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The occurrence of reindeer calves in the diet of nesting Golden Eagles in Finnmark, northern Norway

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To assess the importance of semi-domesticated reindeer *Rangifer tarandus* calves in the diet of Golden Eagles *Aquila chrysaetos*, in Finnmark (northern Norway), we collected prey remains at 37 nests over six years (2001–2006). The study area was divided into 1) a fjord area, which is an important calving area for reindeer, and 2) an inland area where few reindeer give birth. 469 prey items were collected over the years. The diet of eagles was numerically dominated by birds (73% of collected prey items), especially willow/rock ptarmigan *Lagopus* spp. (51%), while mammals made up 27%, with mountain hare *Lepus timidus* as the most common species. Remains of reindeer calves were found in half of the nests studied and made up 8.5% of the collected prey items: 13.2% in the fjord area and 6.5% in the inland area. There was a higher chance of finding reindeer calves at nests in the fjord area than inland, and in nests situated in birch forest than in pine forest. The number of reindeer calves in the Golden Eagle diet in Finnmark corroborates well other studies from northern Fennoscandia. The importance of the Golden Eagle as a predator on reindeer can't, however, be assessed here.

1. Introduction

The Golden Eagle *Aquila chrysaetos* is one of the largest avian predators in mountainous areas in both Eurasia and North America. It has a diverse diet, but major prey groups include gallinaceous birds, hares *Lepus timidus* and often ungulate calves (reviewed by Watson 1997). Several studies have estimated the extent to which Golden Eagles consume various ungulate calves, both wild and domesticated (Bleich *et al*. 2004, Deblinger & Alldredge 1996, Phillips *et al*. 1996). However, few studies have examined the extent to which Golden Eagles prey on semi-domesticated rein-

deer *Rangifer tarandus*, which are kept by the Sámi people of northern Scandinavia and Finland. Norberg *et al*. (2005, 2006) found that the Golden Eagle was the dominating predator of reindeer calves in northern Finland; i.e. in one study area the eagles accounted for 40% of the mortality (Norberg *et a*l. 2005). Moreover, Tjernberg (1983) found that reindeer calves made up about 9% of the diet of nesting eagles in northern Sweden, and estimated that about 0.7% of the calves born were taken by Golden Eagles. Franzén (1996) reported a very low predation rate based on a vast field study, but summarized some proven attacks on reindeer by Golden Eagles. From central Norway there is some information about eagle predation in reindeer herding areas. Using radio collars, Nybakk *et al*. (1999, 2002) found that Golden Eagles accounted for about 6% of the calf mortality. The main area for reindeer husbandry in Norway is, however, Finnmark, the northernmost county (Fig. 1). This area has a reindeer population of about 150,000, although the number varies between years. In recent years there has been controversy over the Golden Eagle as a predator on reindeer in Norway, and the aim of this study was to examine the occurrence of reindeer calves in the diet of nesting Golden Eagles in an important area for semi-domesticated reindeer in central Finnmark. The eagles nest from April until July and reindeer calve in May (Tveraa *et al*. 2003). Thus, the prey remains at the nest late in the breeding season will indicate the importance of reindeer calves for breeding birds (Sulkava *et al*. 1998, Tjernberg 1983). It does not, however, account for predation by sub-adult and other non-breeding eagles.

We collected prey items at nests of Golden Eagles over six years (2001–2006) in two areas in mid Finnmark (Fig. 1): 1) an area surrounding Porsangerfjord (fjord area), which is an important calving area for reindeer, and 2) a woodland, inland area, near the Finnish border, where few reindeer calves are born.

2. Material and methods

The study area was in the Alta, Porsanger and Karasjok municipalities in Finnmark, a major area for reindeer herding in Norway (Fig. 1). The area stretches from sea level to inland Finnmark where altitude varies between 50 and 600 meters. The study area was divided into two sub areas: one near the coast in the area surrounding Porsangerfjord (denoted as fjord area), and one inland area with woodlands surrounding the village Karasjok (denoted as inland area) (Fig. 1). The two areas are about 30 km apart. In the two areas there are about 50 known Golden Eagles territories (including data from 2006). Since all nests were found in woodland, the study areas were divided into two main habitats based on forest types in which the nests were situated. In this case it was 1) pine *Pinus sylvestris* forest, and 2) birch *Betula pubescens* forest.

