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Changes in the diet of the Golden Eagle *Aquila chrysaetos* and small game populations in Finland in 1957–96

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Prey remains and pellets were collected in 1957–97 from the nest sites of the Golden Eagle in the Finnish reindeer husbandry area and in the area south of it. In addition to main prey, mountain hares and grouse, the Golden Eagle often catches also larger prey (Cranes, reindeer calves, adult red foxes), but also much smaller species (red squirrel, stoat, water vole, thrushes). Many waterfowl are included in the diet too, but only very few gulls. Diet percentages of grouse and cranes (51% and 2%) are larger south of the reindeer area, where that of reindeer calves is about eight percent. The annual changes in the densities of mountain hares and grouse have caused corresponding changes in the percentages in the diet of the Golden Eagle. There are exceptions in these correlations between main prey and their percentages that are explained by the changes in the density of the other main prey. Waterfowl, corvids and red foxes are alternative prey in Finland. In other parts of Europe the main prey may include also hedgehogs, marmots and reptiles.

1. Introduction

The Golden Eagle breeds in the northern half of Finland and isolated pairs are also found further south (Fig. 1). Its breeding and diet have been monitored annually since 1958, when the Finnish Nature Conservation Society sought information on nesting sites (Sulkava 1959). Since then most known nests have been checked yearly in June–July. Several summaries of the results have been published (Linkola 1962, Sulkava 1968, Salminen & Sulkava 1976, Virolainen & Rassi 1990 and Ollila 1997). The number of known breeding pairs (territories) doubled from about 100 in the early 1970s to about 200 in the 1990s.

Prey remains and pellets have been collected annually from some nesting sites and sent to the Department of Zoology at the University of Oulu for identification (S. Sulkava). Reports on this material have been published by Sulkava (1959 and 1966) for sites south of the reindeer husbandry area, by Sulkava and Rajala (1966) for the reindeer area, and by Huhtala et al. (1976) and Sulkava et al. (1984) for both areas.

In the other northern countries notable reports on the diet of this species have been published in Sweden (Tjernberg 1981, 1983, Högström & Wiss 1992) and less comprehensive ones in Norway (Hagen 1952, 1976, Haftorn 1959), Russia (Semenov-Tian-Shansky 1959) and Estonia (Zastrov

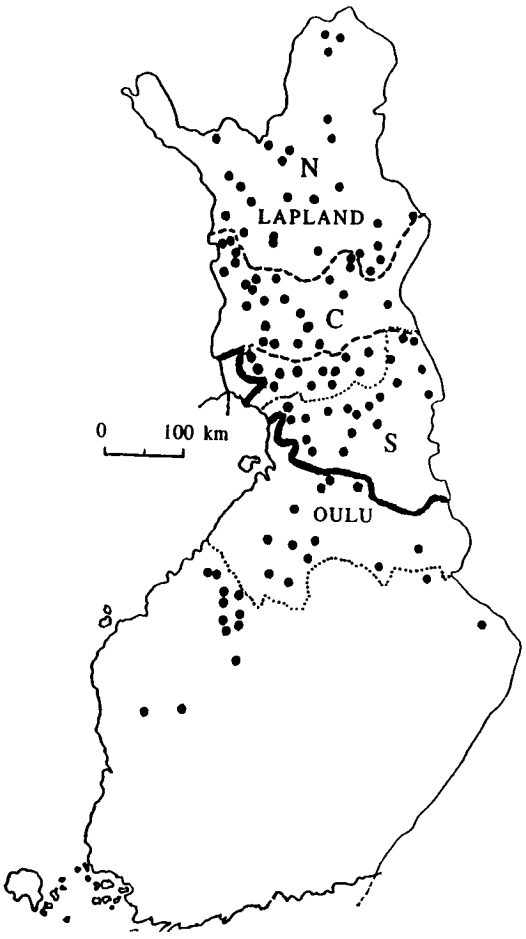

Fig. 1. Areas studied here, containing most of the Golden Eagle territories from which prey remains were collected in 1957–97. Solid line = southern boundary of the reindeer husbandry area; broken line = boundaries of the southern, central and northern zones distinguished here for the reindeer area; dotted lines = provincial boundaries; black dots = Golden Eagle territories where prey remains have been collected.

1946, Randla 1976). Further south in Europe dietary studies have been published in Scotland (Lockie & Stephen 1959, Brown & Watson 1964, Lockie 1964, Lockie et al. 1969, Everett 1971, Watson et al. 1992, Watson 1998), and in the Alps (Uttendörfer 1952, Stemmler 1956, Iselin & Hämmerle 1960, Haller 1982, 1996). The Golden Eagle also breeds in North America, where several dietary studies have been published, e.g., an older summary by Olendorff (1976) and a more recent comparison of methods by Collopy (1983).

This article discusses the diet of the Golden Eagle in Finland in 1957–1997, its regional and annual trends, and correlations with fluctuations in tetraonid and hare populations.

2. Methods and materials

2.1. Areas studied

The material on the diet of the Golden Eagle originates from its entire breeding area in Finland, extending from Southern Ostrobothnia and Northern Karelia (both at about 63°N) to the far north of Lapland (69°N), where the Golden Eagle breeds up to the northern and upper limits of the pine forests (Fig 1).

The composition of the diet is described separately for two main areas: the reindeer husbandry area and the area south of it, while in the reindeer area it is described in three zones, the southern, central and northern parts (Fig. 1).The boundaries between the zones are drawn along boundaries of administrative communes thinking also on the distribution of the material. In all the areas and zones the Golden Eagle breeds mostly in pine-dominated forests, often near wide, open mires which cover 50–70% of the land area over large areas (Atlas of Finland 1960), or on the slopes of hills. Large clear-cut areas have often increased the openness of the hunting terrains of the eagles during recent decades.

2.2. Sampling and identification of diet material

Prey remains were collected from all parts of the breeding area of the Golden Eagle throughout the period concerned (1957–96), but the activity of sampling varied somewhat between the areas, years and decades (mostly 10–30 nesting sites per year). The authors took part in the sampling most intensively in the 1960s and 1970s, when staff at the Meltaus Wildlife Research Station in central Lapland was also studying the Golden Eagle. The majority of the diet samples were collected by volunteer ornithologists or persons authorized to check the breeding of this species.

Sampling at the nests. The nest of the Golden

Eagle in Finland is nearly always in a tree (mostly in pines), but it occasionally nests in measuring towers and exceptionally on a rock shelf. Most of the prey remains and pellets were found in the nest and on the ground underneath it, since they originate from the nestling time, but some remains were also found under resting trees and at feeding sites. The perching (resting) trees are most often pines with thick branches located some 50–200 m from the nest. The female sometimes flies from the nest to a perching tree with prey remains and then drops them. Pellets of adult eagles are also found under these trees. During the incubating period the female eagle may have her feeding sites 40–400 m from the nest, mostly on large stones, but sometimes also on open bog nearby.

