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DIET OF NORTHERN SAW-WHET OWLS IN SOUTHERN WISCONSIN[1]

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Abstract. We measured and analyzed 1,148 pellets of Northern Saw-whet Owls (*Aegolius acadicus*) in Sauk County, Wisconsin from 1986 to 1990. Pellets averaged 3.03 cm long × 1.50 cm wide, and contained 0.645 prey individuals/pellet. Rodents comprised 84.5% of prey individuals and 92.0% of biomass in Saw-whet Owl diets. Deer mice (*Peromyscus leucopus* and *P. maniculatus*) comprised 67.7%, voles (*Microtus pennsylvanicus* and *M. ochrogaster*) 16.1%, and shrews (*Blarina brevicauda* and *Sorex cinereus*) 8.6% of prey individuals. The owls also ate songbirds, insects, and a bat. The owls' food-niche breadth was 2.17.

Key words: Aegolius acadicus; *diet; Northern Saw-whet Owl; pellets; Wisconsin.*

INTRODUCTION

Northern Saw-whet Owls (*Aegolius acadicus*) inhabit many forest types across their range throughout the year (Johnsgard 1988). Their diet consists mostly of rodents, especially deer mice (*Peromyscus*) and voles (*Microtus*), with a few other small mammals and birds (Errington 1932, Graber 1962, Catling 1972, Grove 1985, Snyder and Wiley 1976). Their diet varies with habitat (Cannings 1987, Swengel and Swengel 1987, Marks and Doremus 1988). We collected and analyzed pellets in order to characterize Saw-whet Owl diets in southern Wisconsin.

METHODS

Our study was conducted at 22 sites in four study areas in Sauk County, Wisconsin (43°23′ to 43°34′N, 89°41′ to 89°49′W) from March 1986 to April 1990. Three study areas in the Baraboo Hills include several conifer stands each. The fourth study area is a jack pine (*Pinus banksiana*) barren in Mirror Lake State Park. See Swengel and Swengel (1992) for a fuller description of the study area and our coverage of sites. We collected all Saw-whet Owl pellets found while systematically walking or crawling through sites during the day, usually between 10:00 and 14:00 CST to enhance pellet visibility. Searches occurred in all months, but more than 90% of our effort was in the cold season, from November 1 to April 15. From January 1987 we recorded our searching time.

We distinguished Saw-whet Owl pellets from those of sympatric owls by the Saw-whet's smaller and denser pellets with crushed mammal craniums, and from those of falcons and *Accipiter* hawks by the greater proportion of bones in Saw-whet Owl pellets (Errington 1932, Wilson 1938, Randle and Austing 1952, and pers. observ.).

We measured the maximum length and width of pellets to the nearest 0.05 cm. Because soaking pellets in NaOH damaged key identifying features of bones, especially of birds, we analyzed most pellets by picking them apart. Numbers of mammalian prey were determined by Marti's (1974) method: by counting the number of skulls or by dividing the number of dentaries by two and counting single extra dentaries as new individuals unless another pellet from the same site contained a complementary dentary. Because they were probably underrepresented, all bird or insect remains were counted as individuals. However, when complementary remains of one bird occurred in different pellets from the same site, only one individual was counted. We identified mammal bones using Driver (1949), Jackson (1961), Glass (1973), and Burt and Grossenheider (1976). We calculated food-niche breadth using Levins' (1968) formula and food-niche overlap with Pianka's (1974) equation. To calculate mean mass of vertebrate prey (MWVP), we divided the sum of the vertebrate prey masses by the number of vertebrate prey. Data are reported as mean ± standard deviation (SD), except where noted. We calculated descriptive statistics using the ABstat (Anderson-Bell Corp.) program.

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TABLE 1. Measurements (cm) and number of prey individuals in Northern Saw-Whet Owl pellets found in different subsets of the study area. Values are means ± SD except where noted. Samples sizes are in parentheses.

