DIET OF THE WESTERN SCREECH-OWL IN SOUTHEAST ALASKA

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ABSTRACT: We studied the diet of the Western Screech-Owl (*Megascops kennicottii*) at the northern edge of its range, in southeast Alaska. To describe the diet in the breeding season we collected pellets from beneath roost trees or nest cavities of 10 radio-marked owls, their mates, and their young. Mammals (found in 46 of 48 groups of pellets, 98%) and invertebrates (81%) were the most frequently taken prey, birds (23%) the least. We tallied 115 mammalian and 25 invertebrate prey items (all insects). Mammalian prey was either rodents (Cricetidae) or shrews. To eliminate bias associated with pellet analysis and to describe the diet during the nonbreeding season, we analyzed stomach contents of 15 owl carcasses salvaged from September to February. Insects (47 of 57 prey items; 82%), particularly beetles and caterpillars dominated the contents of these stomachs numerically; mammals constituted only 5 of 57 items (9%). Thus in southeast Alaska Western Screech-Owls feed to a large extent on small mammals, primarily deer mice (*Peromyscus*), and supplement that diet with insects, especially in the winter.

The Western Screech-Owl (*Megascops kennicottii*) is well distributed across western North America (Johnsgard 2002, Duncan 2003), in many parts of which it is associated primarily with riparian habitats. In the Pacific Northwest, habitat loss in productive riparian areas and predation by the recently arrived Barred Owl (*Strix varia*) have raised concern for the status of this species (Elliott 2004), prompting listing of two subspecies, *M. k. kennicottii* and *M. k. macfarlanei*, as of special concern and endangered, respectively, in British Columbia (Cannings and Angell 2001, COSEWIC 2002). Despite recent conservation concerns and the species' wide distribution, little information on its diet is available (Cannings and Angell 2001, COSEWIC 2002).

Knowledge of a bird's diet is fundamental to an understanding of its ecology (Marti et al. 2007). Because lack of sufficient prey is a primary factor limiting growth of populations of birds of prey (Newton 1979, 1998), an understanding of diet can only improve efforts at management and conservation, as it has for the Northern Goshawk (*Accipiter gentilis*; Reynolds et al. 1992). Across the Western Screech-Owl's range, its diet comprises primarily small mammals, birds, worms, insects, and crayfish (Cannings and Angell 2001). In general, southern populations consume more invertebrates than do northern populations, which feed primarily on small mammals, supplementing the summer diet with insects (Hayward and Garton 1988, Cannings and Angell 2001, Davis and Cannings 2008). There is little specific information on the Western Screech-Owl's diet in the northern coastal forests, where

the diversity of mammalian prey is more limited than in other parts of its range (MacDonald and Cook 2007).

We sampled the diet of the Western Screech-Owl at the northern edge of the species' range, in southeast Alaska, by analysis of both pellets and stomach contents. Our objective was to identify and quantify the prey taken in both the breeding (March–August) and nonbreeding (September–February) seasons.

METHODS

Study Area

We analyzed pellets collected near Petersburg on Mitkof Island (56° 48′ N, 132° 56′ W), in southeast Alaska, a sparsely populated region characterized by steep, rugged topography, coastal fjords, and large tracts of temperate rainforest. Mitkof Island is 545 km^2 in size and ranges up to 1011 m in elevation. The island is naturally fragmented by mountainous terrain, wetlands, and various fine-scale disturbances such as wind-throw. Its forest is dominated by western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*), the understory by blueberry (*Vaccinium* spp.), devil's club (*Oplopanax horridus*), and salmonberry (*Rubus* spp.). Commercial logging has entailed extensive clearcutting on some parts of the island. Mitkof Island has a cool, wet maritime climate with average annual precipitation of 288 cm evenly distributed throughout the year (National Weather Service, Alaska Climate Database, http://pajk.arh.noaa.gov/cliMap/akClimate.php).

Data Collection

Using mist nets with an audio lure and a mouse as a decoy (Lewis and Kissling 2009), we captured 10 Western Screech-Owls and attached backpack-mounted radio transmitters (model TW-4, Biotrack, Ltd) with Teflon ribbon to three females and seven males. To describe their habitat use and nesting areas, we located these radio-marked birds at roost and nest sites approximately twice a week from March to May in 2005 and 2006 (Kissling and Lewis 2009). To study the breeding-season diet, we collected pellets (we found no prey remains) from beneath roost trees or nest cavities of the radio-marked birds, their mates, or their young from 26 April to 21 September. Pellets were filed in envelopes labeled with date, time, location, and the individual owl's identity. We also recorded whether the pellet was found alone or in a cluster with other pellets. We dried, weighed, and dissected pellets in the laboratory, separating mammalian, avian, and invertebrate contents. We then identified items to the lowest possible taxon—mammals by dentition and skull characteristics (MacDonald and Cook 2006) and invertebrates by consultation with experts and collections (P. Atkins, U.S. Forest Service, Forestry Sciences Laboratory, Juneau). We were unable to identify birds to species or higher category because of the degradation and fragmentation of feathers and bones in the pellets. To eliminate some biases associated with pellet data (Lewis et al. 2004), we also obtained information from specimens at the University of Alaska Museum of the North, Fairbanks (UAM), where only three of 19 specimens included information on stomach contents: a