Most samples contain prey remains only from the nestling time, and in most cases remains were collected only once a year, in connection with checking of the breeding or ringing the young. In the southern zone of the reindeer area (in the province of Oulu) many large samples were collected in August, after the breeding season, especially in 1989–97. In the eagle research conducted by the Meltaus Game Research station in the 1960s and 1970s material was collected from some nests several times during the breeding season.

Samples and identification of prey. The samples differed greatly in size, so that only a few prey individuals were identified in some samples, while 50–100 were obtained from large ones. Most samples contained remains of 10–30 prey individuals, a rather small number, but still satisfactory; McGahan (1968), for example, found an average of 10.3 prey items per sample in 95 samples in the U.S.A. Many of the small samples were collected during short visits early in the nestling season, and many large samples after breeding, when more time is available to search for remains without disturbing the eagles.

The samples originate from about 100 nesting sites (territories). It is not possible to give an exact number of pairs involved, because many of the nesting trees were destroyed by felling over this long period and the eagles sometimes moved long distances to new sites. All the samples were identified by the authors (SS, KH and RT), mostly in the Department of Zoology of the University of Oulu, where a large reference collection is available in the Zoological Museum. Technical assistance was available for preliminary sorting of the samples in some years.

For identication purposes the prey (remains) were divided into fresh items (prey from the sampling year) and old items (prey from previous years). Old remains were ones in which soft tissues had disappeared, the bones were often greenish and the feathers softened. Bone remains from the sampling year normally have at least some tendons still attached. The difference between fresh and old remains is mostly quite clear, but tendons can remain on dried bones at least over one winter. In the case of large prey species (hare, fox, tetraonids, geese, crane) adult and young specimens were distinguished based on the ossification of bones.

The pellets of the Golden Eagle contain for the most part compressed feathers, hair and small bones. These may partly be from the same prey items as the larger remains. New individuals were included in the prey material on the basis of the pellets only if these had not been found in other remains in the sample (the procedure also followed by Collopy 1983, for example). Pellets are very important for the identification of small prey animals, however, and most of the squirrels, voles, weasels, thrushes etc. in this material were identified only in pellets.

If more than one sample was collected from the same nesting site during one summer, the remains of the larger prey items were compared, as remains from the same individual prey animal could occur on different occasions. When assessing the numbers of prey species, size differences in the bones (between the sexes or individuals) were also taken into account, and right and left side bones were counted separately (as by Mollhagen et al. 1972, for example). The numbers of individuals of each prey species in the material therefore represent minimum numbers during each breeding season.

2.3. Sources of error amongst prey remains

Not all prey individuals eaten at the nest can be identified from remains. Even if remains are collected once a week, only half of the individuals are found (Collopy 1983). Small prey may be eaten whole, and some small remains may be removed

by wind or rain, or may simply not be found. Large remains may be carried away from the nest by the female eagle, and the female may also remove pellets of the young by eating them (Glutz v. Blotzheim 1971, Mollhagen et al. 1972). Larger prey remains may sometimes be removed from under the nest by predatory mammals and even by people (to protect the nest, Collopy 1983, Högström & Wiss 1992). The number of individuals of a species may also be underestimated, in that several individuals may be eaten, but so few remains may be left that the correct number of individuals cannot be determined.

Sources of error are more serious in the material of old remains (from previous years). Small bones are more difficult to find, and small feathers and hair tufts disappear (large feathers and quills may remain but can be difficult to identify), while pellets may brake up. For more comments on differences between fresh and old material, *see* Section 3.2.

2.4. Fluctuations in prey populations

Data on fluctuations in the populations of the main prey of the Golden Eagle, the mountain hare and grouse species (Tetraonidae), were obtained from the Game Division of the Finnish Game and Fisheries Research Institute. The relative abundance of the mountain hare population in spring and early summer is best shown by the results of the wildlife inquiries made during the previous winter, in which local hunters (the provinces of Oulu and Lapland, which are concerned here, have 150 local hunting associations) estimate the abundances of game species on a scale of 0–3 (3 = more abundant than average, 2 = average abundance, 1 = less abundant than average and 0 = absent, *see* Lindén 1991, for example). The winter inquiry indicates relative abundances in mid-winter, but also reflects fairly well the situation during the breeding season of the Golden Eagle, because most of the hares in the prey material (97%, *see* Appendix) are adult animals (mainly from the nestling period of the Golden Eagle in May–July).

The tetraonids in the diet material are also mainly adults (98%, *see* Appendix), and fluctuations in their populations are best shown by the tetraonid censuses carried out during the previous autumn (in August in 1964–83 and since 1989, in July in 1984–88, Lindén 1989, Lindén et al. 1996). The results of the censuses are given as densities (individuals/km^2) but this was somewhat biased in 1964–88, because the counts were made along routes chosen so as to pass through the best grouse terrain (Rajala 1974, Rajala & Lindén 1982). Since 1989 the counts have been performed as wildlife triangles along straight compasslines and the results now represent the real density (Lindén et al. 1996). The differences between the results of route and triangle censuses are so small, however, that they do not disturb the picture of the annual fluctuations in the tetraonid populations (Lindén et al. 1989, 1996). Some inaccuracy in the populations in the next spring and summer may nevertheless be caused by the fact that mortality among tetraonids may vary in different winters (Rajala 1974, Lindén 1981), sometimes on account of changes in the length of the hunting season in autumn. The results of direct field counts of tetraonids are, however, probably a more accurate estimate of fluctuations in their abundance, than are the relative results of winter inquiries used for the mountain hare.

In the comparisons between diet and prey populations the mean densities of grouse (excluding the Hazel Grouse) in the districts of Oulu and Lapland are used. The fluctuations in these districts have in most years been in the same direction, although some differences have occurred (Lindén 1989).

3. Results

The material from the years 1957–96 contains in total 12 907 prey individuals (*see* Appendix) of which 10 290 ind. were from the reindeer husbandry area and 2 617 from the Golden Eagle area south of this. Data contained 6 907 fresh prey individuals (from the sampling year) and 6000 old specimens (from previous years).

The Golden Eagle preys on a great variety of species in Finland, both birds and mammals, and occasionally some snakes (vipers) and frogs. The total material (fresh and old prey) represents 57 bird species and 19 mammals (*see* Appendix). A large proportion of these are caught only occasionally, so that 50 species (63% of all prey spe-

cies) are represented in the total material by less than 10 individuals (less than 0.08% of all prey individuals).

The largest prey items caught regularly during the breeding season — Cranes, male Capercaillies, reindeer calves, adult red foxes and mountain hares — have an average weight of 3.9–5.5 kg, and are often heavier than the male Golden Eagle, which brings most of the prey to the nest. In most cases Golden Eagles cannot carry these to the nest whole, as the maximum weight that a bird of prey can carry is considered to be equal to its own weight (the male Golden Eagle 3.8 kg and the female 5.3 kg) (Glutz v. Blotzheim 1971, Fischer 1976).

