Dispersal of Danish Goshawks *Accipiter gentilis* as revealed by ringing recoveries

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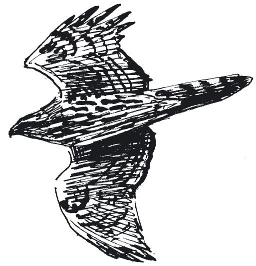

(Med et dansk resumé: Spredning af danske Duehøge Accipiter gentilis *belyst ved ringmærkningsdata)*

Introduction

The Goshawk *Accipiter gentilis* population in Vendsyssel, Denmark, was intensively studied in 1977-1998 (Nielsen 1986, Nielsen & Drachmann 1999a, 1999b), and since 1979 most nestlings produced within the study area were ringed. Here we present an analysis of the recoveries from these ringings aiming at investigating the pattern of dispersal. A large proportion of the recoveries were made in the first calendar year of the bird, making it possible to analyse the early dispersal from the natal area.

The Goshawk is a controversial species due to its tendency to prey upon pigeons, pheasants and poultry (Ziesemer 1983, Bezzel et al 1997, Nielsen & Drachmann 1999a), a behaviour exposing it to human persecution. Several of the recoveries in this study were of Goshawks killed or trapped near pheasant pens, pigeon lofts or chicken runs, which enabled an analysis of the age and sex composition of Goshawks approaching domestic animals.

We show that the Goshawks ringed in Vendsyssel dispersed relatively short distances from their natal nest, with no sex differences in dispersal. Among the Goshawks approaching domestic animals the majority were young individuals.

Methods

The study area covered 2417 km^2 of Vendsyssel (see Nielsen & Drachmann 1999b for a detailed description of the study area). During 1979-1998 a total of 1709 Goshawk nestlings were ringed within this area by JTN (1688 rings from Copenhagen Bird Ringing Center, Zoological Museum) and Arne Grøntved (21 rings from the National Environmental Research Institute, Kalø), or (excluding 75 ringed nestlings that died before fledging) 88% of the approximately 1848 fledglings produced within the study area (Nielsen & Drachmann 1999b). Nestlings were sexed according to size at the time of ringing, which was possible due to the large sexual dimorphism in Goshawks (Glutz et al. 1971); at same time the nestlings were aged by the size of their flight feathers (Holstein 1942). On average nestlings were 23 days old when ringed, and this figure was used for eight nestlings of unknown age at the time of ringing.

Recovery data (June 1979 to January 1999) were provided by Copenhagen Bird Ringing Center at the Zoological Museum, Copenhagen. The age at recovery was calculated as the interval between the time of ringing and the time of recovery plus the age at ringing. According to Kenward et al. (1993), 90% of Goshawk fledglings have dispersed from the nesting area when 65-90 days old, and 98% at 95 days after hatching. Therefore, Goshawks with an age of 49-104 days when recovered (n = 66) were used in the analysis of early dispersal from the nesting areas.

Dispersal distances were highly skewed, with most individuals being recovered towards the shorter end of the total range and only few at long distances from their natal nest. Dispersal distances are therefore given as medians with 25% and 75% percentiles. All statistical analyses are non-parametric and performed according to Zar (1996) with a 5% significance level.

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Results

Age and cause of recovery

Of the 1709 ringed nestlings, 986 were males, 708 females and 15 of unknown sex. When excluding 75 nestlings that died before leaving the nest area (i.e. were recovered in or near the nest) a total of 206 individuals were recovered, a recovery rate of 12.6%. There was no sex difference in recovery rate (89 females of 708 ringed (12.6%), and 116 males of 986 ringed (11.8%), $\chi_1^2 = 0.0003$, $p > 0.95$). One recovered bird was of unknown sex.

The mean age ($\pm$SD) at recovery was 426$\pm$536 days; 122 (53%) were recovered within their first calendar year (1y), and 84 of these (41% of all recovered individuals) were two to four months old. There was no significant difference between the sexes in the age at recovery (Fig. 1, $\chi_7^2 = 5.28$, $p > 0.50$).