The study was started in 2001 and results are presented for the period 2001–2006. Twenty-six nest sites were used in this study (Fig. 1). Seven nests were visited in more than one year (i.e. two or three years). Hence there were 37 successful nesting attempts (i.e. fledged chicks) included in the study, with an annual variation of 5–11 nests.

Nests were visited in summer, mainly in early July, and the area surrounding the nest was searched for prey remains and regurgitated pellets. All prey remains considered to be fresh, i.e. from the sampling year, were collected and frozen for later determination. To assess the freshness of the remains we used a classification similar to Sulkava *et al*. (1998), in which old remains were those in which soft tissue was absent, bones were greenish and feathers were softened. To avoid double-counting, we made sure that the remains were not from the same prey individuals; for example to count as two individual items, we had to find two left or right wings for birds, and similarly for reindeer calves or other mammals (feet, heads, etc.).

Our aim was to collect data from a large number of nests over several years. It was, however, only possible to collect prey at successful nests, since very few prey remains could be found at nests that had been abandoned at an early stage. Nesting success varied greatly between years (G.H. Systad *et al*. in prep), and pairs very often changed their nest site between years. It was thus impossible to collect information from many nests over several years.

Statistical analyses were carried out using the statistical package R (R core team, 2006). To test for factors influencing the probability of having

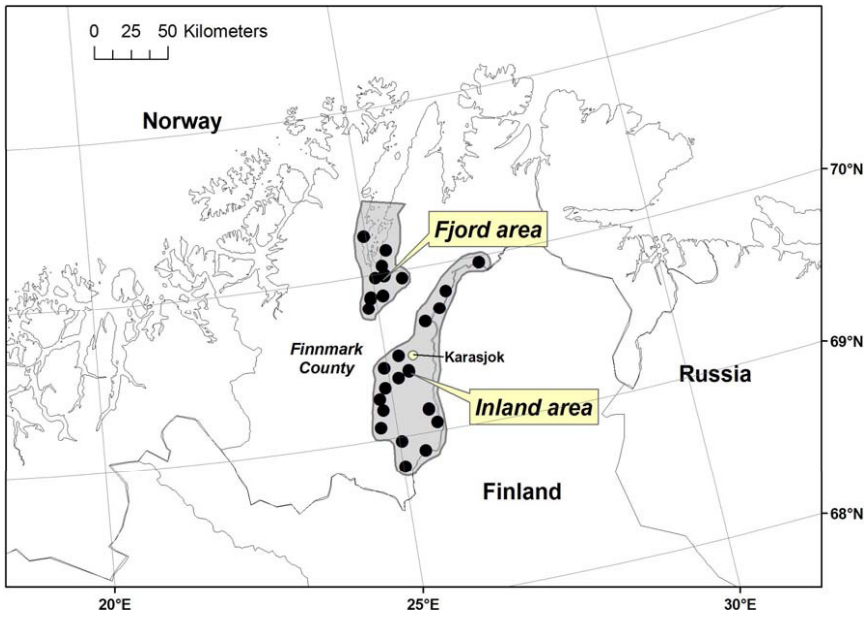

Fig. 1. The study areas in Finnmark, northern Norway. Black circles denote successful Golden Eagle nests during the study period, 2001–2006.

reindeer calves in the diet, we used logistic regression (Wald statistics) with a bivariate response variable (0: nests where no calves were found; 1: nests where calves were found). Independent variables were area and habitat type (forest type around the nest).

In all analyses, we used the number of prey found at each nest as a weight variable. Unfortunately, the number of nests per year was small and no interaction terms testing for differences between forest types in the different areas could be included in the models. Another potential problem with our data set is that some nests (n = 7) occur in the data in more than one year and may lead to pseudo-replication. This may be a source of error since some pairs may have special prey preferences, which again will make the estimates in our analyses more uncertain. We were, however, unable to correct for this potential error source due to the small samples.