The smallest prey items that the Golden Eagle frequently catches are squirrels, stoats, water voles and thrushes (average weights 100–300 g). Some small birds (20–40 g) and several small mammals have also been identified in the pellets of the Golden Eagle. Small mammals found in pellets were excluded here, if remains of a bird of prey feeding on small mammals (e.g., Short-eared Owl) was found in the same sample (the small mammals may originate from its stomach).

The mountain hare is the most common prey species of the Golden Eagle in Finland, accounting for 33% of the fresh material from the reindeer area and 30% from the area further south (*see* Appendix). The second most numerous is the Capercaillie (16 and 23%), followed by the Black Grouse (11 and 20%) and Willow Grouse (8% in both areas). Reindeer calves are important preys in the reindeer area, accounting for 7.7% of the prey items found among the remains. These five species constitute 79–80% of the prey individuals. Other species that make up more than 1% of the diet, at least in one of the main areas, are the Crane, Mallard, Bean Goose, red squirrel and Raven, and the diet also includes the following seven species fairly regularly (0.5–0.9%): the Hooded Crow, Short-eared Owl, water vole, muskrat, red fox, pine marten and stoat.

Among the prey groups, the tetraonids (grouse) dominate in numbers, with 36% of the fresh prey individuals in the reindeer area and 51% further south (*see* Appendix), and waterfowl are an important group, too (5–7%). Waders, birds of prey (mainly owls), crows and thrushes constitute about 1% each (0.4–2.6% in different areas). Among the mammals, mountain hares and reindeer calves are the main prey and only rodents and predatory mammals also occur in appreciable numbers (2.6–4.1 %).

Herring Gulls and Black-headed Gulls have bred on many of the open bogs and lakes in the Golden Eagle area since the 1950s, but during more than 30 years (1957–90) not a single gull was found among the prey. The gulls in the material (26 ind., 0.4% of fresh prey, *see* Appendix) all date from the 1990s.

3.2. Comparison of fresh and old material

According to the sources of error (Chapter 2.3.) the percentages of large prey species should be higher in the old material than in the fresh material and the percentages of small prey lower. There are, in reality, more large birds in the old material (mean weight over 2 kg: male Capercaillies, Bean Geese and Cranes, and occasionally a Whooper Swan or Black-throated Diver, 15.8 and 22.3% in the reindeer area and south of it, *see* Appendix) than in the fresh material (10.4 and 13.2%; for the differences $G = 34.2$ and 23.1, $p < 0.001$, relative to the number of other birds, *see* Appendix). The female Capercaillie (weight 1.8 kg) also has a significantly larger percentage in the old material from the reindeer area than in the fresh material ($G = 19.3$, $p < 0.001$).

Among the large mammals, the percentage of reindeer calves is larger in the old material than in the fresh material, as expected, (9.7%/7.7%, $G = 13.8$, $P < 0.001$), whereas the percentage of the mountain hare is larger in the fresh material (28.6% and 21.8%) despite its relatively large size (mean weight 2.8 kg). One reason for this discrepancy may be that some of the hares from previous years were identified as fresh because their thick tendons were preserved (*see* Section 2.2.). The proportion of this species in the fresh material is therefore often several percent too large. This error may also somewhat smooth over the annual fluctuations of the percentage of hares (although the fluctuation is fairly sharp, Fig. 2).

Smaller birds, as expected, have a higher percentage in the fresh material than in the old material. Birds less than 500 g in weight (the most numerous are the Short-eared Owl, thrushes, smaller

waders, the Hawk Owl, Teal and Hazel Grouse) have proportions of 3.5 and 1.9% in the fresh material in the main areas but only 1.0 and 1.2 in the old material (G-values 102.9 and 3.85, $p < 0.001$ and $p < 0.05$, relative to other birds).

There are also relatively more small mammals in the fresh material than in the old material. Mammals less than 400 g in weight (red squirrel, stoat, water vole, small voles) amount to 4.2% of all prey in the fresh material from the reindeer area, but only 1.1% in the old material, and to 3.4 and 1.4% respectively south of the reindeer area (the difference is significant in both areas, $G = 99.9$ and 10.97, $P < 0.001$).

Among the birds, the Black Grouse, Willow Grouse and Anatidae (excluding geese), for example, represent the size class 0.5–1.0 kg, where the fresh and old materials give the same result in the diet of the Golden Eagle (Table 1). Among the mammals, the pine marten, mink and muskrat, for example, belong to this size class.

The differences between the fresh and old materials are for both small birds and small mammals, however, fairly small (in absolute terms 1.6% and 2.6%), and the difference in the total percentages of large birds is also relatively small (7.3%). As the differences are partly significant, however, the fresh and old materials will be kept separate in this discussion. Only fresh material will be used in the comparisons between the yearly diets.

3.3. Regional differences in the diet

Several prey species and groups have about the same percentage in the diet of the Golden Eagle in all the four zones (Fig. 1), e.g., rodents, predatory mammals, waterfowl, owls and crows (Table 1), but there are also many significant regional

Table 1. Main prey of the Golden Eagle (%) in Finland in 1957–96 in four zones (shown in Fig. 1) from south to north (according to fresh prey remains). Food niche breadth = $1/\Sigma p^2$ (values of p for the prey species or groups from the columns in Tables 1 and 2).

	South of the reindeer area (%)	Zones in the reindeer area (%)		
		Southern	Central	Northern
Mountain hare, *Lepus timidus*	30.1	31.9	37.2	30.5
Red squirrel, *Sciurus vulgaris*	2.1	3.0	1.5	0.3
Muskrat, *Ondatra zibethica*	0.6	0.3	0.5	0.5
Red fox, *Vulpes vulpes*	0.9	1.3	0.9	1.0
Pine marten, *Martes martes*	0.7	0.6	0.6	1.1
Reindeer calf, *Rangifer tarandus*	–	6.1	8.8	12.4
Other mammals	2.0	2.6	3.5	3.1
Mammals, total	36.4	45.7	52.9	48.9
Willow Grouse, *Lagopus lagopus*	7.5	6.5	7.7	11.6
Black Grouse, *Tetrao tetrix*	19.6	12.0	9.4	5.2
Capercaillie, *Tetrao urogallus*	23.6	13.9	18.6	19.8
Tetraonidae, total	51.2	34.9	36.8	37.6
Bean Goose, *Anser fabalis*	1.8	3.8	1.7	2.6
Other waterfowl (Anatidae etc.)	2.6	7.2	2.8	2.9
Crane, *Grus grus*	3.5	1.6	0.8	0.3
Owls, Strigidae	0.3	1.4	1.3	2.6
Crows, Corvidae	1.0	2.9	1.9	2.3
Other birds	2.9	2.3	1.2	2.5
Birds, total	63.3	54.1	46.5	50.9
Other animals	0.3	0.2	0.6	0.2
Material, total ind.	1 595	3 387	1 049	873
Food niche breadth	5.14	6.51	5.03	5.94