The causes of recovery are shown in Tab. 1. Excluding birds found dead from unknown causes, 76 (56%) were killed or trapped near domestic animals (pigeon lofts, pheasant pens, chicken runs) – 58% of these were killed deliberately, 18% were killed accidentally, and 24% were caught and subsequently released. The majority (71%) of Goshawks recovered near domestic animals were 1y individuals (Fig. 2). There were no sex differences neither in the probability of recovery (41 ♀♀ and 35 ♂♂ recovered, $\chi_1^2 = 0.47$, $p > 0.25$) nor in the age at recovery for Goshawks approaching domestic animals (Mann-Whitney U = 615.0, $p > 0.25$).

Dispersal direction and distance

The direction and distance from the nesting area to the place of recovery for the 206 recoveries are

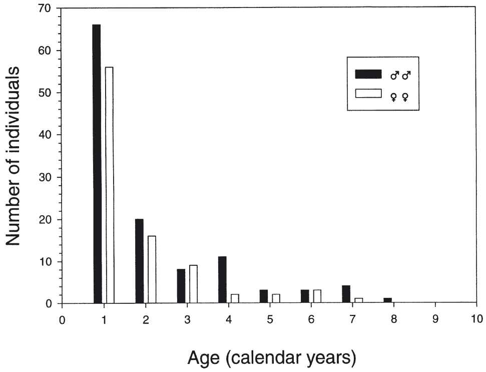

Fig. 1. Age at recovery of Goshawks ringed as nestlings in Vendsyssel, Denmark, in relation to sex.
Alder hos genfundne Duehøge mærket som redeunger i Vendsyssel.

shown in Fig. 3; recovery positions appear from Fig. 4. Few Goshawks dispersed far: 78% were recovered within 40 km from their natal area, while only 6% were recovered more than 100 km away. A 3y male found dead in Västergötland, Sweden, had moved 115 km and was the only individual recovered outside of Jutland.

To evaluate the post-nestling dispersal the 66 recoveries of individuals not older than about three months (104 d) were considered. These recoveries showed no sex differences in dispersal direction (Watson & Williams F = 0.52, $p > 0.50$), and the mean direction of dispersal for both sexes pooled was not significant (Rayleigh's test: z = 0.46, $p > 0.50$), indicating that the direction of dispersal was random. The median dispersal distance within the first three months of life was 18.5 km, the 25% and 75% percentiles being 10.0 km and 30.0 km, respectively. Dispersal distance as a function of age is shown in Fig. 5.

No differences in dispersal distance were found between 1y, 2y and 3y+ birds; neither were there any significant differences in dispersal distance between individuals recovered in their first winter and in subsequent breeding and non-breeding seasons (Tab. 2). Additionally, there were no differences between males and females in dispersal distance (Mann-Whitney U = 5609.5, $p > 0.25$). Thus, no influence of age, sex or season could be detected in the distances moved. Three birds were recovered twice, giving some indication of the within and between year movements of individuals (Tab. 3).

From 18 broods two or three young were subsequently recovered, which made it possible to compare the dispersal distances of nest-mates. There was no consistency in the dispersal directions taken by nest-mates, and no significant correlation existed between the distances moved by siblings ($r_S = 0.25$, n = 18, $p > 0.25$).

The brood size of ringed nestlings varied from two to four, but brood size per se did not influence the dispersal distance within the first three months of life (Kruskal-Wallis H = 1.79, df = 2 , n = 65, $p > 0.40$). To evaluate if long distance dispersal was related to the Goshawk density in a given year, we used the number of nesting individuals (assuming two per nest) plus the total number of young raised as a measure of density within the study area in late summer, when early dispersal took place. This measure only gave an index of the actual density, since it ignored the non-breeding floaters present within the study area each year (own unpublished data). However, dispersal distance within the first

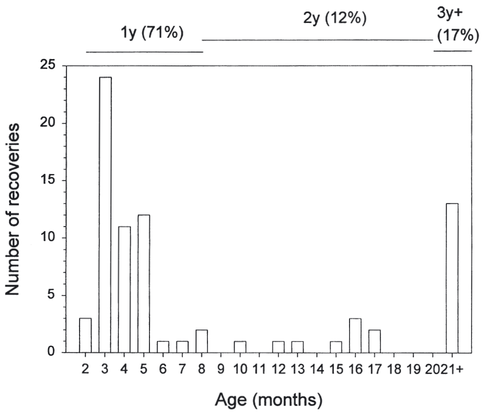

Fig. 2. Age distribution of ringed Goshawks recovered near domestic animals (pheasants, pigeons, and chickens), with age indicated as month and calendar year.
Aldersfordeling af ringmærkede Duehøge genmeldt ved dueslag, hønsegårde og fasanerier, med alderen angivet i måneder og kalenderår.