	All sites	Baraboo Hills	Mirror Lake
Length	3.03 ± 0.70	3.18 ± 0.62	2.59 ± 0.73
Range	0.80–5.30 (957)	1.00–5.30 (707)	0.80–4.80 (250)
Width	1.50 ± 0.24	1.58 ± 0.18	1.25 ± 0.22
Range	0.55–2.05 (1,070)	0.60–2.05 (807)	0.55–1.85 (263)
Prey/pellet	0.645 ± 0.584	0.696 ± 0.579	0.491 ± 0.572
Range	0–3 (1,148)	0–3 (861)	0–2 (287)

RESULTS

PELLETS

We collected 1,148 Saw-whet Owl pellets at 20 of the 22 sites in a total of 109 visits. We found pellets in every month of the year, but collected 93.1% of them between November 1 and April 30. We found Saw-whet Owl pellets in every substantial (> 100 trees) conifer site we checked. Auditory censuses indicated that the 20 sites each hosted separate owls. We found pellet, sight, and vocal evidence that five sites had at least two owls. Our minimum estimate of the number of owls that cast the pellets we found is 25, but the actual number was probably much greater. Our study area has a high density of Saw-whet Owls (Swengel and Swengel 1987, 1992).

During 1987–1990 we found 3.8 pellets/hr in 203.2 man-hr. A white spruce (*Picea glauca*) plantation produced more pellets per unit effort (4.1/hr, effort = 44.1 hr) than nearby tall (11–15 m) red pine (*Pinus resinosa*) stands that lacked limbs for the lowest 5 m of each tree (1.4/hr, effort = 70.3 hr). Our pellet finding rate in this spruce plantation seemed inversely related to the number of hours we searched there in a winter; we found approximately the same number of pellets per season here regardless of the number of visits. One eastern red cedar (*Juniperus virginiana*) had pellets under it during nearly all of our visits during 1986–1989. We found no pellets in deciduous forest, in spite of several Saw-whet Owls' presence there during auditory censuses in 1986–1990.

Pellets contained a high density of bones, were dark and oval shaped when fresh, and lightened to a pale gray as they aged. Typical pellets were 2.20–3.85 cm long (80.3% of 957 measurable pellets, median = 3.0 cm) and 1.20–1.75 cm wide (86.9% of 1,070 measurable pellets, median = 1.5 cm). Pellets averaged larger and contained more prey individuals per pellet in the Baraboo Hills than at Mirror Lake (Table 1).

DIET

Owls frequently cast two pellets per prey individual, because many pellets contained either the front or back half of a mouse. Rodents comprised 84.5% of prey individuals and 92.0% of the biomass (Table 2). Insect parts were surprisingly numerous in Mirror Lake pellets. Because some insect pieces found in pellets appeared too large to have been chewed and eaten by a mouse or shrew, we believe the insects were eaten by the owls rather than by the owls' prey. The insects did not die while decomposing pellets because, like bones of vertebrate prey, their parts were dispersed throughout the pellet; insects that died while decomposing pellets would remain intact in one place.

The proportions of individuals of the two primary prey genera at Baraboo Hills vs. Mirror Lake sites were very different. Baraboo Hills owls ate 76.0% *Peromyscus* and 10.9% *Microtus*, while Mirror Lake owls ate 38.3% *Microtus* and 32.6% *Peromyscus*. In addition, *P. maniculatus* and *M. ochrogaster*, which inhabit more open areas than their congeners *P. leucopus* and *M. pennsylvanicus* in our area (Jackson 1961, Lange 1989), were found in relatively higher proportions in pellets from Mirror Lake than in ones from the Baraboo Hills (Table 2).

The mean mass of vertebrate prey (MWVP) was 26.2 g. The mean prey mass per pellet (MWVP × 0.645 prey/pellet) was 16.6 g. Food-niche breadth was 2.17. We counted different prey species within genera as different prey categories because these species occupy different habitats in our study area. Food-niche breadth at different study areas ranged from 1.56 in dense forests to 5.1 in open habitat at Mirror Lake.

TABLE 2. Frequency and biomass[a] (g) of Northern Saw-whet Owl prey in three subsets of the study area. Biomasses >8 are rounded to the nearest integer.

