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FOOD OF NESTLING NORTHWESTERN CROWS

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ABSTRACT.—Northwestern Crows (*Corvus caurinus*) are typically associated with intertidal beaches where they search for food. In this study I examined the diet fed to nestling crows to determine the importance of intertidal beaches as a food source on Mitlenatch Island, B.C. The diet consisted of marine and terrestrial invertebrates and vertebrates, and fruit. Lepidoptera, Mollusca, Crustacea and Pisces were the most important taxa in terms of total dry weight fed to nestlings. During low tide, when crows have a choice of feeding intertidally or on land, 67% of the diet in terms of dry weight came from terrestrial sources. *Received 15 Oct. 1997, accepted 30 July 1998.*

Northwestern Crows (*Corvus caurinus*) typically occur near tidal shores along the coast of northwestern North America (Godfrey 1966). Like other species in the genus (Kalmbach 1939; Lockie 1955, 1956; Tenovuo 1963; Houston 1977; Hogstedt 1980), adult Northwestern Crows eat a variety of food (Butler 1974). Northwestern Crows feed in the intertidal zone during low tides, eat stored food, or search other habitats during high tides (Butler 1974, 1980; James and Verbeek 1983). Butler (1980) reported on the diet fed to the young in four nests near intertidal beaches. The objectives of this study were to determine the diet of nestling Northwestern Crows on Mitlenatch Island from a larger sample of nests located throughout the island than was available to Butler (1980), and to what extent nestling diet depends on intertidal, marine food.

STUDY AREA AND METHODS

Northwestern Crows were studied on Mitlenatch Island, Strait of Georgia, British Columbia, from 14 May–3 July 1983. The vegetation on the island consisted of patches of shrubs and trees interspersed with meadows (Brooke et al. 1983). Two extensive intertidal beaches provided access to marine invertebrates. The island was used as a nesting site by several marine birds, with the eggs, chicks and fish dropped by Glaucous-winged Gulls (*Larus glaucescens,* 2100 pairs; Campbell et al. 1990) and Pelagic Cormorants (*Phalacrocorax pelagicus,* 315 pairs; Campbell 1990) serving as important food sources for the crows. Nestling food was obtained by encircling the necks of each nestling in a nest with a loop of pipe cleaner to prevent them from swallowing the items. The pipe cleaners were left on for 45 min. This method had no apparent detrimental effect on the nestlings. Fledging success (% fledged of eggs hatched) of collared young in this study was 59%, compared to 37–67% reported earlier (Richardson et al. 1985). I returned to the nest after the parents had made 1–4 (exact number unknown, but see Butler 1980, James and Verbeek 1984) food deliveries to the young. I collected the food from all the young in a nest at that time, put it in a vial with 70% alcohol and treated it as one sample. In total, 388 samples were collected from 58 young in 22 nests located throughout the island, representing about a third of the crow nests on the island. For each food sample I noted whether the intertidal areas around the island were available to the crows (low tide, 279 samples) or not (109 samples). The samples were collected throughout the day, but as low tides in Georgia Strait tend to occur during the day in summer, low-tide samples predominated. Following identification, specimens belonging to the same taxon were lumped together, oven dried for 48 h at 70° C, and weighed. The average age of the young was 13.7 d (SD = 5.0, range 2–26, n = 388).

RESULTS

Marine food.—Polychaete worms were represented mostly by short pieces; the remainder of the worms having been left behind in the tubes among the intertidal boulders. Small decapods (ca 1.5 cm) were fed whole but larger ones were dismembered and legs and body parts fed as separate items. Intertidal Isopoda, represented by the genus *Ligia,* were fed whole. Among the Mollusca, chitons (Amphineura) were fed whole, but clams (Pelecipoda) were removed from the shell and fed in pieces. Fish (species not identified) were found in many samples. The crows caught some stranded fish in tide pools or when they were uncovered hiding among marine algae at or near the tide line. These fish were fed whole when small or in pieces when large. At least 90% of the fish flesh, based on my experience of 7 years of daily visits to about 300 gull nests (Verbeek, 1984, 1986, 1988) and countless hours of watching crows feeding in

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the interidal (Verbeek 1998), was regurgitated by the gulls in the colony. It was recognizable as regurgitated fish because the flesh had mostly disintegrated following partial digestion by the gulls.

