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Diet of Finnish Snowy Owls *Nyctea scandiaca*

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The Snowy Owl has, during the last 70 years, bred in Finnish Lapland only in 1974, 1987, and 1988. We collected diet material directly from nest bowls, and from pellets found around the nests and at the resting sites of adults and young. These three parts may give different results of the diet. In the identification, bones of legs and pelvis were used. The Norwegian lemming was the main prey, but also *Clethrionomys*- and *Microtus*-voles had large parts in the diet. This diet composition has not been observed earlier. The invasions of Snowy Owls to south have sometimes reached areas with good vole populations, but in other cases the owls have successfully preyed upon larger mammals and birds. The Snowy Owl is thus an effective and opportunistic bird of prey, but breeding is possible only if lemmings or voles are available in very large numbers in the arctic breeding area.

1. Introduction

The Snowy Owl is a circumpolar species that breeds almost exclusively on the arctic tundra (e.g., Cramp 1985). In Fennoscandia, its breeding habitat is the tundra-like fell heath above the tree line. The breeding is at least in Fennoscandia very irregular, and in Finland it breeds only occasional. During the last 70 years only three breeding years are known by ornithologists in Finnish Lapland (1974 and 1987–1988, Hakala *et al.* 1974, Forsman 1995). In the arctic tundra, Snowy Owls are nomadic, searching for areas of rich populations of lemmings (e.g., Mikkola 1983). Breeding is observed only in the peak years of the lemming populations (e.g., Watson 1957, Portenko 1972). This is understandable in the arctic tundra, where often only lemmings of the genera *Lemmus* and *Dicrostonyx* are available as small mammal prey (e.g., Watson 1957, Wiklund *et al.* 1998).

Only a few studies have been published on the diet of breeding Snowy Owls, most of them several decades ago. The most recent study from Fennoscandia is over 30 years old (Andersson & Persson 1971), and from North America still older (Watson 1957). More recent material exists only from the Siberian tundra (Wiklund *et al.* 1998). Only scattered observations exist on the diet of the few non-breeding Snowy Owls staying in the breeding areas in years of low lemming- (vole-)

populations (e.g., Wiggins 1953, Portenko 1972). The focus of this study is on the last breeding years of the Snowy Owl in Finland, 1974 and 1987–1988. Diet samples were collected in all of these three years, mainly from nesting sites (Hakala *et al.* 1974, Hytönen 1989). Parts of this material have been published in popular bird books (e.g., Mikkola 1983, Forsman 1995). Small samples are available also from "wintering" sites in southern Finland. This study deals with and discusses the methods used in studying the diet of the Snowy Owl, the diet of the Snowy Owl in Finland in different breeding areas and years, and the diets of Snowy Owls in different parts of the circumpolar breeding area and in wintering sites.

2. Materials and methods

The material for this study was mainly collected directly from the nesting sites of the Snowy Owl. In Enontekiö in 1974 the owls bred on the slightly undulating mountain heath 700–900 m above the sea level. The nests were situated on low elevations of the slopes (Hakala *et al.* 1974). In Utsjoki, breeding took place in 1987 on the peat bogs in the valleys between the fells, where the nests were most often placed on the large peat hummocks (*palsas*). In 1988 the nests in Utsjoki were, as in Enontekiö in 1974, higher up on the mountain heath (Hytönen 1989). In Enontekiö, there were in 1974 about 30 nesting pairs, but only five nests were monitored closely. In Utsjoki, 15 pairs were breeding in both years (1987–1988). The total food material amounted in Enontekiö to 2062 and in Utsjoki to 709 prey individuals.

The material collected from the nest sites consists in this study of pellets and the hair and bone mass from the nest bowls (from broken pellets), and a few feathers of the prey birds. Pellets are found around the nests, at the resting sites (often stones) of adult owls and from the resting places of the young that have left the nest. During most of the nestling time the pellets are left in the nest, where they form a layer several centimetres thick (Watson 1957). In Enontekiö, pellets were collected also from the resting sites of non-breeding owls, and also outside of the breeding season.

