Can geese adjust their clocks? Effects of diurnal regulation of goose shooting

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Since 1994, goose shooting in Denmark has only been allowed from 1½ hours before sunrise to 10 a.m. (since 1997 until 11 a.m.). The aim of the diurnal regulation was to provide autumn-staging and wintering geese with more undisturbed feeding opportunities, and hence to extend the length of their stay in Danish haunts. A field study was carried out during 1994-1997 to investigate the effects of the regulation on the behaviour and site use by geese, focused on greylag geese *Anser anser* and pink-footed geese *Anser brachyrhynchus* at three important Danish sites. Data from earlier studies and monitoring schemes provided baseline information. In one study area with low shooting intensity, greylag geese did not change the timing of their morning departure from the roost to the feeding areas. In two sites with higher shooting intensities, they gradually delayed their morning departure from the roosts over the years. In the two sites with intensive shooting, greylag geese redistributed themselves during the daytime, albeit in small numbers. In the site with low shooting intensity, greylag geese depleted the waste grain resources, the preferred food. In the two sites with higher shooting intensities, the geese left while food was still plentiful. Pink-footed geese did not change their roost flight departure and only marginally redistributed themselves during the daytime. In sites where shooting-free areas were established, numbers of greylag and pink-footed geese immediately increased. The weak reaction by the geese to diurnal regulation was not due to a lack of behavioural flexibility in response, but reflected the fact that staying and adjusting to the diurnal regulation was a less attractive option than moving on to less disturbed sites. In conclusion, the diurnal shooting regulation did not achieve the intended management objectives.

Key words: Anser anser, Anser brachyrhynchus, disturbance, habitat use, hunting

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In the context of current hunting management terminology, the concept of sustainable use is traditionally related to harvesting strategies, but in a broader perspective it can also embrace wider aspects such as including disturbance effects on the site use by target species or biodiversity (e.g. *sensu* Ramsar Convention 1990). In Europe, the issue of hunting disturbance to migratory and wintering waterfowl has gained much attention in recent decades. While it is well documented that hunting disturbance may reduce site use by waterfowl, the impacts on population dynamics remain unresolved (Bell & Owen 1990, Madsen & Fox 1995). To mitigate local hunting disturbance, the typical management approach has been to create refuge areas. Other types of regulations have also been introduced, e.g. regulation of hunting practises or temporal regulations, the effects of which, however, are generally poorly documented (Fox & Madsen 1997).

During the revision of the Hunting and Wildlife Management Act in Denmark in 1992-1993, a political decision was made to improve the conditions for migratory and wintering waterfowl 1) by creating a network of reserves in Danish wetland EU Special Protection Areas (Madsen, Pihl & Clausen 1998) and 2) by reducing goose shooting from 1½ hours before sunrise to 1½ hours after sunset to the morning only. Hence, since 1994, shooting of geese was only allowed from 1½ hours before sunrise until 10.00 a.m. during September-December; from 1997 onwards, the closure was postponed until 11.00 a.m. The aim of this diurnal regulation was to provide geese more undisturbed feeding opportunities and thereby enable them to stay longer in autumn. Similar general restrictions on goose shooting have been implemented in The Netherlands, Sweden and Norway, although their effects have not been described.

The aim of this paper is to examine the effects of the diurnal regulation of goose shooting on the behaviour and site use of geese in Denmark during 1994-1997, focusing on greylag geese *Anser anser* and summarising the effects on pink-footed geese *Anser brachyrhynchus*.

Given the overall hypothesis that the introduced diurnal shooting regulation will increase undisturbed feeding opportunities for geese and prolong their stay in Denmark, it was predicted that the effects would be manifest by 1) a delay in the timing of the morning flight from the roosts to the feeding grounds (perhaps a gradual development over some years because the geese will have to habituate to the new pattern of regulation), 2) a redistribution of feeding goose flocks during daytime, with geese staying away from hunted areas during the morning but returning there during the afternoon, and 3) a general increase in the numbers of staging geese; overall numbers will primarily be determined by the extent of the food resources.

