FACTORS AFFECTING THE NUMBER AND DISTRIBUTION OF WINTERING GEESE AND SOME IMPLICATIONS FOR THEIR CONSERVATION IN FLANDERS, BELGIUM

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ABSTRACT The Oostkustpolders in the NW part of Flanders is an important wintering haunt for Pinkfooted and White-fronted Geese. Their numbers, distribution and behaviour have been studied for nearly 30 years. The numbers of Pinkfeet have been increasing gradually in our study area, whereas the numbers of Whitefronts have mainly increased after the three severe winters 1984/85 - 1986/87. In severe winters there is always a large influx of birds of both species. Pinkfeet arrive in early November and there is a tendency to arrive earlier in recent years. Numbers peak at the end of December. Whitefronts arrive in mid November and peak in the first half of January. By the end of February most geese leave the Oostkustpolders. Over the years the geese dispersed from the core feeding area near Damme to the surrounding polders. This dispersion came about by a shooting ban and the influx of large numbers of birds during severe winters. Within winters, birds disperse over the whole polder area. They seem to follow a pattern of cyclic grazing different parts of the polder. Based on behavioural observations it can be shown that the dispersal occurs when feeding conditions deteriorate due to decreasing grass length. In this way all polders are grazed to a certain extent after which the whole cycle can start again. Although there are clear indications that at some times the maximum number of geese feeding in an area may be reached, the cumulative number of goose-days varies greatly between complexes. No relation is found however with the amount of food but a significant negative correlation is found between the number of goose-days per complex and the time of first arrival in that complex. The density of geese is found to be similar between all the polder complexes studied. The changes in the population of both Pinkfeet and Whitefronts are discussed and the factors influencing the occurrence of geese in the Oostkustpolders and the carrying capacity of the polders are analysed. Finally two contrasting views on goose protection, concentrating versus dispersing the geese, are discussed.

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INTRODUCTION

Habitat decline, through physical loss, agricultural intensification, pollution etc., is one of the major factors influencing natural populations. The more a species is specialized or dependent on a specific environment, the greater the impact of habitat loss upon populations. Wild geese, breeding in the arctic and wintering in temperate regions were once specialised feeders reliant on natural grass- and marshlands. Heavy hunting pressure and loss of wet, permanent semi-natural grasslands caused the decline of most goose species to very low levels during the middle of this century. Recent years have seen an increasing tendency to forage on agricultural land such that most goose populations are now dependent on managed grassland and arable crops.

Since the sixties almost all geese populations have shown an exponential increase through decreased hunting pressure (Ebbinge 1985), adaptable foraging behaviour and improved feeding conditions. The availability of a superabundant food supply (agricultural land) now obscures the factors determining present goose distribution. It is therefore necessary to understand the factors influencing distribution. Increasing numbers can result in increased densities in the existing wintering haunts, leading to overgrazing and agricultural damage, or in an expansion of the wintering grounds. This poses two fundamental questions: what regulates the numbers and densities in the traditional wintering haunts and the discovery and exploitation of new feeding areas. The answers form the basis for sound management of goose populations in the future, management which must aim to reduce agricultural conflict but secure the future of geese populations.

In this paper we describe the 30 year development in numbers and distribution of Pinkfooted (*Anser brachyrhynhus*) and White-fronted Geese (*Anser albifrons*) in the Oostkustpolders (Belgium) and we try to answer some aspects of the above questions.

MATERIAL AND METHODS

Study area

The study area, Oostkustpolders, is situated between Oostende, Brugge and the nature reserve "Het Zwin" on the Belgian-Netherlands border (Meire *et al.* 1988a, b). The area was divided into 13 units further called "polder complex" (Fig. 1), such as the famous site of Damme. These form functional units for the geese: disturbed geese tend to stay within a complex rather than move to another. Each part which is not divided by a road or canal is called a polder. Each polder is subdivided in many fields. In total the study area consists of 132 polders. Polder areas were digitalised from 1:25000 maps, excluding all buildings, gardens and verges. A polder was classified as permanent grassland if at least 75% of the surface was grasslands, otherwise it was classified as arable land.

Counting

During 1959/60 to 1975 counts were made 2 to 3 times a week (Kuijken 1976) and weekly since 1975. As goose numbers and dispersal increased, simultaneous counts from each half of the area have taken place since 1984/85. During the counts, all groups were mapped and the habitat type (grassland/arable land) was noted. During the very severe winter of 1978/79 most birds were forced out of the Netherlands and such large numbers of geese were present throughout the coastal polder area and Flanders, that no reliable overall counts could be made. Additional data from the IJzervallei (mainly from K. Devos and M. Becuwe) are also available (see Meire *et al.* 1988a). Counts from the Netherlands are all taken from the annual reports by the Ganzenwerkgroep Nederland/België (Ganzenwerkgroep 1976 - 1989), except otherwise mentioned.

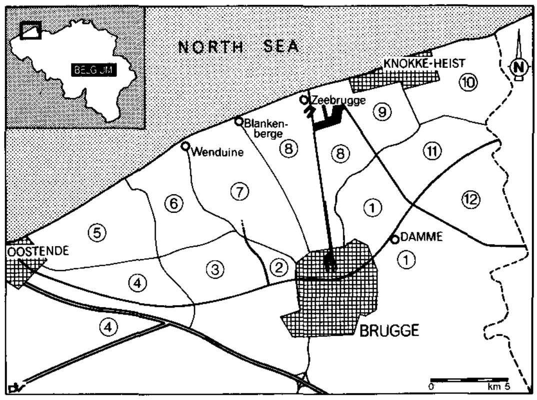


Fig. 1. Map of the study area showing the division into different polder complexes.

Population estimates

The population estimates of the Baltic-North Sea population of White-fronted Goose are based on Kuijken (1976) and the reports of the Ganzenwerkgroep (references above), sometimes adjusted with own data and additions from J. Phillipona. The size of the Svalbard population of the Pink-footed Goose is based on Madsen (1987).

Behavioural observations

During the winter 1984/85 the behaviour of individual geese was observed from small hides in different parts of the Oostkustpolders. Single geese were followed as long as possible. The mean observation time was about 3 minutes. Each activity was coded on a tape recorder, entered into a computer with an event recording program and analysed with SPSS (1986). We used 113 observations of Pinkfeet and 249 observations of Whitefronts, grouped into three periods (based on meteorological situation and number of geese present): period 2 (10/11/84 - 27/11/84); period 3 (28/11/84 - 21/12/84); period 4 22/12/84 - 3/1/85).