Terrestrial food.—Most terrestrial food consisted of invertebrates with some families important in number (Table 1). Terrestrial Isopoda (sow bugs) were represented by the genus *Porcelio.* The smallest invertebrates taken were froghoppers (Cercopidae, Homoptera), some as small as 4 mm. Among moths (Lepidoptera), lasiocampids (tent caterpillars) and tortricids (leaf rollers) predominated. Lasiocampids occurred mainly as pupae (97.7%, the remainder being adults) found among ground vegetation, while the tortricids were mainly larvae (96.9%). Craneflies (Tipulidae, Diptera) were represented as adults. One food sample contained 200 similar cycloraphid (Diptera) pupae that I could not identify to family, hence the large number of unknowns. Most Hymenoptera were carpenter ants (*Camponotus* sp., Formicidae) caught in the air during their nuptial flights, found dead on the tide line, or found alive on land. Many spiders (Araneida) were taken, particularly three families (crab spiders, Thomisidae and Philodromidae; and jumping spiders, Salticidae). These are generally mobile, grassland species that pursue their prey and thus draw attention to themselves. The crows also took many harvestmen (Phalangida), some with bodies as small as 4 mm.

Vertebrates fed to nestlings other than fish regurgitated by gulls, included pieces of coast garter snake (*Thamnophis elegans*). The longest snake I saw killed by crows was 79 cm. I also found the front half of a pacific treefrog (*Hyla regilla*), pieces of deer mouse (*Peromyscus maniculatus*), a piece of a nestling Song Sparrow (*Melospiza melodia*), and pieces of what I presumed were gull embryos and chicks. Fruits fed to the young consisted of 3 western service berries (*Amelanchier alnifolia*) and 50 trailing blackberries (*Rubus ursinus*). Only one food sample contained a piece of grit.

Relative importance of taxa.—Lepidoptera, Diptera and Araneida predominated in terms of total numbers encountered in the food samples (Table 2). Because several taxa (Decapoda, Mollusca, Pisces, Aves) in Table 2 are represented by pieces, rather than whole animals, I could not present the data in terms of percentage composition by number of individuals. In terms of percent occurrence, seven taxa were represented in more than 25% of the samples. This included the three taxa mentioned, Coleoptera, and three marine taxa, Mollusca, Crustacea, and Pisces. Analysis by dry weight showed that the bulk of the diet consisted of Lepidoptera (mostly *Malacosoma* spp.), Mollusca (mostly bivalves), Pisces, and Crustacea (mostly crabs, Table 2).

Source of food.—Although Northwestern Crows feed intertidally when possible (Butler 1974, 1980; Richardson 1983; James and Verbeek 1983), they took fewer (n = 399) intertidal organisms (fish excluded) to their nestlings than terrestrial items (n = 2723, fish excluded) during low tide. In terms of total dry weight (fish included, assuming that 90% of the fish fed during low tide came from the bird colonies), 67% (74.8 g dry weight) of the nestling diet came from terrestrial sources and 33% (36.8 g) from the intertidal during low tides. The number of samples with or without fish did not differ significantly between low tide (83 samples with, 196 without) and high tide (29, 80, respectively; G test: G = 0.178, $P > 0.05$). Fish was available to the crows at all times, regardless of the tides, because most fish was obtained in the gull colony. As expected, significantly (G test: G = 16.74, $P < 0.001$) more samples contained intertidal food other than fish during low tide (140 samples with, 139 without) than during high tide (30, 79, respectively). Thus, marine food other than fish continued to be fed to the nestlings even during high tide.

