

SHORT COMMUNICATIONS

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THE SUMMER DIET OF THE SNOWY OWL (*BUBO SCANDIACUS*) IN ICELAND

UTE STENKEWITZ¹

Icelandic Institute of Natural History, Urriðahóltsstræti 6-8, 212 Garðabær, Iceland
and

University of Iceland's Research Centre at Snæfellsnes, Hafnargötu 3, 340 Stykkishólmi, Iceland

ÓLAFUR K. NIELSEN

Icelandic Institute of Natural History, Urriðahóltsstræti 6-8, 212 Garðabær, Iceland

ABSTRACT.—The Snowy Owl (*Bubo scandiacus*) is a rare resident species in Iceland and nests have been found intermittently. Nests are unusual because lemmings (*Dicrostonyx* spp. and *Lemmus* spp.), the primary prey of the Snowy Owl across much of its distribution, do not occur in Iceland. We studied summer diets by analyzing pellets from three areas in Iceland where owls were detected; breeding was confirmed at two of these sites. We identified 257 prey items (total mass of 73.6 kg) of at least 13 species. Birds made up most of the diet (96.5% by number). The Rock Ptarmigan (*Lagopus muta*) was the primary prey species (30.4%). Shorebirds were important prey (46.2%), and passerines (5.1%), as well as waterfowl (6.3%), were also taken. Wood mice (*Apodemus sylvaticus*; 2.7%) and Arctic fox pups (*Vulpes lagopus*; 0.8%) were taken occasionally. Adult prey birds made up 60.3% and nestlings 36.3% of the diet by number.

KEY WORDS: *Snowy Owl*; *Bubo scandiacus*; *breeding*; *diet*; *Iceland*; *pellet analysis*; *prey*.

DIETA ESTIVAL DE *BUBO SCANDIACUS* EN ISLANDIA

RESUMEN.—*Bubo scandiacus* es una especie residente y rara en Islandia, donde sus nidos han sido hallados de forma intermitente. Su reproducción en Islandia es poco frecuente dado que los lemmings (*Dicrostonyx* spp. y *Lemmus* spp.), su presa principal a lo largo de la mayor parte de su distribución, no están presentes. Estudiamos la dieta de verano mediante el análisis de egagrópillas provenientes de tres áreas de Islandia en donde los búhos fueron detectados y su reproducción confirmada en dos de estos sitios. Identificamos 257 presas individuales (peso total de 73.6 kg) correspondientes a por lo menos 13 especies. Las aves representaron la mayor parte de la dieta (96.5% en término de números). La perdiz *Lagopus muta* fue la principal especie de presa (30.4%). Las aves playeras fueron presas importantes (46.2%), y los passeriformes (5.1%), así como las aves acuáticas (6.3%), también fueron consumidas. *Apodemus sylvaticus* (2.7%) y los cachorros de *Vulpes lagopus* (0.8%) fueron ocasionalmente consumidos. Las aves adultas representaron el 60.3% y los polluelos el 36.3% de la dieta en términos numéricos.

[Traducción del equipo editorial]

The Snowy Owl (*Bubo scandiacus*) is a large owl with a circumpolar arctic breeding distribution. The primary prey during spring and summer over most of its range are lemmings (*Dicrostonyx* spp. and *Lemmus* spp.). Lemmings are known for their cyclic or chaotic changes in numbers (Krebs and Myers 1974, Korpimäki and Krebs 1996), and

the Snowy Owl shows strong numerical response to changes in lemming numbers (Gilg et al. 2006, Therrien et al. 2014). Only very rarely does the Snowy Owl breed outside the range of lemmings, such as on a western Aleutian island (Williams and Frank 1979), in Scotland (Tulloch 1968), and in Iceland (Tryggvason 1941). In Iceland, the Snowy Owl is rare but observed annually and during all seasons, and has bred intermittently since at least the 1930s (e.g.,

¹ Email address: ute@hi.is

Björnsson 1932, Tryggvason 1941, Guðmundsson 1984, Hilmarrsson 2015). In this study, we describe the feeding habits of the Snowy Owl in Iceland during spring and summer based on analyses of pellets.