Grass measurements

In 102 fields in 9 polders most often used by geese, grass height measurements were made in the winter of 1984/85. Measurements were made by dropping a 22.3 x 22.3 cm piece of foam plastic (500 cm^2), with a ruler in the middle, on the vegetation (Kuijken 1969). The ruler was pushed onto the ground and the level of the foam, resting on the grass, could be measured. Grass length correlated with both fresh and dry weight of grass (Van Damme 1977). Measurements were taken in early November ($N = 5540$) when most cattle were removed and reflect the grass length on goose arrival. These measurements were repeated in mid March ($N = 5053$) after the geese left. Mean grass length per polder was calculated. Polder 1, 2 and 3 are situated in complex 1, polder 4 in complex 2, polder 5 in complex 3, polders 6, 7, 8 and 9 in complex 7. In two fields in Damme 50 measurements were taken on 4/11/84 and 2/1/85. More details are given in Lievrouw (1985).

Data analysis

From the counts, maximum numbers of each species were determined and the number of goose-days per complex and per hectare were calculated (for both species together). As not every field or polder per complex is used the number of goose-days ha^{-1} was also calculated per complex based only on the use of the core polder areas within each complex. A significant correlation was found between our measure and the real grazing pressure which was determined by Kuijken (1976) for 9 winters based on detailed mapping ($r = 0.69$, $N = 9$ $p < 0.05$). Goose-days ha^{-1} were calculated for six

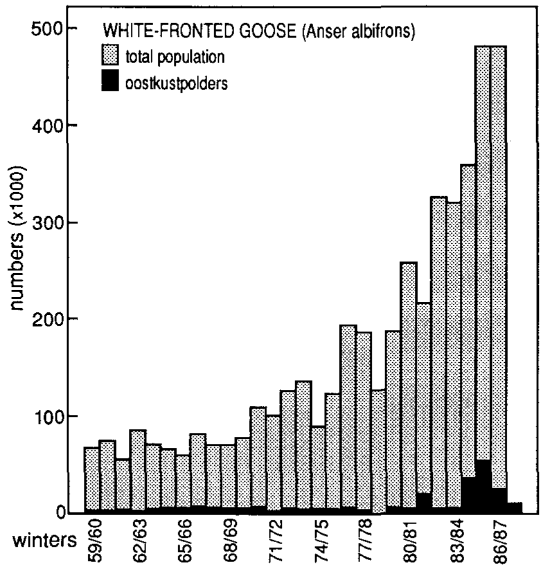


Fig. 2. Estimated population size of the Baltic - North Sea population and maximum numbers in the Oostkustpolders of the White-fronted Goose, *Anser albifrons*.

winters (1982/83 - 1987/88). To compare patterns of occurrence between years the maximum annual count was expressed as 100 and all other counts expressed relative to this. The average per ten days period was calculated and these values were averaged for two periods: 1965/66 - 1973/74 and 1981/82 - 1986/87. For each polder the frequency of use was determined as the total number of counts in the six winters (1982/83 - 1987/88) in which geese were counted in that polder.

RESULTS

Changes in the number of wintering geese

Fig. 2 shows the estimated five-fold increase in the Baltic-North Sea population of the White-fronted Goose and the maximum numbers in the Oostkustpolders. During the early years of the study (59/60 - 66/67) the population in the Oostkustpolders increased from 3 to more than 10% of the overall population. After the severe winter 1962/63 numbers almost doubled, but subsequently peak numbers remained quite stable (Kendal Tau correlation coefficient between year number and maximum number in the Oostkustpolders for the period 1964/65 - 1983/84, excluding severe winters 1978/79 and 1981/82, T = -0.02, N = 18, NS). As the overall population increased in the 1970s, the percentage in the Oostkustpolders dropped to about 2 - 3%. During the cold winters 1981/82 and 1984/85 - 1986/87 10 - 12% were present but in the following mild winters maximum numbers in the Oostkustpolders fell below 2% of the population, although numbers are now higher than before the severe winters.

Patterns for the Pinkfooted Goose differ markedly in some respects (Fig. 3). Overall, the population has nearly doubled in size since the 1960s. Up to 1978/79 maximum numbers in the Oostkustpolders were stable and amounted between 4 and 10% of the population. After 1978/79 maximum numbers increased and during the severe winter 1981/82 more than half of the population was present in the Oostkustpolders. Although numbers dropped in the next mild winter they increased again up to 30% of the population in the mild winter 1983/84 and reached more than 50%

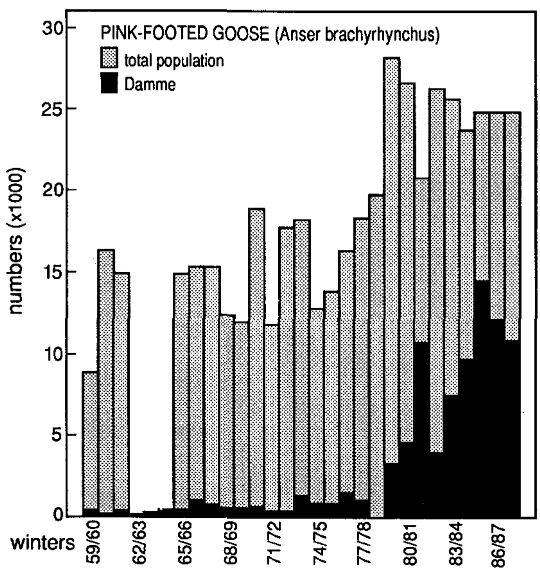


Fig. 3. Estimated population size of the Svalbard population and maximum numbers in the Oostkustpolders of the Pink-footed Goose, *Anser brachyrhynchus.*

Table 1. Average arrival (a) and departure (d) dates and residence time in days of geese in the Oostkustpolders during four 7 year periods.

	Damme			Polder	
Period	a	d	days	d	days
White-fronted geese					
60/61-70/71	24-11	2-3	98	2-3	98
71/72-77/78	15-11	17-2	94	20-2	97
78/79-80/81	13-11	9-2	86	6-3	111
81/82-87/88	5-11	13-2	100	9-3	124
Mean	15-11	21-2	98	1-3	106
Pinkfooted geese					
60/61-70/71	12-11	26-2	106	26-2	106
71/72-77/78	5-11	12-2	99	16-2	103
78/79-80/81	6-11	8-2	94	2-3	116
81/82-87/88	28-10	16-2	112	26-2	122
Mean	6-11	18-2	104	24-2	110

during the severe winters 1984/85 - 1986/87 (Kendal Tau correlation coefficient between year number and maximum number in the Oostkustpolders for the period 1964/65 - 1983/84, excluding severe winters 1978/79 and 1981/82, T=0.6, N= 18, p<0.001). Numbers have also remained high during the subsequent mild winters and the Oostkustpolders have become a regular wintering area of nearly half of the Pinkfoot population.