3. Results

During the six years, prey remains were collected at the nest of 37 successful breeding pairs: 12 in the fjord habitat and 25 in the inland area. The total number of prey items was 469: 144 in the fjord area and 325 in the inland area. Twenty-two species of prey were identified, in addition to seven groups for which species were not determined, such as willow/rock ptarmigan (*Lagopus* spp.), unidentified ducks, wading birds and passerines, as well as rodents (Table 1). Birds made up 73% by number of the collected prey items. Ptarmigan dominated the sample comprising 51% by number of the prey, followed by mountain hare (13%, Table 1). Other important prey were waterfowl, such as geese and ducks, and comprised about 10% by number of the prey remains. There were some differences between the two areas, notably that the proportion of mammals was higher in the fjord area (38%) compared to the inland area (23%), and the importance of birds was higher in the inland area (77% vs. 62%).

In total, 18 (48.6%) of the nests contained remains of reindeer calves, but calves only made up 8.5% by number of all prey items (Table 1). In the fjord area 13.2% of the prey items were from reindeer calves, while in the inland area it was 6.5% (Table 1). There were on average remains from 2.2 individuals in the nests where calves were found (Table 1).

There was a significantly higher probability of finding remains of reindeer calves in nests in the fjord area than inland, and the probability of finding reindeer calves was higher in the birch forest than in pine forest (Table 2).

Table 1. The diet of Golden Eagles in two areas in mid Finnmark (Fig. 1), northern Norway, 2001–2006, determined from remains found at nests. Nr = Number, Prop. = Proportion

		Fjord area (n = 12)			Inland area (n = 25)			Total			
Species	Latin name	Nr of prey	Nr of nests	Prop. of total (%)	Nr of prey	Nr of nests	Prop. of total (%)	Nr of prey	Nr of nests	Prop. of total (%)	Mean Prey items per nest
Mammals											
Reindeer	***Rangifer tarandus***	**19**	**6**	**13.2**	**21**	**12**	**6.5**	**40**	**18**	**8.5**	**2.2**
Mountain Hare	*Lepus timidus*	25	10	17.4	38	18	11.7	63	28	13.4	2.3
Red fox	*Vulpes vulpes*				6	3	1.8	6	3	1.3	2.0
Domestic cat	*Felis silvestris catus*	2	2	1.4	2	2	0.6	4	4	0.9	1.0
American mink	*Mustela vison*				1	1	0.3	1	1	0.2	1.0
Pine Marten	*Martes martes*	1	1	0.7	2	2	0.6	3	3	0.6	1.0
Rodents	Rodentia spp.	3	1	2.1	5	3	1.5	8	4	1.7	2.0
Total mammals		**50**		**34.7**	**75**		**23.1**	**125**		**26.7**	
Birds											
Anatidae											
Bean goose	*Anser fabilis*				15	2	4.6	15	2	3.2	7.5
Goose undet.	*Anser spp.*				5	3	1.5	5	3	1.1	1.7
Mute swan	*Cygnus cygnus*				3	2	0.9	3	2	0.6	1.5
Common Teal	*Anas crecca*	2	2	1.4				2	2	0.4	1.0
Widgeon	*Anas penelope*	2	2	1.4	1	1	0.3	3	3	0.6	1.0
Tufted duck	*Aythya fuligula*	1	1	0.7				1	1	0.2	1.0
Goldeneye	*Bucephala clangula*				1	1	0.3	1	1	0.2	1.0
Red-Breasted Merganser	*Mergus serrator*				2	2	0.6	2	2	0.4	1.0
Goosander	*Mergus merganser*	5	3	3.5	1	1	0.3	6	4	1.3	1.5
Duck undetermined	*Anatinae/Aythyinae*	2	1	1.4	5	4	1.5	7	5	1.5	1.4
Birds of prey											
Hen harrier	*Circus cyaneus*				1	1	0.3	1	1	0.2	1.0
Merlin	*Falco columbarius*	1	1	0.7	1	1	0.3	2	2	0.4	1.0
Long-eared Owl	*Asio flammeus*				5	4	1.5	5	4	1.1	1.3
Galliformes											
Grouse / Ptarmigan	*Lagopus spp.*	65	11	45.1	176	25	54.2	241	36	51.4	6.7
Capercaillie	*Tetrao urogallus*	2	1	0.7	11	6	3.4	13	7	2.8	1.9
Charadriformes											
Whimbrel	*Numenius phaeopus*	3	3	2.1	1	1	0.3	4	4	0.9	1.0
Waders undetermined	*Calidridae* spp.	1	1	0.7	2	2	0.6	3	3	0.6	1.0
Common Gull	*Larus canus*	1	1	0.7				1	1	0.2	1.0
Passeriformes											
Hooded Crow	*Corvus corone*	3	3	2.1	1	1	0.3	4	4	0.9	1.0
Common Raven	*Corvus corax*	3	2	2.1	3	3	0.9	6	5	1.3	1.2
Passerines undetermined	*Passeridae* spp.	3	3	2.1	9	6	2.8	12	9	2.6	1.3
Birds undetermined	*Aves* spp.				7	4	2.2	7	4	1.5	1.8
Total birds		**94**		**65.3**	**250**		**76.9**	**344**		**73.3**	
Overall Total		**144**	**12**		**325**	**25**		**469**	**25**		**12.7**