Prey species	All sites				Baraboo Hills				Mirror Lake			
	n Prey	(%)	Mass	(%)	*n* Prey	(%)	Mass	(%)	*n* Prey	(%)	Mass	(%)
Blarina brevicauda	35	4.7	840	4.4	33	5.5	792	5.2	2	1.4	48	1.2
Sorex cinereus	29	3.9	102	0.5	20	3.3	70	0.5	9	6.4	32	0.8
Myotis spp.	1	0.1	9	0.04	1	0.2	9	0.1	0	0.0	0	0.0
Microtus ochrogaster	8	1.0	328	1.7	2	0.3	82	0.5	6	4.3	246	6.4
M. pennsylvanicus	77	10.4	3,542	18.6	59	9.8	2,714	17.9	18	12.8	828	21.5
M. spp.	34	4.6	1,547	8.1	4	0.7	182	1.2	30	21.3	1,365	35.4
Peromyscus leucopus	363	49.1	8,712	45.8	346	57.8	8,304	54.8	17	12.1	408	10.6
P. maniculatus	11	1.5	220	1.2	9	1.5	180	1.2	2	1.4	40	1.0
Peromyscus spp.	127	17.2	3,035	16.0	100	16.7	2,390	15.8	27	19.1	645	16.7
Reithrodontomys megalotis	4	0.5	66	0.3	1	0.2	17	0.1	3	2.1	50	1.3
Rodent spp.	1	0.1	28	0.1	1	0.2	28	0.2	0	0.0	0	0.0
Songbird	10	1.4	200	1.1	9	1.5	180	1.2	1	0.7	20	0.5
Small songbird	21	2.8	252	1.3	7	1.2	84	0.6	14	9.9	168	4.4
Cardinalis cardinalis	1	0.1	43	0.2	1	0.2	43	0.3	0	0.0	0	0.0
Junco hyemalis	4	0.5	76	0.4	4	0.7	76	0.5	0	0.0	0	0.0
Beetle	12	1.6	6	0.03	0	0.0	0	0.0	12	8.5	6	0.2
Insect	2	0.3	1	0.01	2	0.3	1	0.01	0	0.0	0	0.0
Total	740	100	19,006	100	599	100	15,150	100	141	100	3,856	100

[a] Prey masses (g) used in calculations: *Blarina brevicauda* 24, *Sorex cinereus* 3.5, *Myotis* spp. 8.5, *Microtus ochrogaster* 41, *M. pennsylvanicus* 46, *M.* spp. 45.5, *Peromyscus leucopus* 24, *P. maniculatus* 20, *P.* spp. 23.9, *Reithrodontomys megalotis* 16.6, rodent spp. 28, songbird 20, small songbird 12, *Cardinalis cardinalis* 42.5, *Junco hyemalis* 19, beetle 0.5, insect 0.5. Mammal masses from Jackson (1961), *Cardinalis cardinalis* mass from Campbell and Lack (1985) and *Junco hyemalis* mass from Bent et al. (1968).

Food-niche overlap of owls in different habitats was 0.921 between dense forests and open forests (the most similar habitats), 0.879 between open forests and Mirror Lake pine barren, and 0.714 between dense forests and Mirror Lake pine barren (the most dissimilar habitats).

DISCUSSION

PELLETS

Our mean pellet measurements were the same as in two other studies (Smith and Devine 1982, Grove 1985). Pellets exhibited a similar range of sizes to those found by Smith and Devine (1982) (1.7–4.8 cm long, 0.5–2.2 cm wide), but varied more in length than pellets Grove (1985) found (2.0–4.2 cm). The smaller mean pellet size from Mirror Lake resulted primarily from pellets gathered at one large eastern red cedar (length 2.55 ± 0.76 cm, $n = 208$, width 1.20 ± 0.18 cm, $n = 212$). Other Mirror Lake pellets were more normal sized (length 2.82 ± 0.46 cm, $n = 42$, width 1.50 ± 0.20 cm, $n = 51$). The large red cedar, in the most open roosting habitat we found, might have been a traditional roost for one owl. We found many unusually small (<1 cm wide) pellets under this tree solely because we knew precisely where on the ground to look for them.

DIET

Our mean of 0.645 prey individuals/pellet agrees with previous findings by Errington (1932) and Collins (1963) that Saw-whet Owls frequently cast pellets that lack skulls. Studies recording more than 1.0 prey/pellet (e.g., Rusling 1951, Graber 1962) have counted mammalian prey individuals on the basis of postcranial bones in some pellets. Our results agree with previous authors' that *Peromyscus* is the most important prey of Saw-whet Owls in the midwestern United States, followed by *Microtus* (Errington 1932, Randle and Austing 1952, Graber 1962).