It is obvious that this increase in goose numbers from a few thousands to over 70 000 birds in the winter 1985/86 could have consequences for the phenology and especially the distribution of the geese.

Pattern of arrival, departure and occurrence

The average arrival and departure dates of geese in the Oostkustpolders are given in Table 1. On average, geese arrive now about two weeks earlier than before. Pinkfeet always arrive first. The last geese, mostly Whitefronts, leave early March, some 10 days later than in the 1960s. The mean residence time has increased by some 20 days. The relative pattern of occurrence of both species is given in Fig. 4 for two periods. Although the geese arrive earlier,

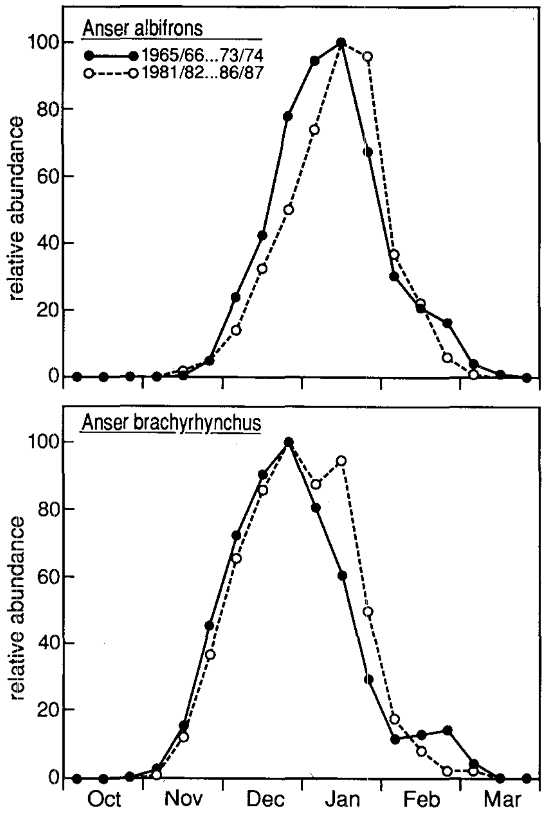


Fig. 4. Relative pattern of occurrence of White-fronted and Pink-footed Geese in the Oostkustpolders in two different periods.

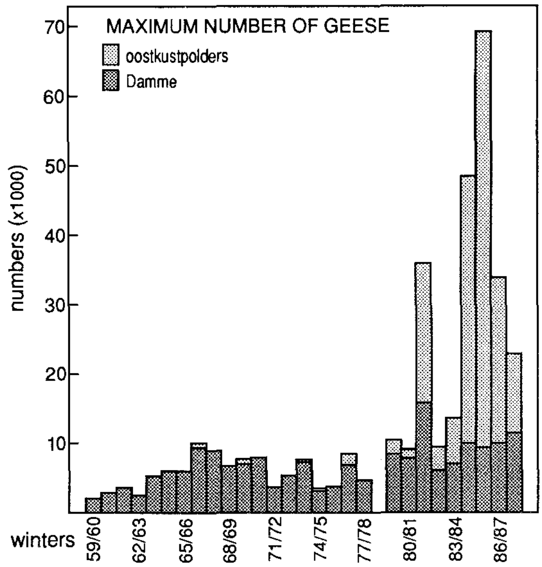


Fig. 5. Number of geese in the Oostkustpolders and Damme at the peak count.

the majority (especially of Whitefronts) arrives later in the season. Large numbers tend to stay longer now but this could be influenced by the occurrence of four severe winters in the second period.

Distribution of geese and seasonal changes

For many years geese were only observed in Damme from which they dispersed to other areas in the Oostkustpolders (Fig. 5). In Fig. 6 this dispersion and the changes in major feeding areas are plotted. Areas visited each winter are called primary feeding areas, those visited less frequently secondary feeding areas. Apart from polders near the nature reserve "Het Zwin", all primary feeding grounds were concentrated near Damme, where under a voluntary agreement with local hunters, no

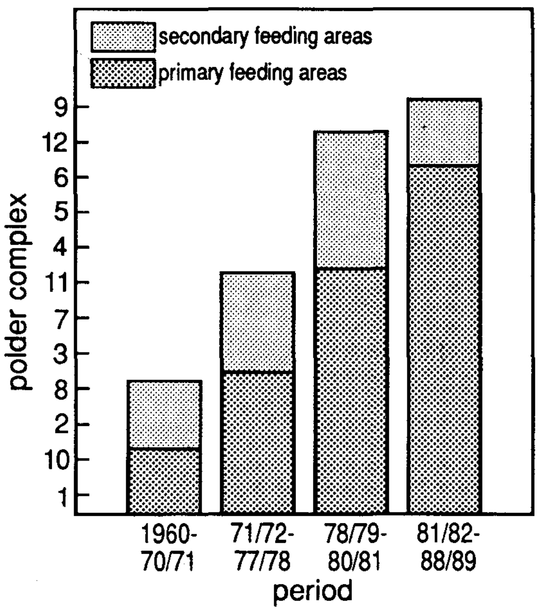


Fig. 6. Distribution of primary and secondary feeding areas of the geese over the different polder complexes between 1960 and 1988.

goose shooting has occurred since 1960 in a zone of 450 ha from December onwards. In an attempt to disperse the geese, which increased in numbers, a shooting ban in an area of 3000 ha around Damme was officially declared in 1968/69. At this time secondary feeding areas near Ramskapelle came into use. After extension of the shooting ban in 1971/72 to 6250 ha, including those secondary feeding areas, they became also primary feeding areas, whereas East of Brugge several secondary feeding areas came in use. At this time however, the majority of birds still remained near Damme (Fig. 5). During the exceptional invasion of geese in 1978/79, they dispersed over the whole polder attempting to find suitable feeding sites. Afterwards the polders near Uitkerke became a primary feeding area. In 1981/82 a national goose shooting ban was declared and many sites used previously by geese became primary feeding areas. Details of this expansion are mapped by Kuijken & Meire (1987) and Meire *et al.* (1988a).