pair of adults (UAM 4180, 4181) collected in April 1982 near Sitka and a juvenile (UAM 20146) collected in August 2004 at Juneau.

To describe the diet in the nonbreeding season, we obtained 15 carcasses of Western Screech-Owls (eight adult and seven juvenile) found dead as a result of collisions with vehicles or windows in southeast Alaska from September to February, 2000–2007. We sexed the specimens and examined their stomach contents. Three of the stomachs were empty. Although we were able to assemble only 12 useful specimens, these data offer the only information about the species' diet in southeast Alaska in the nonbreeding season.

Data Analysis

To avoid counting more than once a single prey item regurgitated in multiple pellets, we analyzed pellets collected at the same time and location as a group. We estimated the biomass of small mammals only, using the midpoint of the range of the species' mass (MacDonald and Cook 2006). In estimating biomass, we considered all unidentified shrews to have the same mass as *Sorex cinereus*, the commonest shrew in southeast Alaska (MacDonald and Cook 2007) and the only one we positively identified. We assumed the proportions of unidentified rodents in our pellet samples were the same as those of the identified rodents (88% mice [*Peromyscus*] and 12% voles [*Microtus*] or lemmings [*Synaptomys*]) and used a weighted average value of 32.0 g for the mass of rodents (MacDonald and Cook 2006). We did not include unidentified mammals in the estimation of frequency or biomass because we were unable to approximate their mass reliably.

RESULTS

Pellet Analysis

We collected 125 pellets in 48 groups, with 1–13 groups per owl (mean 5; standard deviation 4). The total mass of the pellets was 90.3 g, mean 0.72 g), comprising mammalian (84.5 g; 94% by weight), invertebrate (3.1 g; 3%), and avian remains (2.7 g; 3%; Table 1). By group of pellets, mammals were most frequent (98%; $n = 46$), invertebrates were less so (81%; $n = 39$), and birds were least frequent (23%; $n = 11$; Table 1).

We tallied at least 115 mammalian prey items in the pellets. Of these, we could not further identify 5; the remaining 110 represented either shrews (Soricidae; $n = 38$) or rodents (Cricetidae; $n = 72$; Table 2). We identified 65 of the mammalian items to one of five species: cinereous shrew ($n = 3$), northern bog lemming (*Synaptomys borealis*; $n = 2$), meadow vole (*Microtus pennsylvanicus*; $n = 5$), long-tailed vole (*M. longicaudus*; $n = 1$), and Keen's deer mouse (*Peromyscus keeni*; $n = 60$; Table 2).

Two pellets were composed primarily of bird remains, but nine additional pellets had traces of feathers, possibly from the owl itself. We were unable to identify the birds to species or species group, but, given the density of the feathers and bones in the pellet, we are confident that at least two species of birds were depredated.

We identified 25 invertebrate prey items (all insects) to four families in the orders Coleoptera (84%) and Hemiptera (16%; Table 3). Coleopteran

Table 1 Contents (n = 125) by Mass and Frequency of Occurrence in Pellets Collected at Roost and Nest Sites of the Western Screech-Owl, Southeast Alaska, 2005–2006

	Mass		Frequency of occurrence[a]	
Type of prey	Total (g)	%	n	%
Mammalian	84.5	94	46	98
Avian	2.7	3	11	23
Invertebrate	3.1	3	39	81

[a]By group of pellets found together (n = 48).

remains belonged to the Carabidae (n = 5), Dytiscidae (n = 5), and Curculionidae (n = 6); the only Hemipteran family represented was the Belostomatidae (n = 4; Table 3).