The food-niche breadth we found was lower than in most Saw-whet Owl studies, but higher than that of the other southern Wisconsin study (Errington 1932) (Table 3). The food-niche breadth of 1.52 we calculated for the southern Wisconsin data of Errington (1932) is higher than the 1.366 reported by Jaksic (1983) for the same study. This difference results from the way prey individuals are counted. Jaksic (1983) counted postcranial occurrences of *Peromyscus* as prey individuals, while we counted mammals by the number of skulls or dentaries (Marti 1974). The former method generally results in lower food-niche breadths for Saw-whet Owls, but this difference is usually small because the ratios of the

TABLE 3. Food-niche breadth (B), mean mass of vertebrate prey (MWVP) (g), and percentage of rodent and mammal individuals in ten Northern Saw-whet Owl diet studies. Prey masses are from the original studies except as noted. Studies marked by asterisks counted postcranial bones as prey individuals, while the other studies did not. We counted insects when calculating B for Boula's (1982) study. Sample sizes are the number of prey.

Study area	B	*n*	MWVP	*n*	Percent rodents	Percent mammals	Reference
Brit. Columbia	2.57	584	21.9	578	95.5	97.4	Cannings 1987
Washington	2.70	770	23.9	767	95.3	95.4	Grove 1985
Oregon*	1.98	84	20.8[a]	74	85.7	88.1	Boula 1982
Idaho	3.77	714	19.9	714	99.7	100.0	Marks and Doremus 1988
Wisconsin	1.52	66	28.3[b]	66	98.5	98.5	Errington 1932
Wisconsin	2.17	740	26.2	726	84.5	93.2	This study
Illinois*[,c]	2.00	371	19.9[d]	368	94.9	96.5	Graber 1962
Ohio	3.41	113	24.3[e]	112	89.3	99.1	Randle and Austing 1952
New Jersey*[,f]	2.37	96	21.5[e]	95	92.7	99.0	Rusling 1951
Connecticut*	2.75	276	25.2[e]	276	94.2	99.7	Smith and Devine 1982

[a] Calculated by Marks and Doremus (1988); mammal prey only—3 birds excluded.
[b] Mammal masses from Jackson (1961); bird masses from Bent et al. (1968).
[c] Precise prey numbers estimated.
[d] Species composition of *Peromyscus* and *Microtus* estimated; bird masses from Bent et al. (1968), Steenhof (1983), Campbell and Lack (1985), and Grove (1985).
[e] Mammal masses are geometric means of mass ranges in Burt and Grossenheider (1976); bird masses from Bent et al. (1968).
[f] Relative numbers of two shrew species estimated (total shrews = 6), and 1 frog excluded from MWVP calculation.

major prey species as calculated by the two methods remain close.

The mean mass of vertebrate prey (MWVP) we calculated for Errington's (1932) southern Wisconsin study (Table 3) is much higher than the MWVP of 20.3 g Jaksic (1983) obtained using the same data. This difference in MWVP values primarily results from the higher prey masses used in our study than in Jaksic's (1983). Since the two methods for counting prey numbers result in different raw dietary data, food-niche breadths, and MWVP, future diet studies of species that cast two pellets for some prey individuals should be careful to describe the method used.

Saw-whet Owls preyed heavily on woodland species. Published data on habitats of mammals in our area (Jackson 1961, Lange 1989) suggest that 69.6% of the owls' prey were forest dwellers, 18.6% lived in open habitats, 4.9% were habitat generalists, and 6.9% lived in unknown habitats (n = 740). Baraboo Hills owls ate 77.4% forest animals and 12.9% open country animals (n = 599), while Mirror Lake owls ate slightly more open habitat (44.0%) than forest (35.6%) prey (n = 141). All Baraboo Hills sites are forested, while Mirror Lake is an open jack pine barren. Over 97% of the *Peromyscus* identified were *P. leucopus,* a forest species; the rest were *P. maniculatus,* a field species. *Microtus* inhabits open places in our area, *Sorex cinereus* usually inhabits forests, and *Blarina brevicauda* is ubiquitous. We considered *Myotis* and bird habitats unknown because their locations when captured at night were difficult to predict. Insects and one rodent were not assigned to habitat because we could not identify them adequately. Unidentified *Peromyscus* were assigned to forest and open country habitats in the same ratio as that of the identified *Peromyscus* individuals' preferred habitats.

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LITERATURE CITED

BENT, A. C., AND COLLABORATORS. 1968. Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies. Compiled and edited by O. L. Austin Jr. [ed.]. U.S. Nat. Mus. Bull. 237, Part 2:603–1248.