Distribution and changes during one winter

Over time geese have dispersed over the Oostkustpolders but also in the course of one winter several feeding areas are visited. In fact the progression shown in Fig. 6 can be observed each winter as the geese move from one feeding area to another. This is illustrated in Fig. 7, where the presence or absence of geese in each polder complex on each count during the winter 1985/86 is given. In Fig. 8 the cumulative numbers of goose-days in different polder complexes are plotted for a mild (1983/84) and a severe winter (1984/85). Geese always arrive first in Damme (complex 1), remaining all winter, hence the increase in numbers of goose-days throughout. Other polder complexes are visited sequentially, being utilized, abandoned and revisited. In Fig. 8 this results in an increase of the numbers of goose-days followed by a plateau, again an increase etc. While the cumulative numbers of goose- days reach a plateau in one complex, birds are visiting another one resulting in an increase there (Fig. 8). This pattern of sequential and cyclic visiting of the polder complexes can also

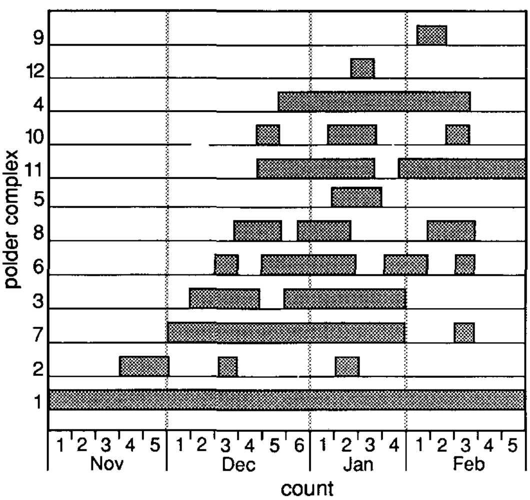


Fig. 7. Distribution of the geese over the different polder complexes during the winter 1985/86. For each count the absence or presence of geese within each polder complex is given.

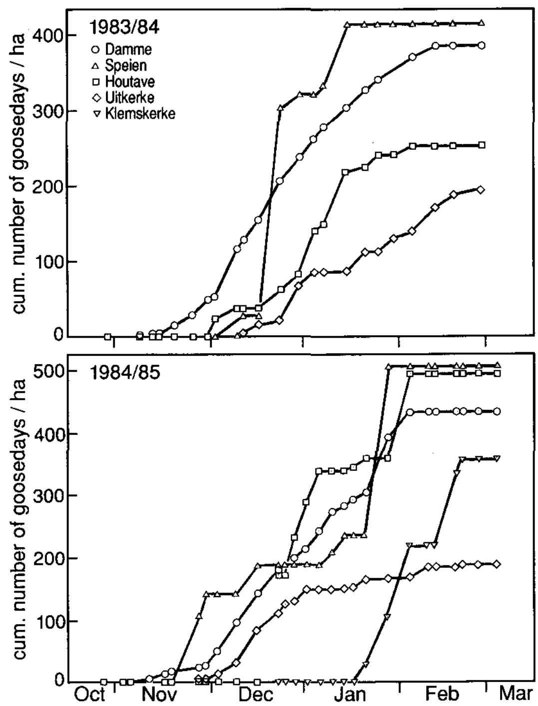
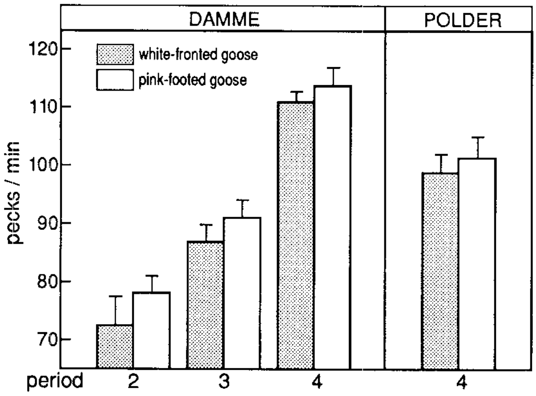


Fig. 8. Cumulative number of goose-days spent in different polder complexes during two winters. Winter 1983/84 was very mild, 1984/85 very severe.

be observed within one complex where the birds move from one field to another (Kuijken 1976).

Dispersion and feeding conditions

This cyclic use of feeding areas can be understood by studying in detail the behaviour of geese, which was done during the severe winter 1984/85. In Fig. 9a, the peck rate of both species is given during three periods in the polder complex of Damme. For both species the increase is very significant. This increased peck rate is correlated with a



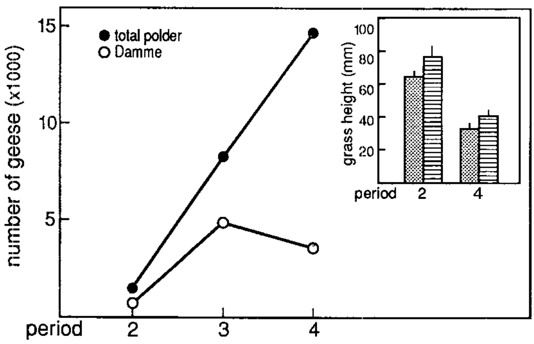


Fig. 9a. Average peck rate of Whitefronts and Pinkfeet in Damme during three time periods (2, 3 and 4; see text) and in the remaining polder area during time period 4', the first period when larger numbers of geese were present out of Damme.

Fig. 9b. Number of geese present in Damme and the Oostkustpolders during the three studyperiods. In the inset the average grass height in two fields (± *SE*) in Damme is given for the second and the fourth time period. All data are from the winter 1984/85.

decrease in the grass length. In two pastures the average grass length decreased by 3 - 4 cm between period 2 and 4, a highly significant decrease (Fig. 9b). In period 2 most geese were counted at Damme whereas in period 4 numbers declined at Damme and most geese dispersed over the other polder areas. Their average peck rate in the other polder areas was at that time significantly lower than in Damme (Fig. 9a; Pinkfeet Mann-Whitney $U = 33$, $N = 24$, $p < 0.05$; Whitefronts Mann-Whitney $U = 14$, $N = 45$, $p < 0.05$). From this we suggest that birds disperse to areas were the feeding conditions are best at that time. When all feeding areas have been exploited and feeding conditions are approximately similar some polders are revisited and the cycle can start all over again. Clearly many other factors, especially disturbance, interfere with this grazing pattern. Polders near Oostkerke for example are visited only after the end of January, which may be explained by the high waterfowl hunting pressure in this area until the end of January, when the shooting season closes.

There seems also to be changes in the distribution over the polder areas. The pattern of cyclic feeding area use is constant from year to year but the commencement of the process seems to start earlier and earlier. Birds start to disperse from Damme earlier and after less goose-days now than earlier (Table 2).

Grazing pressure

Cyclic consumption of the available food supply is probably a successful strategy for geese but

Table 2. Dispersion of geese from Damme to the remaining polder area. The number of days and goose-days between the arrival of geese in Damme and the first day geese are observed in other polder complexes is given.

winter	days	goose-days (in Damme)
82/83	50	121 000
83/84	51	99 000
84/85	56	75 000
85/86	43	80 000
86/87	28	43 000
87/88	28	33 000

Table 3. Number of goose·days ha^{-1} for all the 13 complexes (a) and the core areas of complex 1 to 7 (b) during 6 different winters and for the nine polder areas studied in detail during the winter 1984/85 (c).

