Diet and Prey Consumption Rates of Nesting Boreal Owls, *Aegolius funereus*, in Alaska

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Dietary composition and prey consumption rates of nesting Boreal Owls, *Aegolius funereus,* were investigated during 2004–2006 using two methods. Dietary composition was determined during nest visits through examination of 1882 fresh remains containing at least 11 mammalian and 15 avian species. Consumption rates were calculated based on laboratory examination of seven prey detritus bricks following fledging, yielding 1051 items of five different taxa. During 2003–2006, small mammal snap-trapping was conducted in the vicinity of occupied nest boxes, and relative abundance of potential prey items was estimated. A total of 4020 trap-nights yielded 695 small mammal captures of eight species. Consumption rates of nestling owls ranged from 22.0 to 29.7 g of food per day, averaging 24.2 g (SD = 1.8). Comparisons between availability of small mammals (as indicated by snap-trapping) and consumption (as indicated by nest visits and analysis of prey detritus bricks) showed that Boreal Owls are generally preying on mammals proportionate to their occurrence.

Key Words: Boreal Owl, *Aegolius funereus*, Alaska, consumption rate, diet, nesting, nestling, small mammals.

Knowledge of dietary requirements, both in terms of quality (species of prey) and quantity (how much prey), is an important factor in understanding the ecological niche of any animal. Numerous scientific and popular articles that provide insights into Boreal Owl, *Aegolius funereus*, diets are available. Few accounts, however, have attempted to quantify the amount of prey required to sustain life. Even fewer treatises have attempted to compare consumption rates with availability. This is an attempt not only to provide a list of species preyed upon by Boreal Owls but also to quantify that diet and to compare consumption with availability.

Study Area

Studies were conducted during 2003–2006 in the boreal forest of interior Alaska. Nest boxes (n = 122, 34 of which were occupied during one or multiple years) were situated along primary or secondary roads within 150 km of Fairbanks, Alaska. All box routes were between 64.6°N and 65.5°N and between 146.2°W and 148.7°W. Elevations ranged from 110 to 690 m.

Overstory vegetation was highly variable. White Spruce (*Picea glauca*), often mixed with Paper Birch (*Betula papyrifera*), Eastern Larch (*Larix laricina*) or Balsam Poplar (*Populus balsamifera*), dominated lower elevations. Mid-slopes were highly variable, composed of monotypic stands of Quaking Aspen (*Populus tremuloides*), Paper Birch, or Black Spruce (*Picea mariana*), or some combination thereof. At higher elevations and on poorly drained soils, overstory vegetation was dominated by Black Spruce.

Shrub layers were often present, composed largely of willow (usually *Salix alaxensis* or *S. bebbiana*), Green Alder (*Alnus crispa*), Bog Blueberry (*Vaccinium uliginosum*), High-bush Cranberry (*Viburnum edule*), Wild Rose (*Rosa acicularis*), or Labrador Tea (*Ledum groenlandicum*). Bogs and fens, dominated by graminoids (usually *Calamagrostis* spp.) or low shrubs (Bog Blueberry or Dwarf Birch, *Betula nana*) were scattered sporadically throughout.

Interior Alaska is typified by continental weather patterns, with generally mild summers (mean July temperature of 16.9°C) and cold winters (mean January temperature of –23.4°C). Precipitation, largely in the form of June–August rains, averages 27.7 cm annually. Snow accumulations average 58 cm annually, with snow cover usually persisting until early May.

Methods

Diet Composition

The dietary components of the Boreal Owl diet were examined during incubation and brooding over a three-year period (2004–2006). Prey composition, generally identified to species, was done by examining fresh remains in nest boxes. Usually, prey was identifiable based on gross pelage or feather characteristics. Some specimens, however, were only identifiable based on tooth characteristics (generally soricids or young arvicolines). During nest examinations where prey was documented, feet from small mammals and toes of avians were generally clipped and removed in an effort to prevent double-counting on subsequent box visits. Examination and identification of these fresh prey

remains revealed the prey items that the attendant male had delivered for consumption by the female and, following hatching, for the brood. Additional data were collected from analyses of prey detritus bricks (compacted pellets, uneaten bones and feathers, and owl mutes; Whitman 2008) removed from nest boxes post-fledging (see next section).