METHODS

Snowy Owl pellets were collected in three different areas in Iceland during sporadic incidental visits in summer. Two of the areas are in the Central Highlands. In the northeastern Central Highlands, collections were made on three occasions at three locations within approximately 6 km of each other: on 7 June 1945 by the late Finnur Guðmundsson, and on 24 June 1985 and 5 July 2002 by ÓKN. During 1945, three Snowy Owl nests with eggs were found, but in 1985 and 2002, only single birds were seen in the area and no breeding was detected. Pellets were collected from perches and nests in 1945; all were deemed as “fresh” and having been cast during that spring and summer. In the northwestern Central Highlands, a collection was made on 30 July 1997 by Arnór Þ. Sigfússon at a site where breeding was never confirmed, but a single bird frequented the area in 1997 and fresh pellets were collected from perches. The third area is in the Westfjords, where collections were made on 24 July 2004 by Yann Kolbeinsson, on 13 August 2005 by Stefán Á. Ragnarsson, and on 26 July 2008 and 14 August 2016 by Daniel Bergmann. Breeding has been confirmed repeatedly in this region. In 2004 and 2005, pellets were collected at perches where a nonbreeding pair and a single adult were observed during 2004, and where a nonbreeding pair was detected during 2005. During 2008, pellets were collected at a failed nest where a bird had been observed incubating in spring, at two old nests in the immediate vicinity of the failed nest, and at nearby perches. In 2016, pellets were collected at the same site as in 2008; no birds were observed. The collections from the Westfjords were a mixture of fresh and old pellets.

All the pellets were analyzed by US and ÓKN. We combined prey individuals for the aggregated number of pellets from each collection instead of interpreting diet on the basis of individual pellets. This was done because many of the pellets were broken and their contents mixed when collected, making it difficult to ascertain the exact number of pellets collected. The pellets were opened dry. We identified bird bones, bills, and claws based on reference material from the collection of the Icelandic Institute of Natural History (IINH). We determined bird age according to texture of the bones: bones of young birds are not fully ossified, with open bone ends and a spongy appearance. We determined the minimum number of prey individuals by counting the most frequent bone for each species. For the Rock Ptarmigan (*Lagopus muta*) the most numerous bone was the skull, for the European Golden-Plover (*Pluvialis apricaria*) and Purple Sandpiper (*Calidris maritima*) the humerus, and for the Common Snipe (*Gallinago gallinago*) the tibiotarsus. Bone sizes of the Common

Ringed Plover (*Charadrius hiaticula*) and Dunlin (*Calidris alpina*) were too similar to distinguish. Young birds (chicks) were enumerated by the tarsometatarsus. The wood mouse (*Apodemus sylvaticus*) was enumerated by the minimum number of jaw bones. The arctic fox (*Vulpes lagopus*) was identified and aged based on deciduous teeth and hair and enumerated using the teeth. We estimated prey mass using values from the archives of the IINH, and also Cramp and Simmons (1977, 1983), Cramp (1988), and Cramp and Perrins (1994).

RESULTS

Average dimensions (length and diameter) of 17 intact pellets were 62.7 mm (range 50–79, \pm 9.9 SD) and 30.1 mm (range 25–40, \pm 3.9). We identified a total of 257 prey items representing a total prey mass of 73.6 kg and at least 13 species of birds and mammals (Table 1). Birds made up the largest portion of the owl's diet by number of individuals (96.5%) and biomass (98.1%). The Rock Ptarmigan was the primary prey species (30.4% by number of individuals and 55.8% by mass), followed by the European Golden-Plover (14.0% by number) and the Common Snipe (12.8% by number); although shorebirds in general comprised the highest overall proportion by number of individuals (46.2%), they were a much smaller proportion of the diet by mass (15.2%). Passerines (5.1% by number, 0.5% by mass) and waterfowl (6.3% by number, 23.5% by mass) were also taken. Adult birds made up 60.3% and young 36.3% of the owl diet by number, or 84.9% and 13.1% by mass, respectively. The most frequent young prey species was the Common Snipe (6.6% by number), followed by the European Golden-Plover (3.5% by number). The wood mouse (2.7% by number) and arctic fox pups (0.8% by number) were taken sporadically. Diet varied somewhat between highland areas and was substantially different in the Westfjord area (Table 1).