(a)		winter					
complex	surface (ha)	82/83	83/84	84/85	85/86	86/87	87/88
1	845	305	354	403	629	525	461
2	140	154	321	402	438	180	479
3	1305	17	57	139	432	210	35
4	1300	0	0	56	217	119	94
5	635	4	0	183	98	0	59
6	755	5	35	137	98	140	16
7	1565	128	168	237	290	221	165
8	285	1	0	25	200	134	8
9	45	0	0	0	37	0	0
10	1270	24	13	38	15	9	84
11	845	0	0	53	75	123	6
12	335	0	0	15	14	35	0
13	635	0	9	52	101	59	4
(b)							
1	790	326	378	431	673	550	493
2	110	197	408	503	557	229	610
3	105	5	102	190	1041	944	381
4	500	0	0	75	541	188	246
5	285	10	0	358	173	0	133
6	235	96	249	492	859	393	35
7	755	190	190	185	195	197	232

(c) winter									
polder	1	2	3	4	5	6	7	8	9
complex nr.1	1	1		2	3	7	7	7	7
surface	155	120	95	110	125	140	350	250	155
goose·days ha^{-1}.	540	721	710	556	903	427	411	135	201

as the grass sward becomes shorter the foraging benefit must at a certain time drop below the threshold of profitable return and geese must then leave the area. As winter regrowth of grass is limited the available grass biomass at the onset of winter might determine the number of goose·days which can be spend in an area. In Fig. 10 the number of goose·days near Damme is plotted as a function of the total number of goose·days in the Oostkustpolders. This suggests that, indeed, there is a leveling off of the number of goose·days somewhere between 400 000 and 500 000 goose·days or between 550 and 650 goose·days ha^{-1}. The number of goose·days differ however largely between different complexes as can be seen from Fig. 8 and Table 3.

In 1984/85, grass height was measured at the beginning of the wintering season, in several polders (Fig. 11). Although significant differences exists between polders (ANOVA, $F_{8,5531} = 24.5$; $p < 0.001$) these do not explain the large differences

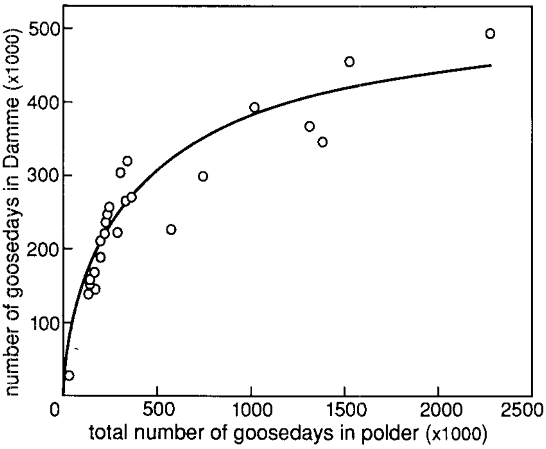


Fig. 10. Number of goose·days in the polder near Damme (complex 1) and the total number of goose·days in the Oostkustpolders. (Line fitted by eye).

in the number of goose·days between polders (Table 3). At the end of the winter the grass was on average 3.6 cm shorter. Again there were significant differences in grass length between the polders (ANOVA, $F_{8,5044} = 111.5$; $p < 0.001$) but there was no correlation between grass biomass which disappeared during the winter and the number of goose·days per polder ($R_s = -0.22$, $N = 9$, NS). There was however a correlation between the number of

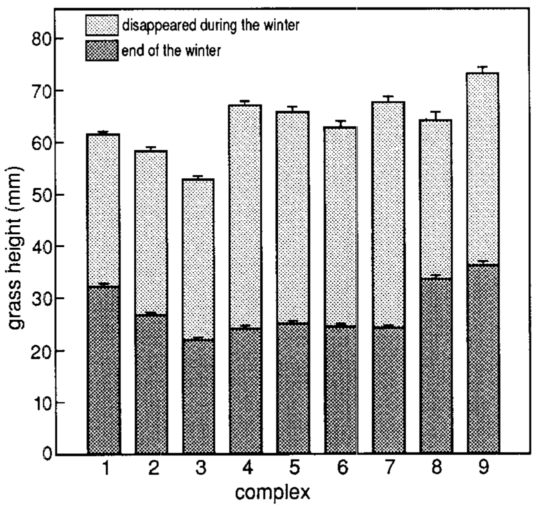


Fig. 11. Grass height (± *SE*) in 9 polder areas in the Oostkustpolders at the onset and the end of the winter.

Table 4. Correlation between the number of goose·days ha^{-1} and the time of first arrival of the geese in a polder complex. Same correlation but based on the data of individual polders (*).

winter	*r*	*N*	*p*
1982/83	-0.826	9	<0.01
1983/84	-0.711	7	NS
1984/85	-0.849	12	<0.001
1985/86	-0.863	13	<0.001
1986/87	-0.891	11	<0.01
1987/88	-0.813	11	<0.01
1984/85*	-0.702	9	<0.05

goose·days ha^{-1} and the time of first arrival of the geese per complex, a correlation which is found for all six winters (Table 4). This is probably partly due to the natural mortality of grass, especially in severe winters. The later the birds arrive in an area the shorter the grass will be due to natural die off and hence the smaller the carrying capacity for geese. Indeed grass measurements in the winter 1984/85 show that in a field not grazed by geese or cattle grass length decreased from 6.9 cm ($N = 50$) to 4.2 cm ($N = 50$) between early November and half March, a highly significant decrease.

Another factor which might influence this relation is goose density. If goose density is regulated below a certain level, geese cannot compensate for the late arrival in a complex by feeding in higher densities. This leads to fewer goose·days in areas visited later in the season. For each count the density of geese was calculated by dividing the number of birds by the area of the complex and in Table 5 the median densities are given. With the exception of (the small) complex 2, mostly used by Pinkfeet only, where the median density is rather high, the values for most other complexes are comparable. With some exceptions, the maximum densities are also comparable. This might indicate a limit to the number of geese feeding per ha.