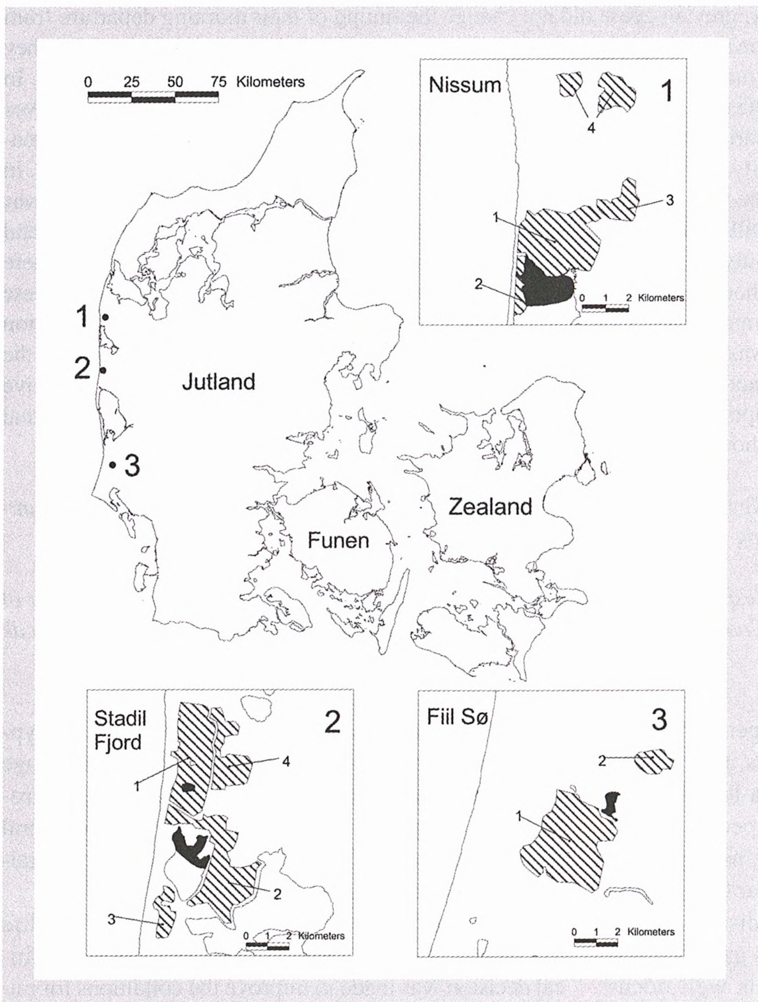

Figure 1. Location of the three study areas Nissum (1), Stadil Fjord (2) and Fiil Sø (3) in western Jutland, Denmark. In the insert maps, filled areas show roosts and hatched areas feeding areas; numbers indicate subareas referred to in the text.

Material and methods

Study populations

Two subpopulations of greylag geese occur in Denmark in autumn. In eastern Jutland, Funen and Zealand, Danish breeding birds congregate at approximately 20 major haunts during August-November before migrating to their wintering sites in The Netherlands and Spain. In western Jutland, geese from the Norwegian breeding population stop at 6-8 sites during August-October before migrating onwards to their wintering sites in The Netherlands and Spain (Nilsson, Follestad, Koffijberg, Kuijken, Madsen, Mooij, Mouronval, Persson, Schricke & Voslamber 1999).

During autumn migration, pink-footed geese from the Svalbard breeding population stage at 2-3 sites in western Jutland from late September to mid-November before migrating to their wintering areas in The Netherlands and Belgium (Madsen, Kuijken, Meire, Cottaar, Haitjema, Nicolaisen, Bønes & Mehlum 1999).

Study areas

The field study was carried out in three internationally important sites, i.e. Nissum Fjord - Rysensten, Stadil Fjord and Fiil Sø, in western Jutland (Fig. 1).