DISCUSSION

Although we report on some pellets collected in the vicinity of active breeding sites (1945 and 2008 collections), most of our data can only be interpreted in the context of Snowy Owl foraging during spring and summer and not specifically associated with breeding activity. Also, pellets from the Westfjord area were a mixture of fresh and old pellets and some of them could have been cast in winter. Birds were the primary summer food of the Snowy Owl at our sites in Iceland, particularly Rock Ptarmigan, which constituted the largest number of a single species detected and the largest biomass. All bird species consumed breed within or near the study areas, and all but the Rock Ptarmigan and the Snow Bunting (*Plectrophenax nivalis*) are migratory. Differences in diet among the three areas most likely reflect local availability. The two study areas in the

Table 1. Analysis of prey remains from Snowy Owl pellets collected at three locations in Iceland 1945–2016. % n = percent number of prey species, % bm = percent biomass of prey species.

SPECIES	AGE	MASS ^a (g)	NE HIGHLANDS (1945)			NE HIGHLANDS (1985, 2002)			NW HIGHLANDS			WESTFJORDS			TOTAL	
			% n	% bm	% n	% bm	% n	% bm	% n	% bm	% n	% bm	% n	% bm	% n	% bm
Birds																
Pink-footed Goose (<i>Anser brachyrynchus</i>)	A	2470	...	...	4.0	18.8	14.3	60.4	...	...	...	...	...	1.6	13.4	
Pink-footed Goose	Y	800	...	...	12.0	18.3	9.5	13.0	...	...	...	...	...	1.9	5.4	
Anatinae spp.	A	800	5.7	9.2	4.0	6.1	...	...	...	...	...	...	...	1.2	3.3	
Anatinae spp.	Y	260	...	...	16.0	7.9	...	...	...	...	...	...	...	1.6	1.4	
Rock Ptarmigan (<i>Lagopus muta</i>)	A	537	82.9	89.6	36.0	36.9	19.0	17.5	19.3	59.1	29.6	55.4				
Rock Ptarmigan	Y	160	...	...	...	...	4.8	1.3	0.6	0.5	0.8	0.4				
European Golden Plover (<i>Pluvialis apricaria</i>)	A	197	...	...	...	...	4.8	1.6	14.8	16.6	10.5	7.2				
European Golden Plover	Y	65	...	...	...	...	33.3	3.7	1.1	0.4	3.5	0.8				
Purple Sandpiper (<i>Calidris maritima</i>)	A	70	...	...	...	...	...	...	5.7	2.3	3.9	1.0				
Purple Sandpiper	Y	25	...	...	...	...	...	...	4.5	0.6	3.1	0.3				
Small shorebird ^b	A	60	...	...	...	...	...	...	3.4	1.2	2.3	0.5				
Small shorebird	Y	20	...	...	...	...	...	...	...	10.8	1.2	7.4	0.5			
Common Snipe (<i>Gallinago gallinago</i>)	A	125	...	...	...	...	...	...	...	9.1	6.5	6.2	2.7			
Common Snipe	Y	40	...	...	...	...	...	...	9.7	2.2	6.6	0.9				
Whimbrel (<i>Numenius phaeopus</i>)	Y	150	...	...	...	...	...	...	0.6	0.5	0.4	0.2				
Common Redshank (<i>Tringa totanus</i>)	A	148	...	...	...	...	...	...	2.8	2.4	1.9	1.0				
Common Redshank	Y	50	...	...	...	...	...	...	0.6	0.2	0.4	0.1				
Redwing (<i>Turdus iliacus</i>)	A	70	...	...	...	...	...	...	0.6	0.2	0.4	0.1				
Redwing	Y	25	...	...	...	...	...	...	0.6	0.1	0.4	0.0				
Snow Bunting (<i>Plectrophenax nivalis</i>)	A	35	5.7	0.4	8.0	0.5	...	...	1.7	0.3	2.7	0.3				
Snow Bunting	Y	15	...	...	...	...	...	...	2.3	0.2	1.6	0.1				
Aves spp.	Y	100	2.9	0.6	12.0	2.3	14.3	2.4	8.5	4.9	8.6	3.0				
Total birds (%)			100.0	100.0	92.0	90.8	100.0	100.0	96.6	99.4	96.5	98.1				
Mammals																
Wood mouse (<i>Apodemus sylvaticus</i>)	A	30	...	...	...	...	...	...	3.4	0.6	2.7	0.3				
Arctic fox (<i>Vulpes lagopus</i>)	Y	600	...	...	8.0	9.2	...	...	...	...	0.8	1.6				
Total mammals (%)			...	...	8.0	9.2	...	...	3.4	0.6	3.5	1.9				
Total number of prey items			35	25	176	257										
Total biomass of prey (g)			17,973	13,113	30,870	73,626										