Another indication of the limitations on the numbers of geese is given in Fig. 12. Here the total area of polder used is plotted in function of the number of goose·days. The total area exploited

Table 5. Median density of geese in the 13 complexes and in the core polders of the 7 most important polder complexes. *N* is the number of counts on which the median is based.

complex	density (ind. ha^{-1})	*N*	density (ind. ha^{-1})	*N*
1	2.92	138	3.12	138
2	7.57	37	9.01	35
3	1.38	53	4.77	22
4	1.94	31	4.31	26
5	1.34	15	4.68	14
6	0.35	45	4.34	42
7	2.05	85	2.19	67
8	0.27	28		
9	4.71	1		
10	0.63	47		
11	0.30	48		
12	0.40	8		
13	2.40	23		

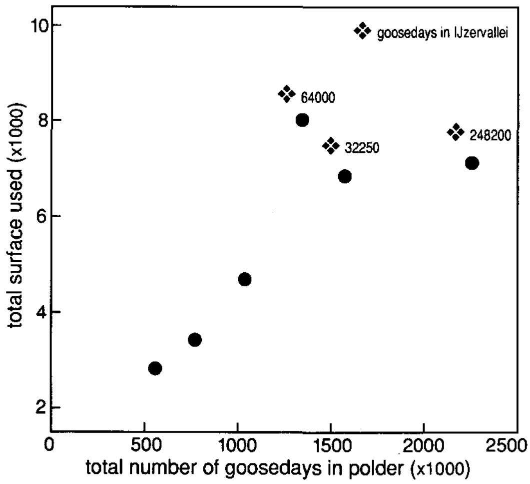


Fig. 12. Total surface used by the geese in function of the total number of goose-days in the Oostkustpolders in six consecutive winters. The number of goose-days in the IJzervallei are also given.

levels off at 7000 - 8000 ha. But as the number of goose-days increases, more birds fly on to spend the winter in the IJzervallei, a wintering area some 40 km further south, as is indicated by the number of goose-days in the IJzervallei on Fig. 12. In the 3 mild winters no geese occurred in the IJzervallei.

DISCUSSION

General remarks

There have been tremendous changes in the number and occurrence of wintering geese in NW-Europe in recent decades. It is clear that many factors, working on different levels, influence these changes. In the Oostkustpolders the numbers and distribution are influenced by total population size, dispersion behaviour, disturbance, geographical situation, food supply, available polder areas etc., factors which we will briefly discuss here.

Overall numbers in NW-Europe and the Oostkustpolders

The expansion in the Baltic-North Sea population of Whitefronts in the early seventies is spectacular. During 1965/66 - 1973/74 the population increased exponentially (Kuijken 1976). Based on extrapolation of this curve the population estimate for 1986/87 was 503 000 birds, remarkably close to the observed 480 000 birds. Ebbinge (1985) argued that this population increase was largely due to the ban on spring shooting in the USSR which became effective in 1970. The increase in population size is not reflected in wintering numbers using the Oostkustpolders. After the severe winter 1962/63 the numbers in Damme nearly doubled but then remained fairly stable until 1983/84, with the exception of the severe winters 1978/79 and 1981/82, although since 1971/72 a regional shooting ban protected the geese in a rather large area. In England the population declined during this period (Owen *et al.* 1986) and the small population wintering in France disappeared (Kuijken 1969). Restrictions of shooting and increase in feeding opportunity has improved conditions in The Netherlands, while in the Niederrhein area (FRG) numbers have also increased dramatically (Mooij 1982, 1991). During severe winters in The Netherlands large numbers of Whitefronts winter in the Oostkustpolders. After the three recent severe winters the numbers increased very substantially, with up to 12 000 in 1987/88 and 17 000 in 1988/89, both very mild winters. Perhaps the population had reached the carrying capacity in The Netherlands and more birds winter further South. This can not explain why earlier constant numbers of birds wintered in Damme. The heavy shooting pressure in Friesland especially in 1985/86 (Anonymous 1989) may also influence this (temporal) shift.

The Svalbard Pinkfeet have increased less spectacular from 15 000 in the late 1970s to 25 000 birds now (Madsen 1987). According to Ebbinge *et al.* (1984) and Madsen (1987) this was due to shooting bans in Svalbard (1975), the Netherlands (1976) and FRG (1977). In contrast to the Whitefronts, numbers of Pinkfeet in Flanders did increase throughout the period and was more rapid than that of the overall population. Indeed the proportion wintering in the Oostkustpolders increased from about 5% in the sixties to nearly 30% in 1983/84, prior to three severe winters, indicating a shift in the wintering grounds of the species. It is well known that the Pinkfoot is very sensitive to disturbance (Madsen 1985). Deliberate disturbance in Friesland by farmers, the shooting ban and relatively undisturbed situation in the Oostkustpolders are probably important causes for this shift in distribution.

Pattern of occurrence

Pinkfeet arrive in the Oostkustpolders first. The earlier arrival in recent years corresponds to that in the Netherlands were the species arrives two weeks earlier now than in the 1970s. This is probably because birds fly straight from Denmark to the Netherlands and Belgium (Schilperoord 1984), due to deliberate scaring of geese in Denmark and the Netherlands by farmers (Madsen 1987). Probably the available autumn food in Filso (Denmark) is limiting now, due to changing farming practices, forcing the growing population to migrate southwards earlier each year (Madsen, pers. comm). The peak numbers of Pinkfeet mostly occur in the late December; this has not changed in 30 years, although, during severe winters a smaller second peak can occur in January (Meire *et al.* 1988a). Remarkable is the disappearance of the small peak at the end of February in recent years, by which time most have gone. It might indicate in earlier years some birds migrated further south. In south-west Friesland, peak numbers occur mostly in November although in some years it was as late as February (Ganzenwerkgroep, several years). In some years (e.g. 1974/75) most Pinkfeet left SW-Friesland by the beginning of December. In other years numbers remained high until the end of February (e.g. 1980/81). This variation is partly due to weather conditions. In December flocks can move south to Damme, and in mild winters northwards to Denmark. In response to the weather conditions the geese can even migrate several times between Denmark and the Netherlands (Madsen 1987). Some important movements between the wintering areas in Friesland and the Oostkustpolders have been documented by Schilperoord (1984) and Meire et al. (1988a). More detailed counts from Friesland are required to compare the pattern of occurrence at both sites.

Whitefronts peak in the first half of January. The pattern of occurrence is quite constant notwithstanding the large changes in numbers. In general numbers decrease much earlier than in the Netherlands.

