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Breeding Success and Productivity of the Golden Eagle *Aquila chrysaetos* in Central Norway, 1970 - 1990

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ABSTRACT

Breeding success and productivity of the Golden Eagle *Aquila chrysaetos* breeding in Central Norway have been monitored from 1970 through 1990. The number of occupied territories visited each year ranged from 3 to 14. The mean number of young fledged per successful breeding pair was 1.28, and the mean number of young fledged per occupied breeding territory was 0.58. The mean breeding success was 46%. The annual variation in breeding success and productivity was large. The productivity was significantly higher the first year after a peak year in small rodent populations compared with other years. Since spring populations of Mountain Hare *Lepus timidus* and Willow Grouse *Lagopus lagopus* fluctuate synchronously with the small rodent population with one year's delay, this indicates that Golden Eagle productivity is affected by the fluctuations in the populations of its main prey species.

INTRODUCTION

Norway has a fairly high and stable Golden Eagle population of about 700-1,000 pairs (Gjershaug 1991). A previous study in Central Norway has documented that Willow Grouse/Ptarmigan, *Lagopus* spp. and Mountain Hare *Lepus timidus* were the main prey of the Golden Eagle during the breeding season, constituting 58% of prey numbers and 83 % of the biomass (Gjershaug 1981).

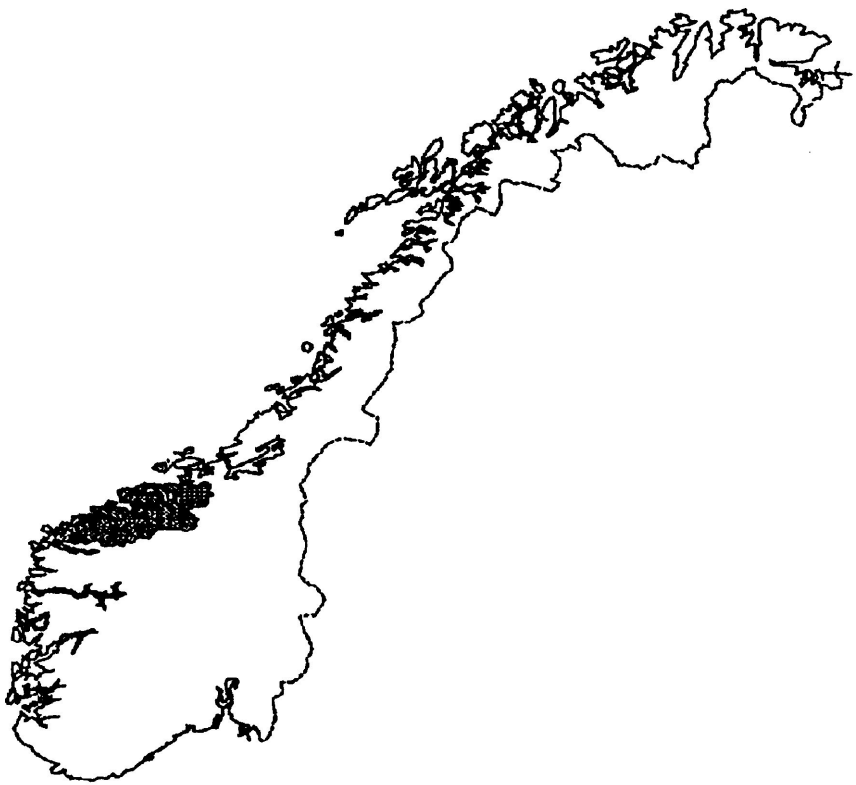
Several studies in boreal Fennoscandia have shown that there are synchronous 3-4 year cycles in the populations of small rodents (voles and lemmings), grouse and Mountain Hare. Spring populations of grouse and hare are highest one year after small rodent peak years (Hagen 1952; Moksnes 1972; Myrberget 1974; Hörnfeldt 1978; Lindlöf & Lemnell 1981; Angelstam *et al.* 1985).

In this study the breeding performance of the Golden Eagle is compared with the fluctuating small rodent population and the spring weather.

STUDY AREA AND METHODS

The study area (Fig. 1) is approx. 15,000 km^2, of which 41% is above the tree-line and 18% is forested (Miljøstatistikk 1978). Elevation of the nesting sites studied ranged from 200 m in the fjord district to 700 m in the inner part of the study area. All Golden Eagle pairs breed near the tree-line in the northern boreal region (Dahl *et al.* 1986). This region is dominated by birch forest and sparse low-productive pine forest.

Figure 1. The hatched region is the study area, a coastal mountain area between 62^{0}N and 63^{0}N in the Møre og Romsdal County in Central Norway.