differences. Mountain hares, for example, have been eaten more frequently in the central zone of the reindeer area than elsewhere, and the percentage of reindeer calves increases towards the north. The percentage of tetraonids is greater south of the reindeer area, as a result of the high values for the Capercaillie and Black Grouse, and the proportion of Black Grouse also decreases significantly towards the north within the reindeer area ($G = 5.36$, $P = 0.023$ for the difference between the southern and central zones). The percentage of Willow Grouse, as expected, is highest in the northernmost zone. Cranes are eaten by the Golden Eagle more frequently south of the reindeer area ($G = 17.2$, $P < 0.001$). The food niche seems to be somewhat wider in the reindeer area than south of it, mainly because of the considerable percentage of the reindeer calves (Tables 1 and 3).

3.4. Long-term temporal changes in the diet in 1957–96

In assessing for long-term changes, the total period 1957–96 was divided into six intervals of 5–8 years, with each period including one peak in the fluctuation of tetraonids (Rajala & Lindén 1982, Lindén et al. 1995) (Table 2). The total Golden Eagle area in Finland is considered as one unit for this purpose. In the first period (1957–63) the material originates mainly from the area south of the reindeer area, and it is partly for this reason that the percentages of the Capercaillie and Black Grouse are larger and that of reindeer calves smaller than during the other periods.

The total proportion of tetraonids in the diet of the Golden Eagle decreased until the early 1980s, especially the percentages of the Capercaillie and Black Grouse (Table 2). This decrease was mainly compensated for by an increase in the proportion of mountain hares. During the last two periods (1986–96) the proportion of hares has decreased rapidly. Obviously, because of several low years for tetraonids this was at first compensated for not by these but by increased use of several other prey items (waterfowl, red fox and squirrel, for example). In the last period (1992–96), when the proportion of hares was still decreasing, the percentage of tetraonids increased clearly. The percentages of the Bean Goose and of crows have

Table 2. Main prey species and groups in the diet of the Golden Eagle (% in fresh material) in six periods in 1957–96 over the total eagle area of Finland. Each period includes one peak in the tetraonid fluctuation.

Period	(57–63)	64–71	72–78	79–85	86–91	92–96
Number of years	7	8	7	7	6	5
Mountain hare	21.5	31.3	33.5	44.6	31.2	24.4
Red squirrel	3.9	0.4	3.1	1.2	4.3	2.3
Red fox	0.2	0.8	0.9	0.5	2.3	1.8
Pine marten	0.7	0.7	0.9	1.0	0.3	0.6
Mink	–	0.1	0.3	1.1	0.7	0.5
Reindeer calf	0.5	4.7	8.0	6.0	6.8	6.9
Capercaillie	30.3	22.7	16.0	13.3	14.0	13.6
Black Grouse	20.8	14.6	9.8	8.8	11.0	13.4
Willow Grouse	6.0	7.2	10.9	5.8	5.5	8.7
Tetraon.,tot.	59.1	46.1	37.6	29.0	30.9	40.2
Bean Goose	0.9	2.0	2.7	3.8	3.3	3.4
Other waterfowl	0.2	3.6	3.4	2.5	5.1	4.3
Crane	3.4	1.9	2.6	0.7	1.2	1.8
Owls	0.5	0.7	1.1	3.0	1.5	0.8
Crows	0.5	1.1	1.8	2.0	2.2	4.2
Others	8.6	6.6	4.1	4.6	11.1	8.8
Material, ind.	435	1 788	1 134	1 211	917	1 412
Food niche	5.13	5.41	5.85	4.22	6.41	8.20

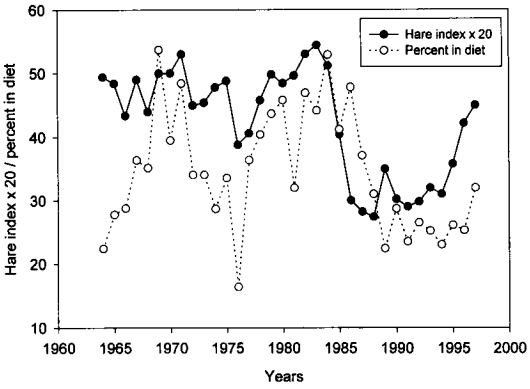

Fig. 2. Annual variations in the relative abundance of the mountain hare (index × 20) and its percentage in the diet of the Golden Eagle in the reindeer area in Finland in 1964–97.

been larger during the last three periods. The food niche has continuously widened to some extent (with the exception of 1979–85, when a high population peak and percentage in diet for hares were recorded) (Table 2).

3.5. Correlation between annual fluctuations in mountain hare populations and diet percentage in 1964–97

The relative density of the mountain hare population in the Finnish Golden Eagle area (provinces of Oulu and Lapland) was above average for most of the period studied here (index over 2.0 in the winter wildlife inquiry) (Fig. 2). Hares were very abundant (index over 2.5) in 1969–71 and 1979–84, and lower than average in 1976 and especially 1985–95. The fluctuation looks rather irregular, but a four-year cycle is nevertheless apparent (in 1967–83). According to the winter inquiry indexes the differences between years seem to be most often small, but road-side censuses in 1979–89 showed that in fact they have been very large in

Table 3. Diet (%) of the Golden Eagle in different parts of Europe: SFre = the Finnish reindeer area (this study); Swe = Sweden (Tjernberg 1983); Norw = Norway (from Högström & Wiss 1992); SFso = Finland south of the reindeer area (this study); Gotl = Gotland, Sweden (Högström & Wiss 1992); Estl = Estonia (Randla 1976); Scot = Scotland (Watson 1998); Alps = (Stemmler 1955, Iselin & Hämmerle 1960, Glutz v. Blotzheim et al. 1971, Henninger et al. 1986, Haller 1996, Watson 1998); Medi = Mediterranean countries (Delibes et al. 1975, Ragni et al. 1986, Watson 1998). Food niche = $1/\Sigma p^2$.