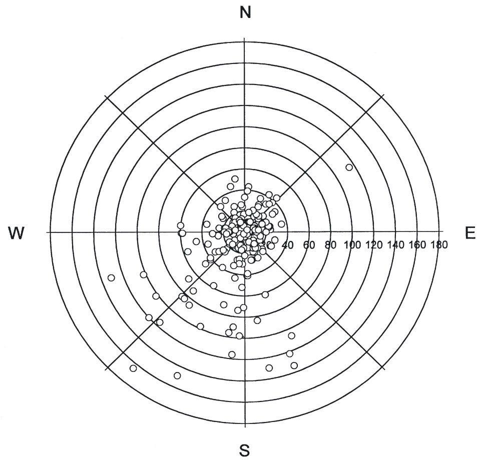

Fig. 3. Direction and distance (km) from place of ringing to place of recovery of 206 Goshawks.
Retning og afstand (km) fra mærknings- til genmeldings-lokalitet for 206 ringmærkede Duehøge.

three months of life was not associated with the density index (r_S = -0.03, n = 66, p > 0.80).

Discussion

For the ringed Goshawks the probability of recovery was related to the location, time and cause of recovery, with birds approaching domestic animals and subsequently being killed, caught or found dead by humans having a greater chance of being recovered than those dying of natural causes in the forests. In general, Goshawks dying close to human settlements would be more likely to be recovered. This was reflected in the cause of recovery (Tab. 1), since only 6% of the recovered individuals where the cause of recovery was known were not directly associated with human settlements (predated and wounded individuals). The ringing recoveries did therefore not reflect the movements of the population as a whole, since the tendency to be recovered by approaching humans tended to concentrate particularly on young individuals (Fig. 1 and 2). This recovery bias towards younger individuals, present also in most other bird species, is one reason why ringing recoveries of birds ringed as young have limited use in mortality estimation of birds (Lakhani & Newton 1983, Kenward 1993). It should not severely influence the analysis of dispersal, however.

The Goshawk came under legal protection in 1967, so persecution of Goshawks was illegal during the period of study, except for a few cases where exemption was granted. Nonetheless, sever-

Tab. 1. Cause of recoveries of 206 Goshawks. "Domestic animals" indicate Goshawks killed or trapped when approaching pheasant pens, pigeon lofts etc.
Genmeldingsårsager for 206 Duehøge. "Fasanerier, dueslag m.m." angiver Duehøge dræbt eller fanget ved disse.

Cause of recovery *Genmeldingsårsag*	Numbers *Antal*	pct
Domestic animals *Fasanerier, dueslag m.m.*	76	36.9
Killed in traffic *Trafikdræbt*	19	9.2
Collision with electric wire *Kollision med ledning*	20	9.7
Collision with building *Kollision med bygning*	13	6.3
Predation *Prædation*	3	1.5
Found injured *Tilskadekommet*	5	2.4
Unknown *Ukendt*	70	34.0