DISCUSSION

The nestling diet is diverse and includes both terrestrial and marine organisms (Table 1). The pipe cleaner method I used to obtain food samples has one drawback in that it does not catch soft material, such as egg yolk (Butler 1974, 1980). On the other hand, even tiny, soft-bodied insects are readily trapped in the tangle of legs of larger insects and saliva. Although marine organisms (fish excluded) are available to the crows only during low tide, some of them are cached (Butler 1980, Verbeek 1997), particularly clams (James and Verbeek 1983). Subsequent retrieval of cached items enables crows to continue to feed ma-

TABLE 1. Number of food items (n = 4877) belonging to various taxa, in the nestling diet of Northwestern Crows on Mitlenatch Island, B.C.

Taxon	n
Fruit	53
Annelida (worms)	20
Crustacea (crabs, etc.)	
Decapoda	234
Isopoda	64
Amphipoda	20
Myriapoda (centipedes, etc.)	
Diplopoda	5
Chilopoda	1
Insects	
Orthoptera (grasshoppers)	
Acrididae	56
Trichoptera (caddisflies)	
Limnephilidae	1
Dermaptera (earwigs)	
Labiduridae	21
Forficulidae	15
Unknown	1
Mallophaga (feather lice)	3
Hemiptera (bugs)	
Scutelleridae	106
Corizidae	10
Pyrrhocoridae	5
Pentatomidae	5
Saldidae	2
Unknown	6
Homoptera (leafhoppers)	
Cercopidae	245
Cicadellidae	11
Aphididae	5
Unknown	1
Coleoptera (beetles)	
Elateridae	100
Cleridae	25
Curculionidae	22
Carabidae	13
Scarabaeidae	12
Dytiscidae	7
Unknown	10
Lepidoptera (moths, etc.)	
Lasiocampidae	715
Tortricidae	430
Noctuidae	99
Geometridae	17
Gracilariidae	17
Pyralidae	7
Unknown	23
Diptera (flies)	
Tipulidae	377
Culicidae	111
Otitidae	62
Chironomidae	50
Bibionidae	26
Heleomyzidae	31
Dolichopodidae	12
Empididae	8
Anisopodidae	6
Tachinidae	4
Syrphidae	3
Coelopidae	3
Anthomyiidae	2
Dryomyzidae	2
Muscidae	2
Tabanidae	2
Unknown	260
Hymenoptera (ants, wasps, etc.)	
Formicidae	198
Andrenidae	32
Ichneumonidae	13
Tenthredinidae	10
Tiphiidae	2
Vespidae	1
Araneida (spiders)	
Thomisidae	239
Philodromidae	223
Salticidae	185
Clubionidae	41
Lycosidae	36
Anyphaenidae	7
Gnaphosidae	7
Tetragnathidae	7
Araneidae	6
Theridiidae	3
Unknown	21
Phalangida (harvestmen)	207
Mollusca (molluscs)	
Pelecypoda	125
Gasteropoda	15
Amphineura	8
Echinodermata (seastars, etc.)	1
Vertebrates	
Pisces	96
Aves	25
Reptilia	13
Mammalia	7
Amphibia	1

TABLE 2. Total number (n = 4877) of food items found in the diet of Northwestern Crow nestlings on Mitlenatch Island, B.C. and number of samples (n = 388) in which they occurred, and total dry weight.

Taxon	Number encountered	Number of samples[a] in which they occurred		Dry weight (g)	
		n	%	Total	%
Fruit	53	33	8.5	5.16	3.2
Annelida	20	19	4.9	3.32	2.1
Crustacea	318	106	27.3	21.84	13.7
Myriapoda	6	3	0.8	0.04	trace
Orthoptera	56	45	11.6	0.78	0.5
Trichoptera	1	1	0.2	trace	trace
Dermaptera	37	21	5.4	0.90	0.6
Mallophaga	3	3	0.8	trace	trace
Hemiptera	134	56	14.4	1.40	0.9
Homoptera	262	60	15.5	0.52	0.3
Coleoptera	189	99	26.4	2.36	1.5
Lepidoptera	1308	196	50.5	50.07	31.4
Diptera	961	136	35.1	4.97	3.1
Hymenoptera	256	68	17.5	5.68	3.6
Araneida	775	181	46.6	4.81	3.0
Phalangida	207	64	16.5	0.51	0.3
Mollusca	148	99	25.5	22.51	14.1
Echinodermata	1	1	0.3	0.63	0.4
Pisces	96	111	28.6	25.91	16.2
Other Vertebrata	46	21	5.4	8.25	15.2