	SFre	Swe	Norw	SFso	Gotl	Scot	Estl	Alps	Medi
Anatidae	7.0	3.5	4.5	4.4	15.2	1.4	3.0	0.1	–
Galliformes	35.7	54.1	52.0	51.2	1.2	18.7	34.0	12.3	18.5
Corvidae	2.6	4.3	2.7	1.0	3.8	2.0	0.4	4.7	5.7
Other birds	6.7	3.7	12.3	6.7	9.1	9.9	3.6	3.6	3.6
Birds, total	52.0	66.0	71.5	63.3	29.3	32.0	41.0	20.7	27.8
Hedgehog	–	–	–	0.1	42.0	0.2	14.0	–	–
Leporidae	32.7	20.7	10.7	30.1	25.3	27.2	27.0	20.9	43.4
Marmots	–	–	–	–	–	–	–	37.8	–
Other rodents	4.1	0.2	1.4	3.7	1.5	5.8	4.0	1.2	4.9
Artiodactyla juv.	7.7	8.1	5.8	–	1.1	30.4	5.0	11.7	3.4
Carnivora	3.1	2.9	?	2.6	0.6	4.0	6.0	5.1	6.1
Other mammals	0.0	2.0	8.6	0.3	0.7	0.3	3.0	1.4	1.1
Mammals, total	47.7	34.1	26.5	36.4	70.6	67.9	59.0	78.1	58.9
Reptilia	0.2	–	–	0.1	0.1	0.2	–	1.6	12.0
Other animals	0.1	–	2.0	0.2	–	0.0	–	–	–
Material, N	5 309	2 803	513	1 595	652	1 256	279	1 708	1 142
Food niche	3.95	2.87	3.24	2.64	3.77	5.44	4.57	3.38	4.35

some cases (Rajala 1983, Rajala & Helle 1990).

The changes in the percentage of the mountain hare in the diet of the Golden Eagle have sometimes been very large: in good hare years it has been 40–50%, but in bad ones only about 20% (Fig. 2). The yearly changes in the hare population and those in the proportion of hares in the diet have mostly run fairly much in parallel, but different directions have also occurred (most clearly in 1974, 1986 and 1989). The positive correlation between the hare population and percentage in the diet is nevertheless a significant one ($r = 0.50$, $p = 0.003$). Thus Golden Eagle preys on mountain hares most often when hare abundance is high.

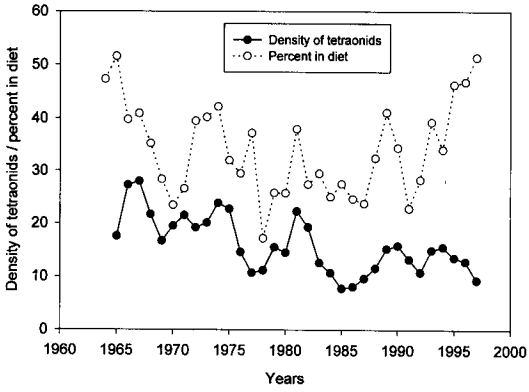

Fig. 3. Annual variations in the density of tetraonids (ind./sq.km) and in their percentage in the diet of the Golden Eagle in Finland in 1965–96.

3.6. Effect of the fluctuations in tetraonids on their percentage in the diet

The mean density of tetraonids (here the Capercaillie, Black Grouse and Willow Grouse) in the provinces of Oulu and Lapland decreased markedly from the 1960s to the 1990s ($r = 0.67$, $p < 0.001$, Fig 3), and figures have even declined between successive peak years (at intervals of 5–8 years).

The proportion of tetraonids in the diet of the Golden Eagle has been in abundant tetraonid years 35–52%, but only 17–28% in low years (Fig. 3). In spite of the significant decline of the tetraonids over the period 1964–97, the percentage of the tetraonids in the diet has not wholly reflected this decline. A clear decrease was recorded in 1965–86 ($r = 0.61$, $p = 0.00279$, but this was arrested in 1986–91 and an increase in the percentage was observed in 1992–96 (Fig. 3), apparently linked to an abrupt decrease in the abundance of the mountain hare (Fig. 2). This suggests that the tetraonids were still quite a good alternative prey for the hare despite their long-term decline. The percentages of other prey groups did not increase (except perhaps for crows, Table 2).

The yearly changes in the field densities and diet percentages of tetraonids follow each other in most years, but some divergent changes occurred during this long period (e.g., in 1972, 1978, 1992 and 1995, Fig. 3). In the 22 first years (1965–86) a highly significant positive correlation between the yearly densities of tetraonids and their percentages in the diet was recorded ($r = 0.61$, $p = 0.0028$), but for the longer period (1965–96) the significance is lower ($r = 0.41$, $p = 0.019$).

4. Discussion

4.1. On the use of fresh and old prey remains to study the diet of the Golden Eagle

Fresh material was used above to study the details of the diet of the Golden Eagle in Finland, especially because this allowed the most reliable between-year comparisons with the food available. Despite their statistical significance, the differences between the fresh and old material were small in percentage terms, and typically applied to prey that were few in number (only the red squirrel amounted to over 1% of total prey individuals). Therefore results of different diet studies over long periods can in practice be compared fairly well as far as the main prey items are concerned (the most numerous medium-sized species) without serious difficulties caused by the age of the remains. Consideration of the ages is also difficult in many cases, as most earlier studies do not indicate or discuss the use of old prey remains (e.g., Tjernberg 1981, Högström & Wiss 1992).

The fresh material (from the sampling year) is

also somewhat biased, especially because in most cases, including the present study, the remains were sampled less frequently than once a week, which according to Collopy (1983) would give the real composition of the diet. As the sources of error are smaller in fresh samples, only fresh material should be used in between-year comparisons. Old and mixed materials are suitable for comparisons between longer periods (e.g., decades).

4.2. Factors affecting predation by the Golden Eagle

Size of the prey. The Golden Eagle is able to catch prey items of very different sizes. The mean weight of a prey item in Finland is 2.14 kg (material from 1957–84, n = 4483 ind.), whereas in northern Sweden it is larger, 2.8 kg (Tjernberg 1983), and in Gotland smaller, 1.3 kg (Högström & Wiss 1992). Rather small animals (100–300 g in weight) are also common prey, both mammals (stoats, squirrels etc.) and birds (thrushes), and sometimes even small birds (Meadow Pipits, Ernits 1979, Watson 1998). Small rodents are often included in the diet in Scotland (Lockie 1964) and in Spain (Delibes et al. 1975). On the other hand the Golden Eagle often catches fairly large animals, red foxes among the mammals (mean weight about 5 kg) and Cranes among the birds (5 kg). Reindeer calves are also relatively large (normal newborn calf 4–5 kg). The Whooper Swan (mean weight 9 kg) is a very occasional prey object, obviously because of its large size; the White-tailed Eagle is also known to avoid preying on swans (Sulkava et al. 1997). In North America the Canada Goose (*Branta canadensis*, mean weight 4.1–5.2 kg) is also avoided by the Golden Eagle as compared with smaller geese (McWilliams et al. 1994). Outside the breeding season, however, especially during winter, the Golden Eagle may sometimes kill still larger prey, e.g., young ungulates (Glutz v. Blotzheim 1971, Fischer 1976, Cramp & Simmons 1977–94).