Carcass Analysis

In the 15 Western Screech-Owl carcasses, mammals (5 of 57 prey items; 9%) did not constitute a large portion of the stomach contents; insects (47 of 57 prey items; 82%) dominated the prey of both adults and juveniles (Table 4) in both the nonbreeding and breeding seasons (Figure 1). Caterpillars (67%) constituted a large portion of the stomach contents from the carcasses, particularly of adults (Table 4). We found no mammals in adults' stomachs, but 5 of the 7 juvenile birds (71%) had mammal hair or bones in their stom-

Table 2 Frequency of Occurrence and Proportion of Biomass of Small Mammals in Pellets Regurgitated by Western Screech-Owls, Southeast Alaska, 2005–2006[a]

Prey	Minimum number	Frequency (%)	Total biomass (g)	Biomass (%)
Soricidae				
Sorex cinereus, cinereous shrew	3	3	11.4	0.5
Unidentified shrew	35	32	133.0	5.5
Cricetidae				
Synaptomys borealis, northern bog lemming	2	2	60.8	2.5
Microtus pennsylvanicus, meadow vole	5	4	177.5	7.3
Microtus longicaudus, long-tailed vole	1	1	45.0	1.9
Unidentified rodent	4	4	128.0	5.3
Peromyscus keeni, Keen's deer mouse	60	54	1860.0	77.0

[a]Unidentified mammals (n = 5) excluded.

Table 3 Minimum Number of Insects Found in Pellets Regurgitated by Western Screech-Owls, Southeast Alaska, 2005–2006

Prey	Description	*n*
Coleoptera		
Unidentified	beetles	5
Carabidae		
Unidentified	ground beetle	2
Pterostichus sp.	woodland ground beetle	3
Dytiscidae: *Dytiscus* sp.	predaceous diving beetle	5
Curculionidae		
Unidentified	snout and bark beetle	4
Hylobius sp.	snout and bark beetle	2
Hemiptera		
Belostomatidae:		
Lethocerus americanus	Giant Water Bug	4

achs (Table 4). Soft-bodied invertebrates other than beetles identified in the stomachs included worms and spiders (Table 4), both of which were limited to specimens recovered in the nonbreeding season (Figure 1).

DISCUSSION

Collection and analysis of pellets is an indirect method of studying birds' diet, but the method allows a large sample to be collected with little disturbance to the birds (Lewis et al. 2004, Marti et al. 2007). Owls typically swallow their prey whole, and highly acidic gastric juices assist in digestion (Duke et al. 1975). Undigested bones and fur and feathers are cast into a pellet that is regurgitated, so pellet analysis is biased toward prey that are not fully or easily digested. Mammals, in particular, are overestimated and

Table 4 Identification and Minimum Number of Prey Items Identified in Stomachs of Carcasses Found Dead (n = 12) and Specimens (n = 3) of the Western Screech-Owl, Southeast Alaska, 1982–2007

	Juvenile (n = 7)	Adult (n = 8)
Prey	n	n
Mammalia	4	
Unidentfied		
Sorex sp. (shrew)	1	
Insecta	4	
Coleoptera: unidentified		2
Coleoptera: *Pterostichus melanarius*.	3	
Lepidoptera: unidentified caterpillar	4	24
Lepidoptera: Noctuidae (caterpillar)		10
Arachnida: Linyphiidae (spider)	2	
Oligochaeta: Lumbricidae (earthworm)		3

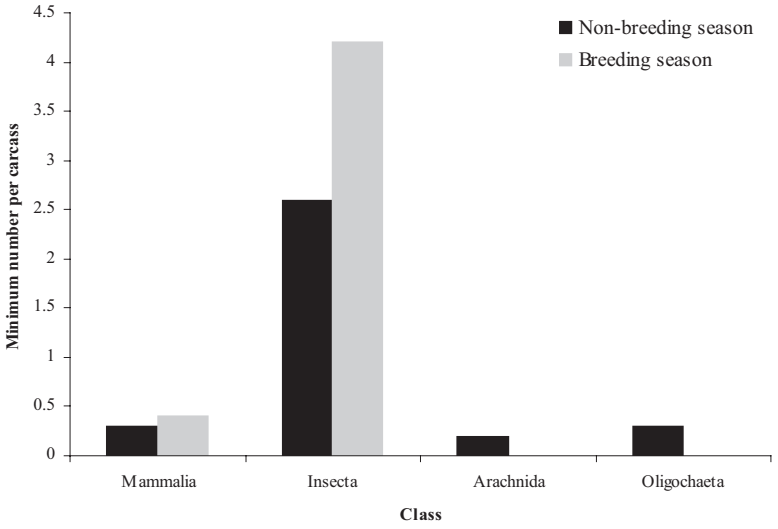

Figure 1. Minimum number per carcass of prey items by class identified in stomachs of carcasses and specimens of the Western Screech-Owl in the nonbreeding (September–February; n = 10) and breeding (March–August; n = 5) seasons in southeast Alaska, 1982–2007.

soft-bodied prey (e.g., earthworms) underestimated when a diet is described from pellets (Lewis et al. 2004).