Andersson & Persson (1971) identified and counted the small mammal prey only from the skulls and jaws found. Koivusaari *et al.* (1977) showed in captivity that the pellets of the Snowy Owl preserve well most bones from the eaten small mammals. Sometimes, however, a few bones may come out in the pellet after the next meal (Watson 1957). In this study the prey individuals have been identified and counted on the basis of both skulls (and jaws) and bones from the legs and pelvis. The bones of small voles have, however, been identified only as "vole sp." (voles and lemmings). On the basis of especially *tibias* and *femurs* the total number of voles has often become larger than on the basis of only skulls and jaws, and this total presumably was a closer estimate of the number of prey.

3. Results

3.1. Diet in Finland in 1974 and 1987–1988

3.1.1. The total diet at the nest sites in Enontekiö and Utsjoki

The Norwegian lemming (*Lemmus lemmus*) has in all years been, by number, the most used prey, but its percentage has large differences between the parts of the material (Table 1). In Enontekiö, its proportion was in the two study years 30–33%, but in Utsjoki 48–58%. The largest percentage was observed in Utsjoki in 1988. The grey-sided vole (*Clethrionomys rufocanus*) has, by number, the second place in the diet: 26–28% in Enontekiö and in Utsjoki somewhat less, 20–22%. The root vole (*Microtus oeconomus*) has been the third important prey species; its percentage has been changing only a little, 11–17% in different parts of the material. The total percentage of *Microtus*-species was larger in Enontekiö (21.2%) than in Utsjoki (13.9%).

Small voles (including lemmings) have thus been the sole important food source for the Snowy Owls breeding in Finland, 92–98% of the prey individuals in the different parts of the material. Other mammals are only occasional in the diet, about 1% in both areas (Table 1). Birds have also been only occasional prey in Enontekiö (1%). In Utsjoki, Snowy Owls fed on birds more often. Ten individuals (1.4%) of the bird prey were *Lagopus*-species. In Enontekiö, Snowy Owls had eaten also

Table 1. Diet of the Snowy Owl in Finnish Lapland 1974 and 1987–1988. The percentage of individual prey items found is given.

Prey item	Study area and year							
	Enont Nests 1974	Enont Sum 1974	Enont Win 74–75	Enont Nest 1987	Utsj Nests 1987	Utsj Nests 1988	Enont total 74–87	Utsj total 87–88
Norwegian lemming, *Lemmus lemmus*	32.7	40.6	31.3	30.4	48.2	58.1	32.5	56.1
Grey-sided vole, *C. rufocanus*	28.3	20.3	23.1	25.5	22.0	20.1	28.0	20.5
Red vole, *C. rutilus*	1.9	5.2	0.5	–	–	0.2	1.7	0.1
Clethrionomys sp.	3.2	4.8	4.2	–	2.1	0.4	3.0	0.7
Root vole, *M. oeconomus*	12.2	9.6	12.6	16.7	13.5	10.9	12.6	11.4
Field vole, *M. agrestis*	4.8	6.4	6.8	2.0	–	–	4.5	–
Microtus sp.	4.0	6.8	3.9	4.9	4.3	2.1	4.1	2.5
Water vole, *Arvicola terrestris*	–	–	0.5	–	–	–	0.1	–
Microtidae sp.	10.7	2.8	14.4	12.7	2.8	3.4	10.9	3.2
Microtidae, total	97.8	96.5	97.3	92.2	92.9	95.2	97.4	94.6
Common shrew, *Sorex araneus*	0.2	0.4	0.2	–	–	–	0.2	–
Mountain hare, *Lepus timidus*	0.1	.	0.6	1.0	–	0.2	0.2	0.1
Weasel, *Mustela nivalis*	0.1	–	0.3	–	–	0.7	0.1	0.6
Stoat, *Mustela erminea*	–	–	–	1.0	–	0.5	0.1	0.4
Red squirrel, *Sciurus vulgaris*	0.5	–	–	–	–	–	0.4	–
Reindeer (carcass), *Rangifer tarandus*	–	–	–	1.0	–	–	0.1	–
Grouse, *Lagopus* sp.	0.3	1.2	0.5	–	1.4	1.4	0.3	1.4
Golden Plover *Pluvialis apricaria*	–	–	–	–	0.7	0.4	–	0.4
Ruff *Philomachus pugnax*	–	–	–	–	0.7	0.2	–	0.3
Wood Sandpiper, *Tringa glareola*	–	–	–	–	–	0.2	–	0.1
Calidris sp.	–	–	–	–	0.7	–	–	0.1
Teal, *Anas crecca*	–	–	–	–	2.1	–	–	0.4
Scaup, *Aythya marila*	–	–	–	–	0.7	–	–	0.1
Snowy Owl juv., *Nyctea scandiaca*	–	–	–	–	–	0.9	–	0.7
Turdus sp.	–	–	0.2	–	–	–	+	–
Charadriidae & Scolopacidae sp.	0.2	–	–	2.0	0.7	0.4	0.3	0.4
Small bird sp.	0.5	0.4	0.5	1.0	–	0.2	0.5	0.1
Aves, total	1.9	2.0	2.3	6.0	7.0	3.7	1.1	3.9
Frog, *Rana* sp.	0.5	–	0.6	–	–	–	0.4	–
Fish, Pisces sp.	–	1.6	–	2.0	–	–	0.3	
Number of prey	1,050	251	659	102	141	568	2,062	709
Nests studied	5	–	–	1	6	12		