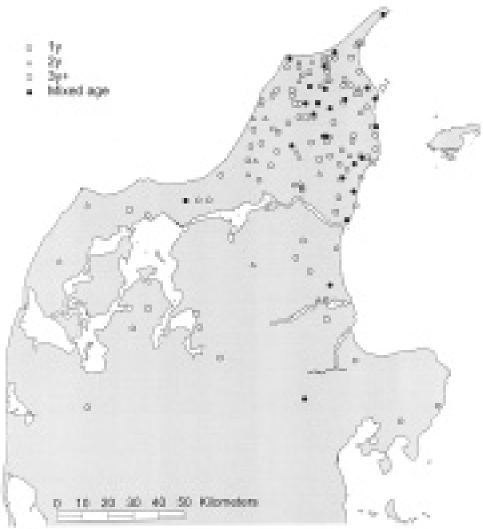

Fig. 4. Recovery position in relation to age (calendar years). "Mixed age" indicate recovery localities where birds of different ages were recovered. One recovery outside of Jutland, a 3y ♂ found in Sweden, is not shown.
Geografisk fordeling af genmeldte Duehøge i henhold til alder (kalenderår). Blandet alder (mixed age) angiver genmeldingslokaliteter, hvor flere fugle med forskellig alder blev genfundet. Ét genfund (ikke vist på kortet) blev gjort uden for Jylland, en 3K ♂ fundet i Sverige.

al Goshawks were killed when approaching pheasant pens, pigeon lofts and chicken runs, and many of those reported dead from unknown causes may also have been killed illegally. The actual proportion of birds recovered near domestic animals is therefore likely to have exceeded the 37% indicated in Tab. 1. The reason that so many (71%) of the Goshawks recovered near domestic animals were 1y individuals (Fig. 2) could be the poorer hunting skill of young individuals, making them prone to approach such places of abundant and apparently easily caught prey. Also, soon after independence young individuals would not yet have establised hunting territories and could be expected to hunt opportunistically over large areas. Female Goshawks take larger prey items than do males (Opdam 1975), and the size range of the domestic birds approached by the Goshawks appeared easier for female Goshawks to kill than for males; however, there was no tendency for females to be more frequently recovered near domestic animals than males.

The lack of any preferred dispersal direction, and the relatively short distances moved, showed that the study population consisted of non-migratory birds. Of course, the straight-line distance between natal area and site of recovery hardly reflects the route taken by the bird, and the sites of

Tab. 2. Dispersal distances of Goshawks ringed as nestlings in relation to age and season. First winter: fledging to February; breeding season: March-August; non-breeding season: September-February, after the first winter. Age is given in calendar years, and dispersal distances are given as 25%, 50% and 75% percentiles (P1, P2 and P3).
Spredningsafstand i henhold til alder og årstid. Første vinter: fra udflyvning til februar; yngletid: marts-august; uden for yngletid: september-februar. Alder er angivet i kalenderår og spredningsafstand som 25%, 50% og 75% percentiler (P1, P2 and P3).

Age/season *Alder/årstid*	Dispersal distance (km) *Spredningsafstand (km)*			n	Kruskal-Wallis test
	P_1	P_2	P_3		
1y	10.6	18.7	33.0	122	
2y	14.3	19.1	33.1	37	p = 0.19
3y+	15.6	25.3	40.9	47	
First winter *Første vinter*	10.6	19.0	32.9	128	
Breeding season *Yngletid*	14.3	19.3	40.0	50	p = 0.10
Non-breeding season *Uden for yngletid*	15.5	30.1	46.1	28	

Tab. 3. Direction and distance of movements by Goshawks recovered twice (n = 3).
Spredningsretning og -afstand for Duehøge genfundet mere end én gang (n = 3).

Ring no. *Ringnr*	Age in days *Alder i dage*	Direction (degrees) *Retning (grader)*	Distance (km) *Afstand (km)*
3032424	109 (1y)	23	10.1
	185 (1y)	186	9.3
3036345	686 (3y)	80	22.2
	1057 (4y)	77	24.5
3047475	92 (1y)	43	38.0
	819 (3y)	195	11.5

recovery need not have been the furthest places visited. The three birds recovered more than once reflect three different age-related movements (Tab. 3): 1) two positions within the first year in different directions, both at radius of 10 km from the natal area; 2) nearby positions during the third and fourth calendar year of the bird (hence a potential breeder, Nielsen & Drachmann 1999b), indicating a high site fidelity between years as reported for breeders in other Goshawk populations (e.g. Höglund 1964, Ziesemer 1983); 3) positions from the first and third calendar year of the bird, with the second closer (12 km) to the natal area than the first (38 km). A tendency for Goshawks to approach their natal area after the initial dispersal has also been found in Norway (Halley 1996), and the larger (albeit non-significant) median dispersal distance of birds recovered in the non-breeding season in this study (30 km) compared to the breeding season (19 km) may reflect the same pattern (Tab. 2).