Prey Consumption Rates

Consumption rates were calculated based on laboratory analyses of prey detritus bricks removed from the nest boxes after the young had fledged. I assume that analyses of prey detritus bricks reflects only what the adult male delivered to the box for consumption by the brood. The adult female must be sustained as well, but I'm assuming that her brief nightly departure from the box was largely in response to her need to defecate and cast a pellet, so evidence of her consumption is not reflected in the contents of prey detritus bricks.

The collection of detritus bricks was facilitated by removing the top and front of formerly occupied boxes. The bricks were then scraped into large plastic bags with a 10-cm metal spatula. Prey bricks were frozen for at least three months before being allowed to air-dry at room temperature until mass stabilized. These detritus bricks were then meticulously separated by hand. Mammalian prey were quantified based on counts of long bones (femurs, humeri, or, most often, tibiofibulae) or mandibles, while avian identification was usually possible based on feather characteristics.

Many of the small mammals noted during nest visits were headless. Whether the male consumed the heads before delivery or whether the female removed and ingested them was not determined. Because of this, far fewer mandibles (one of the heaviest bones of small mammals) were found in the analysis of prey bricks than expected.

In calculating daily food consumption rates by Boreal Owls, I assumed that prey consumed by the brooding female was not reflected in the contents of the prey detritus brick; bricks thus reflected only what was consumed by the brood. Brood size and success (number of chicks fledged) was known from previous nest visits (Whitman 2008). For daily consumption rates, I assumed in all cases that the period from hatching to fledging was 30 days (J. Whitman, unpublished data).

Mean weights of mammalian prey items were calculated from fresh specimens taken in small mammal snap-trap lines during the study (see next section). Mean weights of avians were calculated from live weights of birds captured in mist nets during April–June by the Alaska Bird Observatory (ABO) in Fairbanks. Biomass of anurans was estimated based on weights of Wood Frogs (*Lithobates sylvaticus*) near Fairbanks (J. Whitman, unpublished data).

Comparisons of prey identification techniques (fresh prey examination in the nest boxes vs. analysis of prey detritus bricks in the laboratory) indicated that identification of species consumed was easier and more complete based on nest box visits, whereas estimation of consumption rates was possible only through examination of detritus bricks.

Small Mammal Population Indices

Small mammal snap-trap lines were sampled annually from 2003 to 2006 in proximity to Boreal Owl nest box routes and, with the exception of soricids, are assumed to be reflective of the relative abundance of small mammals available to Boreal Owls in the area. Eight snap-trap transects were completed each July–September in a variety of habitats, and generally 100–200 trap-nights were accumulated annually per transect. Unmodified Museum Special snap-traps (Woodstream Corporation, Lititz, Pennsylvania, USA) were placed approximately 5 m apart along approximately linear transect lines and baited with a combination of peanut butter and rolled oats. Traps were run for at least two 24-hour periods and were checked each morning, at which time any captured animals were removed and the traps were reset or collected. Identification of trapped samples was done to species based on gross characteristics of size, color, and/or tooth examination. In questionable cases, specimen identifications were confirmed by personnel at the University of Alaska Museum of the North (University of Alaska Fairbanks). All small mammal specimens were deposited at the UAF Museum.

Results

Diet Composition

A total of 1882 specimens was examined in nest boxes during the investigation, representing food contributed by the male to both the incubating female before hatching and to the adult female and to the nestlings after hatching. As in other studies (Catling 1972; Bondrup-Nielsen 1978; Hayward 1983; Eurasian summary by Mikkola 1983; Palmer 1986; Hayward 1994; Whitman 2001, 2008), small mammals made up the vast majority of prey (Table 1). Among at least 11 species of small mammals, Northern Red-backed Voles (*Myodes rutilus*) and Tundra Voles (*Microtus oeconomus*) constituted the primary prey, in terms of both numbers and estimated biomass. During 2005, most samples in the genus *Microtus* were not examined closely enough to assign them to species, hence the large number of *Microtus* spp. (Table 1).