Table 2. Logistic regression testing factors influencing the probability of finding reindeer calves at Golden Eagle nests (Wald statistics, n = 37; see method section). Data from Finnmark, northern Norway 2001–2006.

Significant factors	Estimate	SE	χ^2	P
Intercept	2.8092	0.4275	6.5710	***
Area (inland vs. fjord)	–0.5260	0.2243	–2.3450	*
Woodland (pine vs. birch)	–2.2284	0.4081	–5.4610	***

* = p<0.01; ***: p<0.0001

4. Discussion

4.1. Golden Eagle as a consumer of reindeer calves

We found that half of the nests contained reindeer calves, but that overall less than 10% of the prey items were reindeer. The latter figure is similar to that found in the studies of Sulkava *et al*. (1998) in northern Finland (6–12%) and Tjernberg (1983) in northern Sweden (9%). When the other diet components are considered, the Golden Eagles in Finnmark again seem to have a food choice similar to that found in other studies, especially the high occurrence of gallinaceous birds and mountain hare (reviewed by Watson 1997).

In spring, reindeer from inner Finnmark are moved to the coast, where they calve. Thus, few reindeer calve in inner Finnmark (Tveraa *et al*. 2007). As expected, there was a higher probability of finding remains of reindeer calves in the fjord area. The fact that 6.5% of the prey remains in the inland area were reindeer could have at least four causes: 1) there may be more females giving birth than expected; 2) the eagles may specialize in hunting the few calves available; 3) inland eagles may move some distance to hunt for reindeer calves; 4) the density of eagles may be lower inland, allowing for larger territories with the number of reindeer calves per territory sufficiently high to be included in the diets of eagles. We have no data to distinguish between these explanations, but the latter two are unlikely since the density of eagle nests does not seem to differ much between the areas (Fig. 1).

Few others have compared predation on reindeer calves between inland and coastal areas, but Kvam *et al*. (1998) found no differences in predation by Golden Eagles on calves between islands and the mainland in Nord-Trøndelag (in the middle of Norway).

There was a higher probability for reindeer calves to occur at nest sites in birch than in pine forest. This may be due to a higher density of calves in the birch forests or because it's more difficult for eagles to catch calves in the pine forest. At present we cannot distinguish between these explanations or exclude that both factors operate. However, some studies have examined where Golden Eagles tend to hunt in relation to landscape types. For example, Norberg *et al*. (2006) found that eagle predation was much more prevalent in a highland area compared to an area with bogs and forest, while Nybakk *et al*. (1999) found that most reindeer were killed by eagles in open areas rather than in forest areas. It is thus likely that the density of the forest in an area affects the predation pressure by Golden Eagles. Unfortunately, our data did not allow us to test for possible differences in the forest types between the areas.

4.2. Diet assessment from prey remains

There are a number of potential sources of error when assessing diets of Golden Eagles through collection of prey remains. These have been summarized by Tjernberg (1983) and Sulkava *et al*. (1998), and comprise three factors: 1) Prey remains found at nests do not necessarily reflect the diet of adult birds, but are rather related to the diet of their offspring. 2) Some prey types may be much more likely to be found as remains than others. For example, reindeer calves may be much more likely to be found than voles. 3) Some individuals may specialize on certain types of prey, introducing bias in small sample sizes. These sources of error means that it's impossible to as-

sess confidently how much of the diet volume consists of reindeer. Thus, the method used here is not suited to determine the contribution of reindeer calves to the energy budget of the eagles, since it is difficult to assess the relationship between the frequency of prey remains from reindeer calves and the amount of reindeer meat consumed by the eagles and their young. However, in a recent analysis of stable isotopes in feathers from Golden Eagle nestlings in Finnmark, Halley *et al*. (2005) found that about 11% of the diet consisted of reindeer, thus corroborating our results, although the methods are clearly not comparable.