Hunting habits and environment. The Golden Eagle captures most of its prey on the ground. It also often chases birds as they take off from ground (Cramp & Simmons 1977–94). It searches for prey by flying low and trying to surprise the individuals. Sometimes it may also hunt by diving from high up like the Peregrine and catching the prey in the air (Glutz v. Blotzheim 1971, Tjernberg 1986). It is in fact well equipped for pursuit flight, better than the White-tailed Eagle, for example (Kirmse 1998). Common habits in searching for prey are also perching on some high place and "hanging" or hovering in the air in a head wind at the height of some tens of metres (Tjernberg 1986).

Gulls are only occasionally caught (0.3 %) even though they are generally available in Finland and are very easily visible in the field. The minimal preying on gulls has also been noted by Brown (1969) and Tjernberg (1981). The proportion of waterfowl is also relatively small (about 6%) as compared with the diet of White-tailed Eagles in Finnish Lapland, where it is almost three times this amount (about 17%, Sulkava et al. 1997). Obviously the Golden Eagle avoids in Finland hunting on open waters, and this will reduce preying on gulls. In Scotland a study on radio-tagged Golden Eagles (McGrady et al. 1998) also showed that watercourses were the least utilized habitat.

The main bird prey of the Golden Eagle, tetraonids, are probably most often caught on the ground, but they stay in the cover of such dense vegetation for most of their time that the Golden Eagle is not able to chase them. In recent times, however, the fragmentation of the forests by heavy cutting has made it considerably easier for the Golden Eagle to find and catch grouse. This probably contributes to the increase in the percentage of tetraonids in the diet (especially in 1995–96) despite the decrease in tetraonid populations (Fig. 3).

Prey communities. When discussing the choice of prey the effect of the main prey on the proportions (percentages) of other species in the diet must also be considered. Several discrepancies may be observed in the comparisons of the densities and diet percentages of the main prey (the mountain hare and tetraonids) as shown in Sections 3.5. and 3.6. (Figs. 2 and 3), which are partly caused by marked divergent changes in the availability (density) of the other main prey items. At least three discrepancies in the correlation between the availability and dietary percentage of the mountain hare, for example, can be attributed to peak and low tetraonid years: in 1968 the sharp decline in

tetraonids caused a marked increase in the proportion of hares, and in 1974, 1981 and 1989 the peaks in tetraonids reduced the proportion of hares. Correspondingly, two discrepancies in the correlation between the tetraonid populations and their proportions in the diet (in 1972 and 1985) are explained by the fact that in a low hare year the proportion of tetraonids was higher than would be presupposed by their availability.

Both the mountain hare and the tetraonids seem to be "important and preferred main prey" for the Golden Eagle, because fluctuations in the populations of both of them cause corresponding changes of about the same level in the diet of the eagle. This is somewhat surprising, because the eagle must hunt hare and grouse using partly different techniques (mammals always on ground/ birds move often in the air). In this case, however, the difference between a mammal and a bird may be small, as the eagle may often catch the grouse on ground before they take off.

The preferences of the Golden Eagle for the mountain hare and grouse are obviously closely related, but the hare seems to be paramount as the correlation between its abundance in the field and its proportion in the diet over the period of 27 years (1964–91) was closer than the corresponding correlation for the tetraonids ($r = 0.59$ vs. 0.45; $P < 0.001$ and 0.012). This comparison is weakened, however, by the fact, that the abundance of the hare is expressed here only as a relative index whereas the abundance of tetraonids is a real density.

A relatively high preference for tetraonids may nevertheless be presumed from the fact that their proportion in the diet of the eagle has decreased more slowly than the long-term density of tetraonid populations (Fig.3). The proportion of tetraonids has even increased in the 1990s, although populations have been weak, and the mountain hare population has already increased somewhat after the last low years in 1990–94.

The populations of both main prey (hare and grouse) have thus been relatively weak for the last 10 years (1986–96, Figs. 2 and 3), and consequently the proportions of several alternative prey items (red squirrel, red fox, waterfowl, crows, Table 2) have increased to some extent. These could not compensate sufficiently for the decrease in the main prey, however, and the Golden Eagle had to eat relatively large numbers of grouse even though their populations were weak.

4.3. The diet of the Golden Eagle in different parts of Europe

Gallinaceous birds (Tetraonidae and Phasianidae) and hares (Leporidae) are the main sources of nutrition for the Golden Eagle in most parts of Europe, accounting most often for 60–80% of its prey (Table 3). The most clear exceptions are the Alps, where the marmot (*Marmota marmota*) is the main prey (38%) and the island of Gotland, where it is the hedghehog (42%). In addition, the proportion of the European souslik (*Citellus citellus*) is fairly high locally in eastern Central Europe (Voskar et al. 1969). In southern Europe reptiles are an important prey group, and in most areas of Europe the calves of ungulates are a group that is numerically small, but obviously an important food source because of their relatively large size.

The Golden Eagle has also occasionally been known to eat also frogs (Glutz v. Blotzheim 1971), fish (Hagen 1952, Haftorn 1959, Voskar et al. 1969), large insects (Pinn 1967) and eggs from the nest of a duck (Tommeraas 1993), and dead animals (carcasses) even in summer (Fischer 1976, Tjernberg 1981). Some special learning abilities may be included in its behaviour, in that in southern Europe it opens tortoises by dropping them on rocks (Fischer 1976) and in the Alps it sometimes kills the calves of ungulates and foxes by dropping them repeatedly from a height (Glutz v. Blotzheim 1971).

Regional differences in the diet of the Golden Eagle are obviously mostly connected to the corresponding differences in the composition of the prey fauna available, most clearly in cases where the eagle commonly consumes a prey that is not available in other areas (e.g., marmots in the Alps or tortoises in southern Europe). The many regional differences in the diet show, that the hunting skills of the Golden Eagle are numerous and adaptable.

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Selostus: **Kotkan ravinnon vaihteluista Suomessa 1957–97 suhteessa pienriistan runsaudenvaihteluihin**

Aineistoa kotkan ravinnosta on kerätty vuosittain vuodesta 1957 alkaen, pääosaksi pesien tarkastusten yhteydessä, mutta osaksi myös pesinnän jälkeen. Saalisjätteitä ja oksennuspalloja on koottu etupäässä pesistä ja pesäpuiden juurelta, mutta myös pesän ympäristön ruokailupaikoilta ja istumapuiden alta. Määritettäessä jätteet on jaettu pesimisvuoden tuoreisiin ja aikaisempien vuosien vanhoihin saaliisiin. Vanhat jätteet sisältävät alle puolikiloisia saaliita vähemmän kuin tuoreet. Pienten saaliiden (oravat, rastaat yms.) jätteitä löytyy etupäässä oksennuspalloista. Jäniksen ja kanalintujen vuosittaisia osuuksia kotkan ravinnossa on verrattu riistantutkimuksen tietoihin pienriistan runsauden vuotuisista vaihteluista.