Collectively, avians contributed only about 6% to the biomass of the diet. At least 14 species of birds were identified (Table 1), with Dark-eyed Juncos (*Junco hyemalis*) the leading contributor numerically, but the much larger Gray Jay (*Perisoreus canadensis*) being the primary contributor in terms of biomass. Based on examinations of prey during nest visits, no frogs or insects contributed to the diet.

TABLE 1. Numbers and biomass estimates of prey taken by Boreal Owls in interior Alaska during nesting in 2004–2006 based on examination of fresh prey delivered to nest boxes.

	2004	2005	2006	Mean weight	Total prey	Total biomass	Percentage (all prey biomass)
MAMMALIA							
Myodes (Clethrionomys) rutilus	50	354	511	23.1	915	21 136.5	46.4
Microtus pennsylvanicus	3	10	48	25.6	61	1 561.6	3.4
Microtus oeconomus		17	444	27.1	461	12 493.1	27.4
Microtus miurus			2	22.2	2	44.4	0.1
Microtus xanthognathus		2	24	60.0	26	1 560.0	3.4
Microtus spp.	2	71		25.0	73	1 825.0	4.0
Synaptomys borealis		3	130	20.9	133	2 779.7	6.1
Lemmus trimucronatus		2	24	24.0	26	624.0	1.4
Zapus hudsonius		1	3	15.9	4	63.6	0.1
Sorex spp.	1	17	51	4.0	69	276.0	0.6
Tamiasciurus hudsonicus			1	70.0	1	70.0	0.2
Lepus americanus			3	70.0	3	210.0	0.5
Total mammals	56	477	1 241	24.0	1 774	42 643.9	93.6
AVES							
Dark-eyed Junco							
Junco hyemalis		2	19	18.2	21	382.2	0.8
Yellow-rumped Warbler							
Dendroica coronata		2	9	12.9	11	141.9	0.3
Wilson's Warbler							
Wilsonia pusilla			1	7.7	1	7.7	tr
Common Redpoll							
Acanthis (*Carduelis*) *flammea*		2		12.6	2	25.2	0.1
Boreal Chickadee							
Poecile hudsonicus			1	11.8	1	11.8	tr
Black-capped Chickadee							
Poecile atricapillus		9		11.6	9	104.4	0.2
Savannah Sparrow							
Passerculus sandwichensis			1	17.1	1	17.1	tr
White-crowned Sparrow							
Zonotrichia leucophrys			1	24.8	1	24.8	0.1
American Tree Sparrow							
Spizella arborea		1		16.6	1	16.6	tr
Fox Sparrow							
Passerella iliaca			2	34.3	2	68.6	0.2
Gray Jay							
Perisoreus canadensis		4	6	67.3	10	673.0	1.5
Hermit Thrush							
Catharus guttatus	1		5	27.5	6	165.0	0.4
Swainson's Thrush							
Catharus ustulatus			1	28.0	1	28.0	0.1
American Robin							
Turdus migratorius			3	76.2	3	228.6	0.5
Boreal Owl (siblicide?)							
Aegolius funereus	1		5	75.0	6	450.0	1.0
unidentified passerine		6	26	16.8	32	537.6	1.2
Total avian	2	26	80	26.7	108	2 882.5	6.4
TOTAL PREY	58	503	1 321	24.2	1882	45 526.4	100.0

Prey Consumption Rates

Consumption rates are based on what is assumed to reflect the total dietary intake of Boreal Owl nestlings during the 30-day period from hatching to branching (fledging), and probably does not reflect consumption by the attendant adults. A total of seven prey detritus bricks from 2005 was analyzed from nesting boxes following fledging of the young owls (three to six nestlings per box; Table 2). These data do not provide precise estimates of individual species consumed, but they do reveal total numbers of prey.

Consumption rates by the young owls ranged from 22.0 to 29.7 g of food per chick per day (mean 24.2 g (SD = 1.8)). This number, surprisingly, is very close

TABLE 2. Numbers and biomass estimates of prey taken by Boreal Owls in interior Alaska during nesting in 2005 based on examinations of prey detritus bricks from occupied nest boxes.