BOULA, K. 1982. Food habits and roost-sites of Northern Saw-whet Owls in northeastern Oregon. Murrelet 63:92–93.

BURT, W. H., AND R. P. GROSSENHEIDER. 1976. A field guide to the mammals, 3rd Edition. Houghton Mifflin, Boston.

CAMPBELL, B., AND E. LACK. 1985. A dictionary of birds. Buteo Books, Vermillion, SD.

CANNINGS, R. J. 1987. The breeding biology of Northern Saw-whet Owls in southern British Columbia, p. 193–198. *In* R. W. Nero, R. J. Clark, R. J. Knapton, and R. H. Hamre [eds.], Biology and conservation of northern forest owls: sym-

posium proceedings. U.S. Forest Service Gen. Tech. Rep. RM-142.

CATLING, P. M. 1972. Food and pellet analysis of the Saw-whet Owl (*Aegolius acadicus*). Ontario Field Biol. 26:72–85.

COLLINS, C. T. 1963. Notes on the feeding behavior, metabolism, and weight of the Saw-whet Owl. Condor 65:528–530.

DRIVER, E. C. 1949. Mammal remains in owl pellets. Am. Midl. Nat. 41:139–142.

ERRINGTON, P. 1932. Food habits of southern Wisconsin raptors. Part I. Owls. Condor 34:176–186.

GLASS, B. P. 1973. A key to the skulls of North American mammals, 2nd Edition. Bryan P. Glass, Stillwater, OK.

GRABER, R. R. 1962. Food and oxygen consumption in three species of owls (Strigidae). Condor 64: 473–487.

GROVE, R. A. 1985. Northern Saw-whet Owl winter food and roosting habits in north-central Washington. Murrelet 66:21–24.

JACKSON, H.H.T. 1961. Mammals of Wisconsin. Univ. of Wisconsin Press, Madison.

JAKSIC, F. 1983. The trophic structure of sympatric assemblages of diurnal and nocturnal birds of prey. Am. Midl. Nat. 109:152–162.

JOHNSGARD, P. A. 1988. North American owls: biology and natural history. Smithsonian Institution Press, Washington, DC.

LANGE, K. I. 1989. Ancient rocks and vanished glaciers: a natural history of Devil's Lake State Park, Wisconsin. Worzalla Publishing, Stevens Point, WI.

LEVINS, R. 1968. Evolution in changing environments. Monogr. Pop. Biol. No. 2. Princeton Univ. Press, Princeton, NJ.

MARKS, J. S., AND J. H. DOREMUS. 1988. Breeding-season diet of Northern Saw-whet Owls in southwestern Idaho. Wilson Bull. 100:690–694.

MARTI, C. D. 1974. Feeding ecology of four sympatric owls. Condor 74:45–61.

PIANKA, E. R. Niche overlap and diffuse competition. Proc. Nat. Acad. Sci. USA 75:2141–2145.

RANDLE, W., AND R. AUSTING. 1952. Ecological notes on Long-eared and Saw-whet Owls in southwestern Ohio. Ecology 33:422–426.

RUSLING, W. J. 1951. Food habits of New Jersey owls. Proc. Linnaean Soc. of New York 58-62:38–45.

SMITH, D. G., AND A. DEVINE. 1982. Winter food of the Saw-whet Owl. Connecticut Warbler 2(4):52–54.

SNYDER, N.F.R., AND J. W. WILEY. 1976. Sexual size dimorphism in hawks and owls of North America. Ornithol. Monogr. 20:1–96.

STEENHOF, K. 1983. Prey weights for calculating percent biomass in raptor diets. Raptor Research 17: 15–27.

SWENGEL, S. R., AND A. B. SWENGEL. 1987. Study of a Northern Saw-whet Owl population in Sauk County, Wisconsin, p. 199–208. *In* R. W. Nero, R. J. Clark, R. J. Knapton, and R. H. Hamre [eds.], Biology and conservation of northern forest owls: symposium proceedings. U.S. Forest Service Gen. Tech. Rep. RM-142.

SWENGEL, S. R., AND A. B. SWENGEL. 1992. Roosts of Northern Saw-whet Owls (*Aegolius acadicus*) in Southern Wisconsin. Condor 94:699–706.

WILSON, K. A. 1938. Owl studies at Ann Arbor, Michigan. Auk 55:187–197.