In 1970 - 1990 the breeding territories were visited once each year when the young were large, mainly from end of June. As the Golden Eagles often have

several nests within their breeding territory, it is difficult to determine if the pair is breeding or not. Therefore territories in which I most certainly knew all alternative nests were selected. To a great extent the territories were preselected as recommended by Steenhof & Kochert (1982). Due to available time and resources the number of occupied territories monitored each year ranged from 3 to 14. As there was only one visit each year, it was often not possible to distinguish between non-breeding and unsuccessful breeding.

For want of data on grouse and hare populations from the study area, the productivity index of Willow Grouse (number of young shot per 2 adults) from all Norway was used (Myrberget 1991). This index is compared with Golden Eagle productivity the following years as the variation in spring population of Willow Grouse largely depends on production of young the previous year (Myrberget 1972). Peak years in the grouse population are not always synchronous in different parts of Norway (Myrberget 1982). This makes Myrberget's (1991) index a very crude estimate of the variation in abundance of Willow Grouse in my study area. Therefore the peak years in small rodent populations were also used as an estimator of prey abundance, also with one year delay. It is not possible to give the amplitude of the various peaks in the small rodent population because sufficient exact data are lacking.

Data on weather conditions (temperature, amount of precipitation, number of days with precipitation and number of days with strong wind $\geqslant$ 6 Beaufort) for the period January - April were obtained from the monthly reports from the Norwegian Meteorological Institute. Unfortunately, data from the whole period were available from only one station in the study area (Meisingset), and this station is situated near sea level and need not be representative for the weather conditions in the Golden Eagle territories.

The terminology used in this paper follows to a great extent Postupalsky (1974). The terms used are briefly defined as follows.
Territory: an area containing one or more nests.
Occupied territory: a territory where one or more of the following criteria were observed in the breeding season.

a) egg(s) or young in nest
b) newly outflown young
c) one or two adult birds on or near the nest
d) nestbuilding

Successful breeding: a nest producing fledged young.
Breeding success: the proportion of occupied territories producing fledglings.
Brood size: the average numbers of fledglings per successful breeding.
Productivity: the average number of fledglings per occupied territory.

RESULTS

There was great variation between years in the proportion of pairs with successful breeding, ranging from 0 to 100% (mean 46%). The number of young produced per occupied territory ranged from 0 to 1.8 (mean 0.58). The mean number of young for successful pairs ranged from 1 to 2 (mean 1.28) (Table. 1).

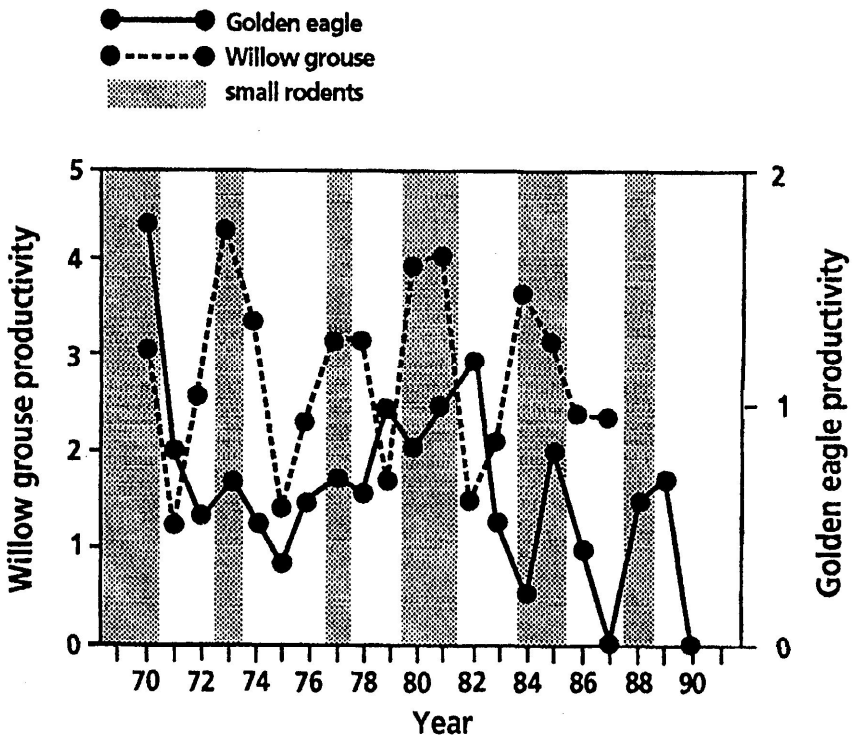
Table 1. Breeding success, brood size and productivity of the Golden Eagle. Number of territories surveyed within parantheses.