Another question is whether the reindeer calves eaten by the eagles are actually killed by the eagles themselves or whether the calves are scavenged by the eagles, after having been killed by another predator or died from other causes. This is obviously of significance as to whether the eagle should be regarded as a threat to reindeer husbandry, but there are few data to address this question. Bjärvall *et al*. (1990) estimated that only 0.25% of the reindeer calves in a study area in northern Sweden were taken by Golden Eagles. Nybakk *et al*. (1999) found that Golden Eagles in central Norway accounted for 5.3–6.7% of the total predation, and that predation, overall mostly by lynx *Lynx lynx*, accounted for 18.3–40.5% of all deaths. Norberg *et al*. (2005, 2006) found that the Golden Eagle killed 2–3% of all radio-tagged calves in northern Finland, and that they took 21–70% of all predated calves, depending on district. In both studies, the calves taken by the eagles were lighter than average (1.6–4.1 kg) at the time of tagging. This suggests that the Golden Eagles may select calves in poor condition.

4.3. Conclusions

In Finnmark, there are probably between 120 and 150 pairs of nesting Golden Eagles (T.V. Johnsen, unpubl.), and between 30–50% of these nests may produce young in a given year (G.H. Systad *et al*. in prep.). If we assume that half of the pairs feed on reindeer calves and that each of these pairs brings 2.2 calves to their nest during the nestling season, between 44 and 83 reindeer calves are brought to successful nests in Finnmark. This is a very small fraction of the reindeer calves produced since the population is about 150,000 animals. However, this does not take into account the number of calves eaten by unsuccessful and non-breeding eagles, or what successful eagles feed on without bringing them to the nest. Furthermore, this study covered primarily May and June, and predation on ungulate calves by eagles may be higher later in the summer (Nybakk *et al*. 1999, Warren *et al*. 2001, Norberg *et al*. 2006).

In conclusion, our study seems to corroborate other studies in Fennoscandia, suggesting that reindeer calves contribute about 10% of the diet of nesting Golden Eagles in Finnmark, depending on the location of the nests in relation to reindeer distribution.

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Poronvasojen osuus maakotkien ravinnosta Norjan Finnmarkissa

Keräsimme saaliseläinten jäänteet 37 maakotkan pesältä Norjan Finnmarkissa kuuden vuoden (2001–2006) aikana saadaksemme selville poron vasojen merkityksen maakotkan ravinnossa. Tutkimusalue jaettiin vuonoalueeseen, joka on poroille tärkeä vasomisalue, sekä sisämaahan, missä vain harva yksilö vasoo. Tutkimuksen aikana kerättiin 469 saaliseläinten jäännöstä. Lukumääräisesti eniten maakotkat söivät lintuja (73 %). Riekot ja kiirunat vastasivat yksistään 51 % saaliseläimiä. Nisäkkäiden osuus saaliseläimistä oli 27 %. Lukumääräisesti tärkein nisäkäs oli jänis. Poron vasojen jäänteitä löytyi puolesta pesistä ja lukumääräisesti niiden osuus kaikista saaliseläimistä oli 8.5 %. Vuonoalueella vasojen osuus oli 13.2 % ja sisämaassa 6.5 %. Vuonoalueen pesistä löytyi suuremmalla todennäköisyydellä poron vasojen jäänteitä kuin sisämaan pesistä. Samanlainen ero oli koivu- ja mäntymetsissä sijainneiden pesien välillä. Tutkimuksen tulokset ovat samansuuntaiset kuin muissakin pohjoisessa Fennoskandiassa tehdyissä tutkimuksissa. Maakotkan merkitystä porojen saalistajana ei tämän tutkimuksen perusteella voi kuitenkaan arvioida.

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