Enont = Enontekiö area, NW Finnish Lapland
Utsj = Utsjoki area, NNE Finnish Lapland
Sum = summer, Win = winter

some frogs and two salmon fish (obviously brown trout from the brooks of the area).

3.1.2. Diet of non-breeding Snowy Owls in Enontekiö in 1974–1975

In addition to breeding pairs, several single Snowy Owls were observed in Enontekiö in summer 1974; no signs of nesting were found at their staying sites. Pellets were collected at the resting places of 11 non-breeding owls, and 251 prey individuals were identified from the pellets. The diet of the non-breeding owls was rather close to the diet of the breeding pairs (Table 1). The main prey were the same (lemming and the grey-sided vole), but their percentages were different: the non-breeding owls fed more on lemmings, but less on grey-sided voles ($\chi^2 = 8.25$, P = 0.041). The hunting grounds of non-breeding owls may have been partly in different habitats if compared with breeding pairs.

Local Snowy Owls (n = 10) were seen in Enontekiö in 1974–1975 also outside of the breeding season, and a large number of pellets were collected at their staying sites (mostly at resting stones) (A.K.). In total, 659 prey individuals were identified from the pellets (Table 1). The composition of this diet is very near to the diet of the breeding pairs in the summer of 1974, e.g. Norwegian lemmings have a percentage of 31–33%.

3.2. The diet of Snowy Owls in the "wintering" areas in southern Finland

The invasions of the Snowy Owl to south have in a few cases reached areas where small voles have been the main food for them. This happened in Finland in the winter of 1961–1962, when many Snowy Owls were wintering in the outer archipelago of the southern coast of Finland. K. Mikkola and U. Skaren collected pellets in January 1962 (on Rönnskär island) and identified from the pellets 110 prey, 109 field voles (*Microtus agrestis*) and one Long-tailed Duck (*Clangula hyemalis*). In the same winter, some Snowy Owls were also wintering in the wide fields of western Finland (Southern Ostrobothnia), where they (according to a small pellet sample from Ilmajoki, 36 prey) also fed only on *Microtus*-species (here *Microtus rossiaemeridionalis*, Sulkava S. & P. 1967). In the winter of 1974–1975 Snowy Owls and their pellets were again found on the islands of the southern coast of Finland, and 53 prey were determined (by A. K.). Voles were the main prey (85%), but most were water voles (*Arvicola terrestris*), and 20% of prey were birds of several species.

4. Discussion

Lemmings have often fully dominated the diet materials collected from the breeding sites of Snowy Owls (see our Table 2). According to some earlier reports the breeding Snowy Owls feed mostly on lemmings also in areas, where other voles are available, too (e.g., Gabrielson & Lincoln 1959, Hagen 1960). Diet materials from the breeding season have in Scandinavia been published from Sweden (Andersson & Persson 1971) and from Norway (Lövenskiöld 1947 and Hagen 1960). In 1994, a Swedish expedition collected diet material from several places in the coastal tundra of northern Siberia (Wiklund et al. 1998), and in 2002 P. Saurola (unpubl.) collected pellets of breeding Snowy Owls in Taimyr peninsula (Table 2). Despite of the large temporal dispersion of the materials available, small voles (including lemmings) have in all areas been almost the sole food of breeding Snowy Owls with 96–99% of prey individuals (Table 4). The distribution of prey between the vole genera (lemmings, Microtus and Clethrionomys) has, however, been very different in separate cases. Only in Fennoscandia have Snowy Owls been breeding in areas (high mountain heaths), where also other small voles than lemmings may be available in large numbers. In Norway, *Microtus*-voles (*M. oeconomus*) have already been the main food of breeding Snowy Owls. Our study shows that also a *Clethrionomys*-species (*C. rufocanus*) may be a very important part of the breeding time diet. However, small voles (including lemmings) together clearly are also in Fennoscandia almost always the sole food of breeding Snowy Owls.