Kotkan pesimisajan kookkaimmat säännölliset saalislajit, kurki, metso, poronvasa, kettu ja jänis painavat 4–5 kg. Pienimpiä kotkan yleisiä saalislajeja ovat orava, kärppä, vesimyyrä ja rastaat, joiden keskipainot ovat 100–300 g. Jänis on kotkan useimmin ottama saalislaji (30–33%); seuraavina ovat metso, teeri, riekko ja poronvasa (kukin 8–23%). Vesien linnuista sorsalinnut ovat kotkalle merkittävä saalisryhmä, mutta lokit joutuvat hyvin harvoin kotkan saaliiksi.

Alueelliset erot ravinnon koostumuksessa ovat yleensä pieniä. Kanalintuja kotka syö jonkin verran enemmän poronhoitoalueen eteläpuolella; varsinkin teeren osuus vähenee pohjoiseen päin (Taulukko 1). Poronvasan ja riekon osuudet ovat suurimpia poronhoitoalueen pohjoisosissa. Kurki joutuu useammin saaliiksi poronhoitoalueen eteläpuolella. Kanalintujen osuus kotkan ravinnosta pieneni 1950-luvun lopulta 1980-luvun alkupuolelle (n. 50–30%), ja samana aikana jäniksen osuus kasvoi (n. 20–45%). Tämän jälkeen jäniksen osuus pieneni jäniskannan jyrkän heikentymisen mukana, ja kanalintujen osuus nousi pian huomattavasti (Taulukko 2).

Sekä jäniksen että kanalintujen vuosittaiset runsauden vaihtelut ovat aiheuttaneet vastaavia muutoksia niiden osuudessa kotkan ravinnosta (Kuvat 2 ja 3). Riippuvuudesta on useita poikkeamia, jotka ovat aiheutuneet toisen pääsaaliin runsauden toisensuuntaisesta muutoksesta. Jänis näyttää olevan hiukan kanalintuja suositumpi saalis voimakkaamman riippuvuussuhteen mukaan. Esimerkiksi sorsalinnut, varislinnut ja kettu ovat Suomessa merkittäviä toissijaisia saaliita, joiden osuudet ravinnosta kasvavat pääsaaliiden vähentyessä. Kotkan monipuolisuutta saalistajana osoittaa myös se, että etelämpänä Euroopassa (Taulukko 3) sen keskeisinä saaliina voivat olla myös siili, alppimurmeli ja kilpikonnat.

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Appendix. Numbers and percentages of the prey items consumed by the Golden Eagle in the Finnish reindeer husbandry area and south of it in fresh and old material in 1957–96.

	South of the reindeer area				Reindeer area			
	Fresh 1957–96		Old 1957–96		Fresh 1958–96		Old 1958–96	
	N	%	N	%	N	%	N	%
Hedgehog, *Erinaceus europaeus*	2	0.1	–	–	–	–	–	–
Mountain hare, *Lepus timidus* ad.	453	28.4	211	20.6	1 523	28.7	1 147	23.0
Mountain hare, *Lepus timidus* juv.	27	1.7	22	2.2	213	4.0	143	2.9
Rabbit, *Oryctolagus cuniculus*	1	0.1	2	0.2	–	–	–	–
Red squirrel, *Sciurus vulgaris*	33	2.1	6	0.6	120	2.3	23	0.5
Norwegian lemming, *Lemmus lemmus*	–	–	–	–	5	0.1	–	–
Water vole, *Arvicola terrestris*	10	0.6	2	0.2	33	0.6	12	0.2
Muskrat, *Ondatra zibethica*	10	0.6	14	1.4	19	0.4	48	1.0
Field vole, *Microtus agrestis*	–	–	–	–	5	0.1	–	–
Microtidae sp.	5	0.3	3	0.3	34	0.6	11	0.2
Brown rat, *Rattus norwegicus*	1	0.1	–	–	–	–	–	–
Rodentia, total	59	3.7	25	2.4	216	4.1	94	1.9
Red fox, *Vulpes vulpes* ad.	3	0.2	–	–	4	0.1	12	0.2
Red fox, *Vulpes vulpes* juv.	12	0.8	7	0.7	61	1.1	37	0.7
Vulpes / Alopex juv.	–	–	–	–	2	0.0	2	0.0
Raccoon dog, *Nycter. procyonoides*	1	0.1	1	0.1	–	–	–	–
Pine marten, *Martes martes*	11	0.7	8	0.8	36	0.7	43	0.9
Mink, *Mustela vison*	5	0.3	1	0.1	26	0.5	9	0.2
Stoat, *Mustela erminea*	4	0.3	1	0.1	26	0.5	8	0.2
Weasel, *Mustela nivalis*	–	–	–	–	1	0.0	–	–
Otter, *Lutra lutra*	–	–	–	–	2	0.0	–	–
Domestic cat, *Felis domestica*	–	–	2	0.2	4	0.1	1	0.0
Badger, *Meles meles*	–	–	1	0.1	–	–	–	–
Carnivora, total	36	2.6	21	2.1	162	3.1	112	2.2

(Continues ...)

Appendix 1. Continued.