Changes in wintering distribution

Increases in numbers of wintering geese in NW-Europe have resulted in many more wintering haunts being used, as in the Netherlands and Niederrhein area where the numbers increased from a few hundred to 150 000 (Mooij 1991). From our data and those from Niederrhein it is obvious that protection and severe winters play a very important role in the distribution of geese. The appearance of Pinkfeet in Friesland in the very severe winter 1955/56 and the subsequent development of this area into one of the most important wintering haunts of the species (Timmerman 1977) is another example. However there must be other factors involved. In Damme a small population of geese has occurred for many years and after the severe winter 1978/79 when probably the largest part of the population visited Flanders no increase in Whitefront numbers was observed, notwithstanding the large increase in the population. After the severe winters 1984/85 - 1986/87 Whitefronts nearly doubled in numbers. Numbers of Pinkfeet on the other hand had already increased before the severe winters but the rate of increase seems quicker after the severe winters. This is surprising since protection in the Oostkustpolders is much better than in the Netherlands. Other factors explaining this large scale distribution of the species are not presently understood.

Use of the feeding grounds

Within winters, geese disperse over the whole polder area. Different polders or complexes are visited sequentially. Why the birds always arrive first in Damme remains unclear but does not seem correlated with available food or disturbance levels, and may simply be the result of tradition. The earlier dispersion from Damme in recent years (Table 2) might indicate a change in this pattern. Tradition is probably also important in determining the sequence in which different complexes are used. The use of individual polders seems related to their size and disturbance levels.

Our data indicate that the birds utilize an area for some time and then, as feeding conditions deteriorate, move to another area, revisiting the site after some time. Based on detailed mapping Kuijken (1976) found that individual fields were used on average every 7 days but with differences between central and marginal parts (respectively every 4 days to every 16 days or more). This strategy is also described by Lorenzen & Madsen (1985) for the Pinkfeet on the Tipperne peninsula (Denmark) and Prop (1991) studying Brent geese feeding on saltmarshes in spring where the revisiting frequency was related to the growth rate of *Plantago*, their preferred food plant. In winter normally no grass growth occurs and there is some natural die off. The advantage for geese in revisiting an area is probably the fact that the grass recovers after trampling by geese. The presence of droppings can also have an effect, especially as geese roost on feeding grounds. In the end most feeding areas are grazed to the same extent. This mechanism is quite similar to the ideal free distribution of Fretwell & Lucas (1969).

The number of goose·days ha^{-1} in the Oostkustpolders is low compared with that of Owen (1973). Comparison is however very difficult since grazing pressure calculated for individual fields will of course be larger than when it is calculated for a polder complex. Clear however is that the carrying capacity, expressed as the numbers of goose·days which can be spent or the number of geese which can winter in an area, is very difficult to estimate. Figures 5, 10 and 12 give strong evidence that at certain times geese have to disperse to other feeding areas. The cumulative number of goose·days might differ however considerably between polders. These differences can not only be explained by differences in the amount of food present. Based on the results presented the carrying capacity is function of the available food, the time of first arrival of the geese and the density of geese.

It is well known that geese do not feed near to roads or obstacles (Kuijken 1969, Owen 1972, Madsen 1985) and that disturbance determines the distance from the road. In the Oostkustpolders, it is clear that, as no goose shooting occurred in the last 8 years, geese are feeding nearer to roads and visiting feeding areas not used in the past. If we take a circular feeding area with a radius of 800 m, with birds avoiding a zone of 100 m around the edge, the available feeding area is about 155 ha. If as a consequence of protection they learn to feed up to 50 m from the edge their available feeding area increases up to 177 ha or a 15% increase. For an area with a radius of 500 m the gain is 21%. Thus lower disturbance levels cause a lower energy expenditure to flying, allows the birds to exploit a significantly larger part of the present polder areas and are better able to use their strategy of foraging and cyclic revisiting.

Different views on goose protection

In developing strategies for the management of geese two opposing views have developed, both aiming to reduce the conflict between geese and agriculture while conserving a healthy population. Owen (1977) and Owen *et al.* (1987) advocated the use of refuge areas in which one tries to *concentrate the geese* in rather small areas managed to provide optimal feeding conditions, a technique used in Britain especially by the Wildfowl Trust (e.g. The New Grounds in Slimbridge; Caerlaverock), in the Netherlands (e.g. Ganzengouw) and America. By concentrating the geese in the refuge areas damage is reduced on nearby farmland. At the New Grounds, they succeeded in attracting the geese, through improved management, from a larger area to the inner refuge (Owen 1977). At Caerlaverock, the refuge carrying capacity increased substantially but as the population of Barnacle Geese (*Branta leucopsis*) increased as well, areas outside the refuge were increasingly used (Owen *et al.* 1987).

The opposing view favours protection (a shooting ban) of large areas for geese to *disperse them* over as large an area as possible, reducing the grazing pressure per field and avoiding agricultural damage. This has been used with success in Flanders and in the Niederrhein area. The results presented here and by Kuijken (1976) and Lorenzen & Madsen (1985) clearly indicate that goose populations (at least Whitefronts and Pinkfeet) tend to disperse as much as possible into small flocks. Indeed, the advantages of group feeding such as a reduction of vigilance time in function of group size are obvious only when group size increase from a few to about 100 individuals (Lazarus 1976, Dick 1988). In larger flocks no effect of group size on behaviour could be found (Lievrouw 1985, Ysebaert 1987, unpublished data). Here, we show goose dispersal results in improved feeding conditions as they are visiting "fresh areas" but the dispersal itself is probably independent of the food supply as is indicated by the earlier dispersion from Damme in recent years. This dispersal results in moderate grazing pressure, which on permanent semi-natural grassland normally does not cause agricultural damage. This system has in our opinion several advantages over the strict refuges. First it makes use of a fundamental aspect of the behaviour of the geese: dispersion, whereas in a refuge just the opposite occurs. In limited sites, birds reach artificially high densities and when geese move outside such refuges high feeding concentrations cause agricultural (and psychological) problems to surrounding farmers. Secondly, if populations become very dependent on a few refuge sites they are very vulnerable. By dispersing the geese local adverse conditions only affect small parts of the population. Thirdly, by providing the birds with a superabundant selected food source, the populations become dependent on such management practices instead of having the birds adapted to semi-natural food resources mainly in permanent grasslands. Where field crops are threatened, local scaring can avoid damage. The problem with the closed shooting and dispersal model is that there is no mechanism to limit population growth as the geese can use more and more feeding grounds, which are still available, unless population regulation takes place on breeding or moulting grounds. Finally a distinct advantage of the dispersal model is that it needs the preservation of semi-natural grasslands in a way which is interesting for other aspects of nature conservation as well (Kuijken 1988). In recent years of increased habitat losses, conservation strategy must give priority towards multifunctional ecosystem management, rather than protection of single species.

ACKNOWLEDGEMENTS

We are very grateful to Marc Lievrouw who collected part of the behavioural data presented in this paper, to Tom Ysebaert for his help with the analysis of the data and for producing the figures. He together with Koen Devos and André Dhondt provided many stimulating discussions. Tony Fox greatly improved the language and style of this paper.