^a Prey mass was estimated using values from the archives of the IINH, Cramp and Simmons (1977, 1983), Cramp (1988), and Cramp and Perrins (1994).

^b The Common Ringed Plover (*Charadrius hiaticula*) and the Dunlin (*Calidris alpina*) could not be separated based on bone size and are combined here as "Small shorebird".

Central Highlands are in alpine tundra and far from lowland areas, whereas the Westfjord study area is also located in alpine tundra but adjacent to lowland valleys. Lowland species such as Common Snipe, Whimbrel (*Numenius phaeopus*), Common Redshank (*Tringa totanus*) and Redwing (*Turdus iliacus*) were frequent prey items in the Westfjords study area, but not found among pellets collected at the Central Highland sites. The Pink-footed Goose (*Anser brachyrhynchus*), an important prey at the Central Highland study sites, does not nest in the Snowy Owl area in the Westfjords.

Snowy Owls in other regions without lemmings also prey on a variety of bird species during the breeding season. On Agattu Island, Alaska, birds taken included Ancient Murrelet (*Synthliboramphus antiquus*), storm petrels (*Oceanodroma* spp.), Lapland Longspur (*Calcarius lapponicus*), Snow Bunting, and Green-winged Teal (*Anas crecca*; Williams and Frank 1979). On the Shetland Isles, besides the main prey European rabbit (*Oryctolagus cuniculus*), birds such as the Eurasian Oystercatcher (*Haematopus ostralegus*) and Parasitic Jaeger (*Stercorarius parasiticus*) are important (Tulloch 1968). Other bird species occasionally taken on the Shetland Isles include Rock Dove (*Columba livia*), Common Tern (*Sterna hirundo*), Northern Lapwing (*Vanelus vanellus*), Common Redshank, Whimbrel, Common Snipe, and Eurasian Skylark (*Alauda arvensis*). Consumption of arctic fox pups by Snowy Owls is rare, but has also been reported from areas with lemmings such as Wrangel Island (Krechmar and Dorogoy 1981) and northeastern Greenland (Gilg et al. 2006).

The only wild rodent living away from human habitations in Iceland is the wood mouse; it only occurs sporadically within the Central Highlands (Hersteinsson 2004). This species may be more important for the Snowy Owl in winter, when birds are more likely to be observed in lowland areas, than during the breeding season. A winter pellet from northeast Iceland contained six wood mice (ÓKN unpubl. data), and another from west Iceland contained four mice (Bergmann 2007).

It is of interest to note that another lemming specialist, the Long-tailed Jaeger (*Stercorarius longicaudus*), is also a rare breeding bird in Iceland (Bergmann 2008). Its nesting grounds are not alpine tundra (the preferred habitat of the Snowy Owl), but the heathland areas in northeastern Iceland, where the jaegers have been seen preying on moorland birds such as the Common Snipe (ÓKN unpubl. data).

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