	South of the reindeer area				Reindeer area			
	Fresh 1957–96		Old 1957–96		Fresh 1958–96		Old 1958–96	
	N	%	N	%	N	%	N	%
Reindeer calf, *Rangifer tarandus*	–	–	1	0.1	408	7.7	485	9.7
Reindeer ad., *Rangifer tarandus*	–	–	–	–	5	0.1	18	0.4
Sheep, *Ovis aries*	1	0.1	1	0.1	–	–	–	–
Small mammal sp. ad.	1	0.1	2	0.2	–	–	2	0.0
Large mammal sp. juv.	–	–	–	–	4	0.1	9	0.2
Mammalia, total	580	36.4	285	27.9	2531	47.7	2010	40.4
Black-throated Diver, *Gavia arctica*	1	0.1	–	–	–	–	2	0.0
Mallard, *Anas platyrhynchos*	38	2.4	26	2.5	123	2.3	112	2.2
Teal, *Anas crecca*	3	0.2	–	–	26	0.5	1	0.0
Pintail, *Anas acuta*	–	–	–	–	3	0.1	1	0.0
Wigeon, *Anas penelope*	–	–	–	–	7	0.1	1	0.0
Tufted Duck, *Aythya fulicula*	–	–	–	–	7	0.1	1	0.0
Goldeneye, *Bucephala clangula*	–	–	–	–	3	0.1	2	0.0
Common Scoter, *Melanitta nigra*	–	–	–	–	2	0.0	2	0.0
Red-breasted Merg., *Mergus serrator*	–	–	1	0.1	10	0.2	2	0.0
Goosander, *Mergus merganser*	–	–	–	–	4	0.1	1	0.0
Bean Goose, *Anser fabalis*	28	1.8	29	2.8	171	3.2	203	4.1
Anser sp.	–	–	–	–	2	0.1	–	–
Whooper Swan, *Cygnus cygnus*	–	–	–	–	3	0.1	–	–
Anatidae sp.	12	0.8	13	1.3	12	0.2	60	1.2
Anatidae, total	82	5.1	69	6.8	373	7.0	388	7.8
Common Buzzard, *Buteo buteo*	–	–	1	0.1	1	0.0	1	0.0
Rough-legged Buzzard, *Buteo lagopus*	–	–	–	–	1	0.0	–	–
Goshawk, *Accipiter gentilis*	2	0.1	3	0.3	4	0.1	–	–
Merlin, *Falco columbarius*	–	–	–	–	1	0.0	1	0.0
Kestrel, *Falco tinnunculus*	–	–	–	–	2	0.0	–	–
Falconidae, total	2	0.1	4	0.4	9	0.2	2	0.0
Willow Grouse, *Lagopus lagopus*	119	7.5	62	6.1	402	7.6	370	7.4
Black Grouse, *Tetrao tetrix*, male	179	12.2	114	11.2	271	5.1	375	7.5
Black Grouse, female	114	7.1	83	8.1	266	5.0	249	5.0
Black Grouse, m / f	19	1.2	26	2.5	14	0.3	23	0.5
Capercaillie, *Tetrao urog.* male	125	7.8	110	10.8	316	6.0	478	9.6
Capercaillie, *Tetrao urog.* female	247	15.5	143	14.0	524	9.9	740	14.9
Hazel Grouse, *Bonasa bonasia*	4	0.3	3	0.3	8	0.2	–	–
Tetraonidae sp. juv.	29	1.8	11	1.0	94	1.8	40	0.8
Tetraonidae, total	816	51.2	552	54.0	1895	35.7	2275	45.7
Domestic Hen, *Gallus domesticus*	2	0.1	–	–	2	0.0	–	–
Crane, *Grus grus* ad.	34	2.1	72	7.0	32	0.6	66	1.3
Crane, *Grus grus* juv.	22	1.5	17	1.7	32	0.6	39	0.8
Lapwing, *Vanellus vanellus*	1	0.1	–	–	12	0.2	–	–
Golden Plover, *Pluvialis apricaria*	–	–	–	–	3	0.0	–	–
Snipe, *Capella gallinago*	–	–	–	–	3	0.0	–	–
Woodcock, *Scolopax rusticola*	2	0.1	–	–	1	0.0	–	–
Curlew, *Numenius arcuata*	1	0.1	1	0.1	54	1.0	7	0.1
Whimbrel, *Numenius phaeopus*	1	0.1	–	–	21	0.5	1	0.0

(Continues ...)

Appendix 1. Continued.

	South of the reindeer area				Reindeer area			
	Fresh 1957–96		Old 1957–96		Fresh 1958–96		Old 1958–96	
	N	%	N	%	N	%	N	%
Wood Sandpiper, *Tringa glareola*	2	0.1	–	–	3	0.1	–	–
Spotted Redshank, *Tringa erythropus*	–	–	–	–	1	0.0	–	–
Greenshank, *Tringa nebularia*	–	–	–	–	4	0.1	–	–
Ruff, *Philomachus pugnax*	–	–	–	–	12	0.2	–	–
Charadriidae sp.	4	0.3	1	0.1	26	0.5	16	0.3
Charadriidae-Scolopacidae, total	11	0.7	2	0.1	140	2.6	24	0.5
Lesser Black-backed Gull, *L. fuscus*	–	–	–	–	1	0.0	–	–
Herring Gull, *Larus argentatus*	–	–	–	–	15	0.3	–	–
Common Gull, *Larus canus*	–	–	–	–	1	0.0	–	–
Black-headed Gull, *Larus ridibundus*	2	0.1	–	–	6	0.1	–	–
Sterna sp.	–	–	–	–	1	0.0	–	–
Laridae, total	2	0.1	–	–	24	0.4	–	–
Hawk Owl, *Surnia ulula*	1	0.1	2	0.2	18	0.3	7	0.1
Great Grey Owl, *Strix nebulosa*	1	0.1	1	0.1	14	0.3	6	0.1
Ural Owl, *Strix uralensis*	2	0.1	3	0.3	4	0.1	4	0.1
Short-eared Owl, *Asio flammeus*	1	0.1	2	0.2	46	0.9	24	0.5
Tengmalm's Owl, *Aegolius funereus*	–	–	–	–	1	0.0	–	–
Strigidae sp.	–	–	–	–	1	0.0	–	–
Strigidae, total	5	0.3	10	1.0	84	1.6	41	0.8
Raven, *Corvus corax*	5	0.3	3	0.3	72	1.4	61	1.2
Hooded Crow, *Corvus corone*	8	0.5	3	0.3	56	1.1	49	1.0
Magpie, *Pica pica*	1	0.1	–	–	–	–	1	0.0
Jay, *Garrulus glandarius*	2	0.1	–	–	1	0.0	–	–
Siberian Jay, *Perisoreus infaustus*	–	–	–	–	4	0.1	1	0.0
Corvidae, total	16	1.0	6	0.6	133	2.6	112	2.2
Wood Pigeon, *Columba palumbus*	–	–	–	–	4	0.1	1	0.0
Cuckoo, *Cuculus canorus*	–	–	2	0.2	–	–	–	–
Swift, *Apus apus*	–	–	–	–	1	0.0	–	–
Great Spott. Woodpecker,*Dendr. major*	–	–	–	–	3	0.1	–	–
Black Woodpecker, *Dryocopus martius*	–	–	–	–	3	0.1	–	–
Great Grey Shrike, *Lanius excubitor*	–	–	–	–	1	0.0	–	–
Mistle Thrush, *Turdus viscivorus*	–	–	–	–	3	0.1	–	–
Fieldfare, *Turdus pilaris*	–	–	–	–	1	0.0	–	–
Song Thrush, *Turdus philomelos*	–	–	–	–	1	0.0	–	–
Turdus sp.	6	0.4	2	0.2	17	0.3	4	0.1
Yellowhammer, *Emberiza citrinella*	2	0.1	–	–	–	–	–	–
Aves sp.	12	0.8	3	0.2	5	0.1	12	0.2
Aves, total	1010	63.3	737	72.1	2763	52.0	2964	59.5
Viper, *Vipera Berus*	1	0.1	–	–	15	0.3	3	0.1
Lizard, *Lacerta vivipara*	1	0.1	–	–	–	–	–	–
Frog, *Rana* sp.	3	0.2	–	–	3	0.1	–	–
Pike, *Esox lucius*	–	–	–	–	–	–	1	0.0
Material, total	1595		1022		5312		4978	