In Alaska, on the basis of our analysis of regurgitated pellets, the Western Screech-Owl consumes primarily small mammals during the breeding season. Keen's deer mouse, one of the most common and widely distributed mammals in southeast Alaska (MacDonald and Cook 2007), dominates the diet at this season. Although invertebrate remains contributed very little to the pellets' total mass, they occurred in nearly all groups of pellets. All invertebrates in pellets were insects and nearly all were beetles (Coleoptera), the hardened forewings (elytra) of which often persisted and allowed identification of beetle remains. It is likely that other soft-bodied invertebrates were digested without leaving evidence in pellets. Invertebrates are notoriously difficult to detect with an indirect technique like pellet analysis, and the diets of known insectivores, such as the Flammulated Owl (*Otus flammeolus*), are not studied by pellet analysis (McCallum 1994). Thus, by this method, it is difficult to assess the importance of invertebrate prey to the Western Screech-Owl in southeast Alaska. Because both insects and mammals were consistently represented in the pellets, we conclude that, during the breeding season, these owls feed on small mammals, primarily deer mice, but supplement their diet with numerous invertebrates, which were probably underestimated in our analysis. Avian remains were insignificant in the diet.

We intended carcass analysis to provide information about diet without the bias associated with pellet analysis (Lewis et al. 2004). Yet, except for the

two specimens from Sitka, the carcasses were of birds found dead, so they may not be an unbiased sample, possibly composed of birds predisposed to mortality, as from starvation. Because Keen's deer mouse and the other mammalian prey species are active in southeast Alaska year round, we were surprised that few owl stomachs contained mammalian remains. Western Screech-Owls regurgitate a large pellet about 4 hours after consuming a small mammal, then usually produce a second pellet about 1/3 of the size of the first 1 hour later; after the second pellet is cast, the bird is ready to begin hunting and feeding again (Cannings and Angell 2001). Therefore, analysis of stomach contents might be positively biased toward invertebrates, in terms of frequency of occurrence, because an owl cannot cast a pellet without a large amount of undigested material (e.g., mammalian remains) in the stomach. In other words, to cast a pellet, an owl would need to consume many invertebrates but only one small mammal. Regardless, the carcass analysis provided information on soft-bodied invertebrates, especially insects, which appear to constitute an important part of the Western Screech-Owl's diet year round. Although our sample is small, we found a greater diversity of invertebrates eaten in the nonbreeding season. Perhaps invertebrates provide an alternative food source when foraging is restricted to areas with little snow cover. The value of invertebrates in the Western Screech-Owl's diet has been documented elsewhere throughout the year (Smith and Wilson 1971, Fraser et al. 1999).

One benefit of pellet analysis in the study of the diet of mammal-eating owls is that it can provide specimen evidence of small mammals that are rare or difficult to trap. For example, there are no specimen records of the northern bog lemming for Mitkof Island (MacDonald and Cook 2007), yet we found two individuals in our study. Because these owls were equipped with radio transmitters, we are confident that they were not flying to neighboring islands to hunt (Kissling and Lewis 2009). Such records are especially important in an island ecosystem where endemism has become a heightened concern for conservation biologists and managers (Cook et al. 2006). Analysis of owls' diet, therefore, may contribute to the understanding of small mammals' distribution, given some basic understanding of the owls' food habits and preferences.

Despite the limitations and potential biases of our methods, we provide the first data on the diet of the Western Screech-Owl in southeast Alaska. As elsewhere, this species' diet is diverse, with small mammals, especially deer mice, constituting most of the biomass, but insects contribute significantly throughout the year (Cannings and Angell 2001 and references therein, Davis and Cannings 2008). We suspect that the diet varies little spatially across southeast Alaska because deer mice and, presumably, insects, are ubiquitous and well-distributed on all islands (MacDonald and Cook 2007). Temporally, however, we speculate that invertebrates are especially important food when small mammals are scarce or unavailable, as during heavy snow. Because Western Screech-Owls defend their territories year round (Cannings and Angell 2001), their diet may in part explain their close association with riparian habitats in southeast Alaska, where an overstory of large trees provides protection from heavy snow accumulation on the ground and thus increased access to prey there

(Harestad and Bunnell 1981, Kirchhoff and Schoen 1987). Therefore, to provide year-round habitat for the Western Screech-Owl, and likely other birds, we advocate protecting low-gradient streams at low elevations in southeast Alaska.

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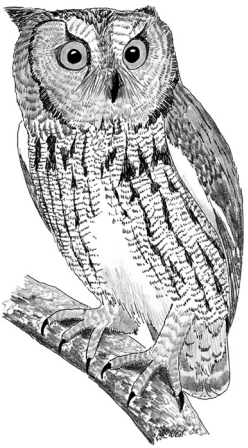

Western Screech-Owl

Sketch by George C. West