they feed in the same way at the same sites. It is possible, however, that nestlings only a few days old are unable to capture the faster-moving insects such as Diptera or Cicindelidae.

The absence of marine worms from feces in this study may be because our technique is ineffective in identifying soft-bodied organisms. However, marine worms are scarce in the Magdalen Islands. Only 5.7% of the 140 soil samples taken contained worms. Oligochaeta found were also very small and probably are not eaten by the plover. Doyon and McNeil (1978) analyzed the stomach contents of 159 birds of the family Scolopacidae in Havre aux Basques and found only a single Oligochaeta despite the abundance of this worm in the soil samples they collected from the feeding grounds.

Unlike other shorebird species, the Piping Plover is a surface feeder. Organisms found in the droppings are principally adult organisms living at the beach surface, which suggest that the Piping Plover finds its prey by sight. The movement and size of these organisms probably attract the bird's attention, leading to their capture. Prey buried in the ground are less visible to the plover and are eaten only occasionally or when the bird taps the ground with its foot to make the organism come out on the surface (Cairns 1977).

The Piping Plover requires feeding grounds rich in surface invertebrates. There is some evidence to suggest that motor vehicle traffic on beaches reduces the abundance of available invertebrates (Wheeler 1979). This factor also decreases the feeding time, which reduces the productivity of Piping Plover pairs (Flemming et al. 1988).

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