Lemmings have been the sole food only in the Siberian tundra (99%, there have been two lemming species available in both Siberian materials). In Sweden, Norwegian lemmings amounted in

Table 2. Overview of the diet of breeding Snowy Owls in Fennoscandia and on the Siberian tundra

	1 FIN %	2 SWE %	3 NOR %	4 NOR %	5 SIB -94 %	6 SIB -02 %
Lemmus	41.5	90.3	17.9	84.6	71.8	67.8
Dicrostonyx	–	–	–	–	26.8	31.6
Clethrionomys	28.4	1.0	0.1	–	0.1	–
Microtus	18.4	7.3	80.6	10.8	0.4	–
Microtidae sp.	8.0	–	–	1.0	–	–
Small voles, total	96.3	98.6	98.6	96.4	99.1	99.3
Other mammals	1.1	0.5	0.5	–	0.3	–
Birds	2.4	1.0	0.8	3.4	0.6	0.7
Other prey	0.4	–	0.1	–	–	–
Number of prey	1,861	206	1,395	288	994	152
Food niche	2.92	1.22	1.47	1.37	1.70	1.79

1. FIN = Finnish Lapland 1974 and 1987–88
2. SWE = Swedish Lapland 1969–70 (Andersson & Persson 1971)
3. NOR = Hardangervidda 1934 (Lövenskiöld 1947, from Cramp 1985)
4. NOR = Hardangervidda 1959 (Hagen 1960)
5. SIB 1994 = Siberian tundra (Wiklund et al. 1998)
6. SIB 2002 = Siberian tundra, Taimyr (P. Saurola 2002, unpubl.)

1969–70 in the diet to 85% and in the older Norwegian material (from 1959) to still more, 90% (Table 2). In Finnish Lapland (in 1974–88) lemmings occurred in the diet in a much lower proportion, on the average 41.5%. In the old Norwegian material from Hardangervidda (in 1934) the proportion of lemmings was still much lower, only 18%, and *Microtus*-species were then the main prey (81%).

Finnish Lapland is the only area where all three vole genera simultaneously have comprised large proportions of the diet of the breeding Snowy Owls. This rather even relation was about the same in all three breeding years and in both breeding areas in Finland in all years studied (Table 1). Therefore, the food niche value of the Snowy (calculated according to the prey groups in Table 2) Owl is in Finland much larger (2.9) than in other areas (1.2–1.8).

When collecting diet samples from the nest sites of the Snowy Owl one should collect carefully 1) the total hair and bone (pellet) mass layer from the nest bowl, 2) pellets near the nest bowl (to a distance of some metres) and 3) pellets from the surrounding (to 200–300 m from the nest) at the resting sites of adults and young. These three parts of the material originate partly from different periods of the breeding season, and therefore they may give somewhat different compositions of the diet. Additionally the pellets underestimate the number of greater prey, especially birds in the diet; these prey are more often found in the nest material (large bones and feathers, Portenko 1972, Cramp 1985). Prey species were earlier often identified on the basis of skulls and jaws only (e.g., Andersson & Persson 1971). All large bones of the prey (e.g., *tibia, femur, pelvis*) should, however, be used in identifying. It is often observed that the head is lacking in many of the prey brought to the nest (eaten by the adults before bringing to the nest) (e.g., Pitelka *et al.* 1955, Watson 1957). From these prey only the bones of the body and legs may be left in the nest. In some studies the extra prey brought to the nest have been mentioned as a separate part of the diet material; such caches of 5–10 prey individuals have often been observed (e.g., Sutton & Parmelee 1956, Watson 1957), but also a store of 83 prey has been found (Pitelka *et al.* 1955). In this study such caches were not found, because the material was collected after the nestling time.