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SAMENVATTING

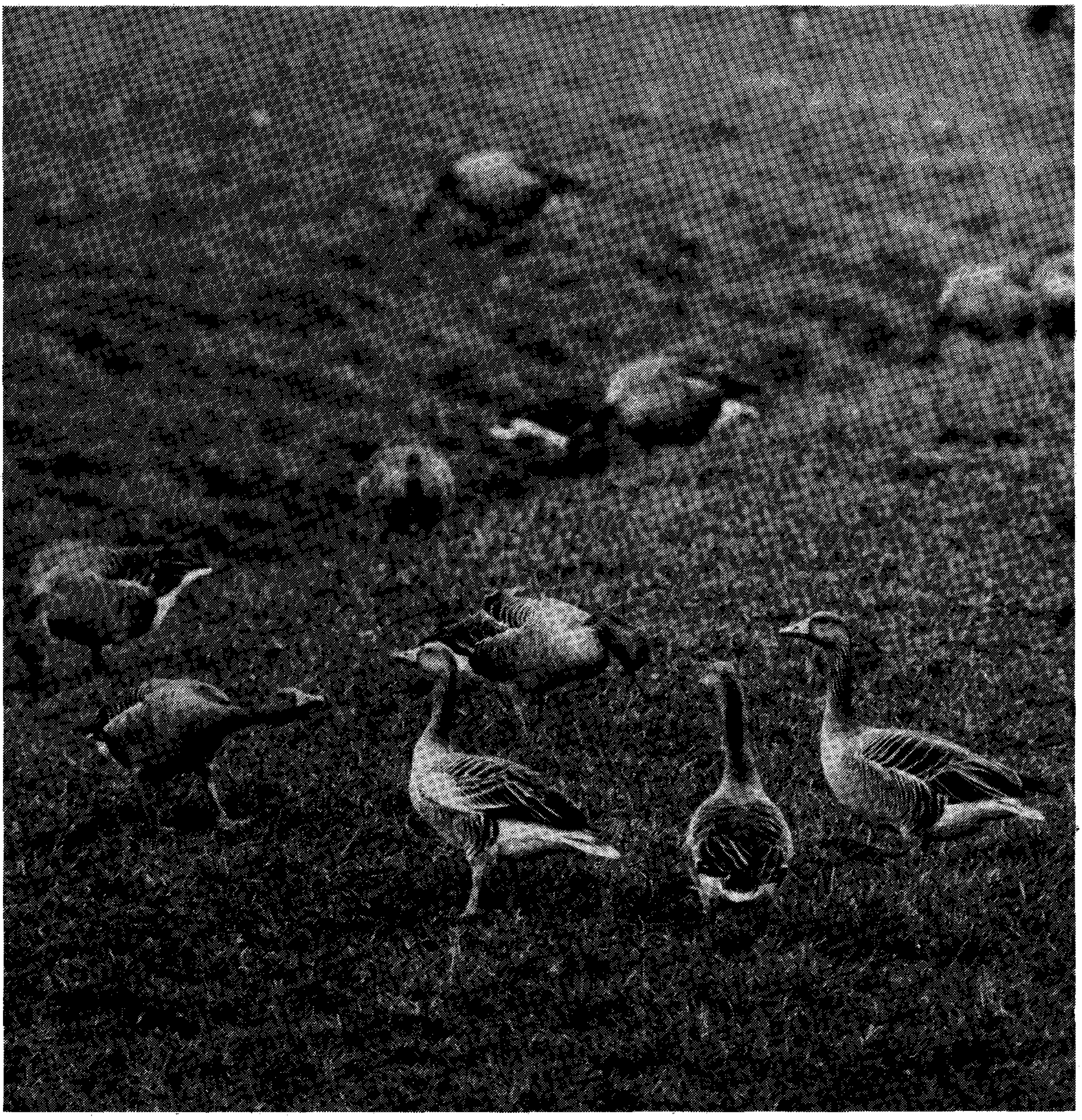
De Oostkustpolders in NW-Vlaanderen (Fig. 1) is een belangrijk overwinteringsgebied van de Kolgans en de Kleine Rietgans. Hun voorkomen, aantallen, verspreiding en gedrag werden gedurende de laatste dertig jaar bestudeerd. De aantallen Kleine Rietganzen namen geleidelijk toe in het studiegebied, dit in tegenstelling tot de Kolgans die vooral na de drie strenge winters, 1984/85 - 1986/87, in aantal toenam (Fig. 2 & 3). Gedurende strenge winters is er van beide soorten steeds een grote influx van dieren uit noordelijker gebieden.

De Kleine Rietgans komt begin november toe in de Oostkustpolders. De aankomstdatum vervroegt gedurende de laatste jaren. Maxima worden eind december bereikt. Kolganzen komen aan midden november en bereiken een piek half januari. Eind februari zijn de meeste ganzen uit de polder vertrokken (Tabel 1, Fig. 4). Gedurende de waarnemingsperiode zijn de ganzen zich vanuit het centrale gebied rond Damme gaan verspreiden over een groot gedeelte van de Oostkustpolders (Figs. 5 & 6). Deze verspreiding werd veroorzaakt door een jachtverbod en de influx van grote aantallen tijdens strenge winters.

Ook tijdens dezelfde winter verspreiden de vogels zich over de volledige polder. Hierbij volgen ze een patroon waarbij de verschillende delen van de polder cyclisch afgegraasd worden (Fig. 7 & 8). Gedragswaarnemingen hebben aangetoond dat deze verspreiding het gevolg is van een verslechterend voedselaanbod omdat het gras korter wordt (Fig. 9). Op deze manier wordt het gras van de volledige polder tot op eenzelfde niveau afgegraasd, waarna de cyclus opnieuw kan beginnen.

Hoewel er in sommige gevallen een duidelijke aanwijzing is dat de maximale aantallen ganzen die in een gebied kunnen foerageren bereikt wordt (Fig. 10), is het cumulatief aantal gansdagen sterk verschillend in de diverse bestudeerde poldercomplexen (Tabel 3). Er is geen verband gevonden tussen het aantal gansdagen en de hoeveelheid voedsel (Fig. 11). Wel was er een duidelijk negatief verband tussen het aantal gansdagen in een complex en de datum van aankomst in het gebied (Tabel 4). De dichtheid van ganzen is vrij gelijklopend in de verschillende poldercomplexen (Tabel 5).

In de discussie worden twee verschillende visies over de bescherming van ganzen tegenover elkaar gezet.



Greylag Goose (photo Jan van de Kam).