Nest Box I.D.	Number						Estimated total prey mass	Young owls fledged	Grams of prey/ nestling/day
	Voles	Flying Squirrels	Shrews	Avians	Frogs	Total			
STE04	225	0	10	1	1	237	5 346.5	6	29.7
STE09	159	0	7	3	1	170	3 899.0	5	26.0
STE10	83	0	2	1	0	86	1 981.5	3	22.0
STE29	152	2	8	3	2	167	4 036.0	6	22.4
STE30	140	0	1	4	0	145	3 386.0	5	22.6
STE31	111	0	3	2	1	117	2 674.5	4	22.3
STE32	118	0	7	4	0	129	2 893.0	4	24.1
SUM	988	2	38	18	5	1 051	24 216.5	33	169.1
MEAN	141.1	0.3	5.4	2.6	0.7	150.1	3459.5	4.7	24.2

TABLE 3. Small mammal captures in snap-traps on eight standardized lines in interior Alaska during 2003–2006.

Species	2003	2004	2005	2006	Total	Percentage of total
Myodes (Clethrionomys) rutilus	35	111	299	38	483	69.5
Microtus pennsylvanicus	3	24	39	8	74	10.6
Microtus oeconomus	0	0	7	8	15	2.2
Synaptomys borealis	1	7	9	5	22	3.2
Tamiasciurus hudsonicus	1	0	0	0	1	0.1
Sorex cinereus	17	18	44	17	96	13.8
Sorex hoyi	0	0	1	1	2	0.3
Sorex monticolus	0	0	2	0	2	0.3
Total catch	57	160	401	77	695	100.0%
Total trap-nights	957	815	1015	1233	4020	

to the estimated mean weight of each prey item delivered (23.0 g). Thus, prey deliveries and consumption equate to one prey item per chick per day. For a clutch of five Boreal Owls, approximately 150 prey items sustains them through the 30-day nestling period.

Two taxa of prey were identified from analyses of prey detritus bricks that were not documented during examination of fresh remains during box visits. Two Northern Flying Squirrels (*Glaucomys sabrinus*) and five Wood Frogs were identified from bones gleaned from prey bricks. Alternately, three neonate Snowshoe Hares (*Lepus americanus*) were identified during nest visits but were not documented through prey brick analysis. However, no prey brick analysis was done in the nest boxes where hares were documented.

Small Mammal Abundance

Snap-trap lines for small mammals provided an annual index of abundance of the various species. A total of 4020 trap-nights was accumulated over the four-year period, resulting in the capture of 695 small mammals. Capture rates (captures per 100 trap-nights) varied considerably annually, but varied little between sites during any particular year (Table 3). A total of 695 individuals of eight species was captured, with Northern Red-backed Voles accounting for more than half (69.5%) of the mammals captured.

Discussion

Information on diet was gathered in two ways. Examination of fresh-caught prey during nest box visits provided data on prey composition, but revealed little concerning the quantity consumed during the incubation/brooding period. A careful analysis of prey detritus bricks, on the other hand, yielded data that are more difficult to interpret for species of prey consumed but provide more precise estimates of numbers of prey of any particular taxon. Analysis of total consumption rates using prey bricks reveals the minimum numbers of prey consumed. Early in the brooding stage, very little is consumed by the nestlings (which weigh about 10 grams at hatching; J. Whitman, unpublished data), and it appears that the attendant female removes early detritus before it accumulates. Generally, very little prey detritus accumulates in the boxes until the oldest chick is about 10 days of age. Therefore, consumption rates reported herein should be considered bare minimums for the entire brooding period.

Comparisons of prey species selection (fresh examination during box visits) with availability (snap-trapping) indicates that Boreal Owls are small mammal specialists, but actual species of prey taken suggests that they are generalists at this level, taking an array of mammalian prey in proportion to their occurrence.

Generally, proportions of mammalian prey species were quantitatively surprisingly similar to captures in snap-traps.

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