	Percent occupied territories with successful breeding		*Number of young per successful breeding*		*Number of young per occupied territory*
1970	100	(4)	1.8	(4)	1.8
1971	50	(4)	1.5	(2)	0.8
1972	33	(6)	1.5	(2)	0.5
1973	33	(3)	2.0	(1)	0.7
1974	39	(13)	1.4	(5)	0.5
1975	25	(12)	1.3	(3)	0.3
1976	50	(12)	1.2	(6)	0.6
1977	58	(12)	1.1	(7)	0.7
1978	50	(14)	1.3	(7)	0.6
1979	83	(6)	1.2	(5)	1.0
1980	75	(4)	1.0	(3)	0.8
1981	75	(4)	1.3	(3)	1.0
1982	80	(5)	1.5	(4)	1.2
1983	50	(4)	1.0	(2)	0.5
1984	20	(5)	1.0	(1)	0.2
1985	56	(9)	1.4	(5)	0.8
1986	43	(7)	1.0	(3)	0.4
1987	0	(6)		(0)	0
1988	43	(7)	1.3	(3)	0.6
1989	71	(7)	1.0	(5)	0.7
1990	0	(12)		(0)	0
1970-1990	46	(156)	1.28	(71)	0.58

There was no significant relationship between either breeding success or productivity and year (Spearman rank test: $rs = -0.3351$, $n = 21$ and $rs = -0.1716$, $n = 21$). There was a significant negative correlation between brood size and year ($rs = -0.6392$, $n = 19$, $p < 0.05$). But there was no significant difference between the brood size in the period 1970-79 and 1980-90 ($\chi^2 = 1.36$, $df = 1$, n.s.).

A high correlation was found between breeding success and productivity of the Golden Eagle (Spearman rank test: $rs = 0.9073$, $n = 21$, $p < 0.001$), but not between brood size and productivity ($rs = 0.3835$, $n = 19$, n.s.). There was a significant correlation between the productivity index of Willow Grouse and the small rodent population (Spearman rank test: $rs = 0.7479$, $n = 18$, $p < 0.001$) (Fig. 2).

Figure 2. Golden Eagle productivity (number of young per occ. terr.) compared with the peak years of small rodents and Willow Grouse productivity (number of young per 2 adults shot in autumn, data from all Norway, after Myrberget 1991).



There was furthermore a significantly higher breeding success and productivity one year after a small rodent peak year compared with other years ($\chi^2 = 4.6$, $df = 1$, $P < 0.05$) and Mann-Whitney U-test ($z = -2.388$, $p < 0.05$); but there was no such significant difference in brood size ($\chi^2 = 1.47$, $df = 1$, n.s).

A multiple regression analysis and Spearman rank correlation tests were carried out for all the weather variables, the grouse index with one year delay,

and the productivity of the Golden Eagle. There was no significant relation between any of these variables.

DISCUSSION

By preselecting territories as recommended by Steenhop & Kochert (1982), one usually gets a less biased estimate of breeding success. This approach involves minimal disturbance and has the advantage that one does not have to distinguish nonbreeders from unsuccessful breeders. In this study background information from other persons was used to a great extent to identify traditional breeding territories.

The breeding performance in this study was approximately the same as in Sweden, 1.21 young/successful breeding and 0.64 young/pair (Tjernberg 1983) and in Finland, 1.22 young/successful breeding and 0.64 young/pair (Virolainen & Rassi 1990).

Larger breeding success and productivity one year after small rodent peak years could indicate that the breeding performance of the Golden Eagle fluctuates parallel with its main prey species, as several studies have shown that there are synchronous 3-4 year cycles in small rodents, grouse and Mountain Hare in boreal Fennoscandia. A similar relationship between breeding performance of Golden Eagles and prey abundance has been reported by Murphy (1975), Tjernberg (1983), U.S. Department of the Interior (1979), Phillips *et al.* (1990), Watson *et al.* (1987) and Watson *et al.* (1989).

There were no more young per successful breeding in years after small rodent peak years compared with other years, which indicates that brood size does not fluctuate so much with prey abundance in this study. It seems that the food situation in spring has more influence on the breeding frequency than on whether the eagles have one or two young. This is contrary to the findings of Watson *et al.* (1987), who found that there was a better correlation between prey and brood size than with breeding success.

The absence of relationship between Golden Eagle breeding performance and weather could partly be a result of the fact that the weather data used were from one station near sea level, which perhaps was not representative for the weather situations at the elevations where the eagle nests are situated. Golden Eagles are well adapted to the weather conditions they meet, but some studies have shown that adverse weather conditions in spring could have effects on their breeding success (Phillips *et al.* 1990; Clouet 1981; Tjernberg 1983). In this study it was found that the year with most adverse weather in March (1990 had 300% more precipitation than normal and 12 days with storm in March) also was the year with the lowest breeding success (none of 12 occupied territories

was successful). But as this year also was a year with low prey abundance, the bad breeding performance of the Golden Eagle could be the result of the combined effect of food and weather.

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