The timing of early dispersal from the natal area could be inferred by examining the dispersal distance as a function of age (Fig. 5). One male was recovered 30 km from its natal nest 49 days after hatching, but all other recovered birds were at least 62 days old. This agrees with the Goshawk dispersal pattern reported by Kenward et al. (1993), where most individuals dispersed 65-90 days after hatching. Contrary to other studies, where males have been shown to move furthest (Haukioja & Haukioja 1971, Marcström & Kenward 1981), we found no sex difference in the distance moved by the Goshawks in our study population.

Nest-mates apparently did not accompany one another during dispersal, since the direction moved by siblings differed in 12 out of 18 cases. Only few young individuals dispersed over considerable distances (more than 60 km), and these movements were not associated with population density, so increased intraspecific competition could not explain the occurrence of long dispersal distances.

Dispersal determines gene flow and is important for inbreeding avoidance. We have no information on the frequency of matings between close relatives (siblings, parent-offspring). However, in the closely related Sparrowhawk *Accipiter nisus* no cases of inbreeding were found even though the birds tended to settle near their birthplace (Newton & Marquiss 1983). Also, mild inbreeding does not normally cause problems with inbreeding depres-

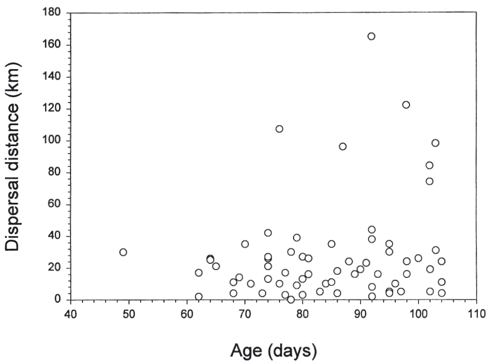

Fig. 5. Relationship between dispersal distance and age at recovery for Goshawks recovered within their first 104 days of life (n = 66).
Spredningsafstand som en funktion af alder hos Duehøge genfundet i løbet af de første 104 dage efter klækning.

sion in wild bird populations, and – depending on the effective population size and the mating system – the dispersal of relatively few individuals per generation between subpopulations is considered sufficient to avoid inbreeding (Thornhill 1993).

Acknowledgments
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Resumé
Spredningen af danske Duehøge *Accipiter gentilis* **belyst ved ringmærkningsdata**

I årene 1979-1998 blev 1709 Duehøgeunger ringmærket i Vendsyssel, og heraf blev 206 genmeldt efter at de havde forladt reden. Sandsynligheden for at blive genmeldt var lige stor for hanner og hunner, og aldersfordelingen for genmeldte individer var også ens for begge køn (Fig. 1). Hovedparten af genmeldingerne blev gjort nær bebyggelser (Tab. 1), og når der ses bort fra de fugle, der blev genfundet som følge af ukendte årsager, blev 56% af Duehøgene genmeldt ved fasanerier, dueslag og hønsegårde. Det var hovedsageligt unge fugle, som opsøgte sådanne steder (Fig. 2).

De fleste (78%) genmeldinger blev gjort mindre end 40 km fra redestedet, og der var ingen foretrukket spredningsretning (Fig. 3). Eneste fugl genmeldt uden for Jylland var en 3K ♂ fundet i Västergötland, Sverige. De nærværende ringmærkningsdata viser således, at Duehøgene i Vendsyssel er standfugle, hvor det formodentlig primært er ungefuglene, der bevæger sig rundt over større afstande. Den tidlige spredning væk fra redestedet blev undersøgt ved hjælp af 66 Duehøge, som blev genmeldt to til tre måneder (maks. 104 d) efter klækningen. Blandt dem blev 73% genmeldt mindre end 30 km fra reden, og kun 14% blev genfundet over 50 km væk. Der var ingen sammenhæng mellem spredningsafstand og kuldstørrelse eller den generelle tæthed af Duehøge i området i et givet år, så intraspecifik konkurrence påvirkede ikke Duehøgenes tendens til at bevæge sig langt væk fra stedet, hvor de var opvokset.

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