There are only some observations on the diet of the few non-breeding Snowy Owls staying in summer in breeding areas (after the crash of the vole/lemming populations); birds (often *Lagopus*-

species) seem to be their main prey (Wiggins 1953, Portenko 1972). Among the Aleutian breeding islands there is a large island (22 km^2), where no mammals are available. Adult Snowy Owls stay here in summer and feed only on birds (and do not breed, Williams & Frank 1979). In Finnish Lapland (in 1974), several non-breeding Snowy Owls were local in a situation where other owls simultaneously bred in the same area. In this case, the diet of non-breeding individuals was similarly dominated by voles and lemmings as was the diet of breeding pairs (Table 1).

In Fennoscandia, the root vole and the grey-sided vole are the basis for the breeding of the Snowy Owl. The dominance of lemmings in northern tundra areas stems from the fact that there only lemmings are available as small mammal prey. In the Siberian tundra, the Snowy Owl has sometimes seemed to prefer one of the two lemming species; the Snowy Owl is, however, here probably an opportunist, and the availability determines the relation of the species in the diet (Portenko 1972, Wiklund *et al.* 1998).

The hunting ability of the Snowy Owl is very diversified, even if the breeding time diet is almost only small voles. The versatility is shown by the diets in the southern wintering areas, where the Snowy Owl may successfully prey on different birds and larger mammals (e.g., Gross 1944, Campbell & MacColl 1978). Lemmings and small voles when peaking in their abundance are food items that are reached quickly and hunted easily enough during breeding. Voles and lemmings are available also during the late winter and early spring before breeding. The Snowy Owl is a good example of the specialization of breeding birds of prey in the north.

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Tunturipöllön ravinnosta Suomessa

Tunturipöllö pesii Suomen Lapissa harvoin, viimeisten 70 vuoden aikana vain kolmena vuonna, 1974 Kilpisjärvellä ja 1987–88 Utsjoella. Kaikkina vuosina ja molemmilta pesimisalueilta kerättiin ravintoaineistoja, joiden määritystuloksista on tätä aikaisemmin vain osia esitelty yleisissä lintukirjoissa. Aineistoina ovat pesäkuoppiin kertyneet saalisjätemassat ja pesien ympäristön oksennuspallot aikuisten ja maastopoikasten lepopaikoilta. Kaikki nämä osa-aineistot olisi hyvä kerätä, koska ne voivat olla koostumukseltaan erilaisia. Saaliiden määrityksessä on käytetty kallojen ja leukojen lisäksi myös raajojen ja lantion luita. Kun osa saaliseläimistä tuodaan pesälle päättöminä, saadaan myös vartalon luita käyttäen oikeampi tulos.

Tunturisopuli oli molemmilla alueilla eniten käytetty saalislaji (lukumäärien mukaan eri tapauksissa 30–58 %), mutta myös sekä metsämyyrän että peltomyyrän sukuisilla myyrillä (Clethrionomys- ja Microtus-lajeilla) oli ravinnossa huomattavat osuudet (eri tapauksissa 11–21 %). Näin monipuolista pesivien tunturipöllöjen ravinnonkäyttöä ei aikaisemmin ole havaittu. Aikaisemmissa raporteissa eri puolilta tunturipöllön arktista pesimisaluetta sopulit ovat useimmiten olleet vallitseva pääravinto, 85–99 % saaliseläimistä, vain kerran (Norjassa) Microtus-laji (lapinmyyrä) 81 %.

Pesimisalueelta etelään (ravinnon loppuessa pesimisalueella sopuli/myyräkantojen romahdettua) vaeltaneiden tunturipöllöjen ravinto on ollut eri tapauksissa hyvin erilaista. Joissakin tapauksissa vaeltajat ovat osuneet hyvälle myyräalueelle, mutta usein erilaiset linnut ovat voineet muodostaa pääosan ravinnosta. Suomessa vaeltajia pysähtyy talveksi Pohjanmaan peltoaukeille, jos siellä on hyvä myyrävuosi. Etelä-Suomessa pöllöt törmäävät Suomenlahteen, jonka ulkosaarilla on toisinaan osunut olemaan hyvä myyrävuosi (silloin pöllöjen ravinto on ollut lähes pelkkiä peltomyyriä), toisinaan taas pöllöjen on ollut tyydyttävä sekalaiseen jopa lintuvoittoiseen ravintoon.

Tunturipöllö voi siten olla tarvittaessa hyvin monipuolisesti saalistava petolintu. Yleinen pesiminen on kuitenkin mahdollista vain, jos populeita ja/tai muita myyriä on hyvin runsaasti tarjolla; käytetty on ravinto tällöin lähes pelkkiä pikkumyyriä.

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