[a] Sample as defined in Methods.

rine food to their young during high tide. Northwestern Crows obtain some terrestrial food in shrubs and trees, but most food is found on the ground. Lepidoptera, mostly pupae of *Malacosoma* sp., were the most numerous, representing more than 35% of total dry weight (Table 2). The crows probably avoided *Malacosoma* caterpillars because they were hairy; they did eat noctuid, geometrid and tortricid caterpillars, all of which were non-hairy. In other dietary studies of nestling *Corvus* (Lockie 1956, Yom-Tov 1975, Houston 1977), earthworms (Lumbricidae) formed part of the diet. Mitlenatch Island has no earthworms, hence their absence in the diet. In Vancouver, B.C., adult Northwestern Crows do eat earthworms (pers. obs.). In contrast to Carrion Crows (*Corvus corone*; Yom-Tov 1975), Northwestern Crows took only adult craneflies. The pacific treefrog in the diet was unexpected as no amphibians occurred on the island. The frog was most likely caught on nearby (ca 6 km) Hernando Island, to which crows flew regularly. Nesting passerines are uncommon on the island (Verbeek, 1998), which explains why I found only one nestling in the diet.

Mitlenatch Island provides three sources of food for crows: intertidal areas; meadows, shrubs, and trees; and the colonies of nesting seabirds. The crows regularly fed among nesting seabirds, where they obtained regurgitated food (mostly fish), eggs, and chicks (Butler 1980, Verbeek 1982, Butler et al. 1984, Verbeek 1988). Dead gull and cormorant chicks and regurgitated fish attracted invertebrates to the seabird colonies, and crows likely took some of these as well, but I do not know how many or which ones. Some fish was also obtained intertidally (e.g., *Clinocottus acuticeps, Liparis florae, Anoplarchus purpurescens*; Butler 1980). Terrestrial invertebrates came from areas other than the seabird colonies as well. Thus, it is not possible to apportion much of the food fed to the nestlings during low tide to any one of the three specific sources. Considering only items in food samples fed during low tide, when the crows had a choice of feeding intertidally or elsewhere, marine food (intertidal invertebrates and fish, and all pelagic fish caught by the gulls) comprised 51% of total dry weight, and terrestrial invertebrates, vertebrates (minus fish), and fruit 49%, or 1132 and 1211 kJ, respectively,

using caloric values in Cummins and Wuycheck (1971), and Johnson and coworkers (1985). If I subtract 90% of the fish from the marine food and add it to the terrestrial food, then intertidal food represented 33% of total dry weight (704 kJ), versus 67% for food derived from all terrestrial sources (1693 kJ). Intertidal beaches are thus less important as a food source for nestling crows during low tide on Mitlenatch Island than I had expected. This does not mean that the intertidal beaches are unimportant to Northwestern Crows. As stated elsewhere (Butler 1980, James and Verbeek 1984), the intertidal areas are particularly important early in the nesting season. As the season progresses, the crows gradually de-emphasize their use of beaches in favor of grasslands as more and more invertebrates become available on land (Butler 1980). By the time the grasslands begin to dry out in early June and invertebrate abundance declines, the crows begin to spend more time in the bird colonies. Although there is an obvious influx in the tidal component of the diet during low tide, adults may find it energetically worthwhile to take abundant terrestrial food near the nest, regardless of the state of the tides. By foraging near the nest they may save time and energy otherwise expended in flight to more distant tidal sources and they can stay closer to the nest to protect its contents (Butler 1980). This is particularly important because the mean internest distance of the crows is small (Butler et al. 1984).

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