Nissum Fjord-Rysensten
The site is used by autumn-staging greylag geese, which roost in the northern part of the fjord (a wildlife refuge with no shooting) and feed in farmland areas north of the fjord (no refuge) and in salt marshes west of the fjord (Nissum, Area 2; see Fig. 1) which is part of the refuge. The farmland is primarily used for growing spring and autumn sown cereals, with some pastures and rape fields. Shooting is performed by landowners or is rented to groups of hunters. No organisation of shooting exists between groups of hunters.

Stadil Fjord
The site is used by autumn-staging greylag geese and pink-footed geese. The geese roost on lakes with no shooting and feed in the surrounding farmland areas. The farmland is primarily used for growing spring cereals, but also includes pastures, rape fields and winter sown cereal fields. Until 1997, shooting in the core areas used by geese was organised in 3-4 syndicates of hunters with some voluntary restrictions on goose shooting to provide geese with undisturbed feeding opportunities, e.g. daily bans on shooting in certain areas and no shooting during the middle of the day. However, in one of the study areas (Stadil Fjord, Area 2; see Fig. 1), the syndicates were split and voluntary restrictions were abandoned during the study period. In other areas (Areas 3 and 4 and areas fringing Area 1 and 2), shooting was not organised in syndicates. From 1998 onwards, Area 1 and the western part of Area 2 have become part of a wildlife reserve with limited shooting.

Fiil Sø
The site is used by autumn-staging greylag geese and pink-footed geese. The geese roost on the lake with no shooting and feed in the surrounding farmland areas. The farmland is primarily used for growing spring and autumn sown cereals, but also includes seed grass pastures and rape fields. The shooting in the core area (Fiil Sø, Area 1; see Fig. 1) is organised in one syndicate with voluntary rules on shooting days and daily bans of shooting in certain areas. In the area to the north (Area 2), shooting is not organised.

Methods

Roost flight observations
The time of morning departure from the roost to the feeding grounds in each of the three study areas was recorded on randomly selected mornings during September-October 1994-1997. The time and size of each flock of geese leaving the roost were noted. Observations started approximately one hour before sunrise and continued until the last geese had left the roost. Observations were carried out from an elevated point overlooking the roost site. Only observations carried out on mornings with a visibility of >1 km were used in the analyses.

The timing of departure is expressed by the time at which the first geese, the median (50% of all geese) and the last geese departed from the roost, respectively.

Observations of goose numbers, distribution and shooting
In each of the three study areas the numbers of geese present were recorded approximately twice per week from mid-August to late October 1994-1997. Goose numbers in the fields were counted from the ground using binoculars (10×) and telescopes (20-30×) and the position of flocks was recorded on field maps (1:25,000). Observations were carried out during mornings (before 11.00 a.m.) or afternoons (after 11.00 a.m.).

The number and distribution of hunters were recorded during the goose counts or during the morning roost flight observations. The exact number of hunters present was mostly difficult to assess, partly because they were well hidden in the terrain, partly because in some areas shooting stopped within 1-2 hours after sunrise. To give a crude expression of the shooting intensity, the proportion of mornings with hunters present was used and only days with observations made during the first two hours after sunrise were included.

Food supplies and exploitation by geese
To assess food availability and its between site and year variation, crop type and field status (unharvested, harvested, ploughed, newly sown) was mapped for each study area on approximately 1 September and 1 October 1994-1997. Crops were mapped using field maps (1:25,000).

From an earlier study it was known that geese primarily feed in stubble fields during autumn, taking spilt grain after harvest (Madsen 1985). To express the rate of exploitation of the grain resource, the density of spilt grain was recorded at approximately two-week intervals in harvested cereal fields. In each study area, 3-4 fields were selected each year; only newly harvested fields with the straw combined and not yet used by geese were included. Most fields could be followed from the time of harvest to the time of departure of the geese; however, because some fields were ploughed quickly following harvest, the field sample size was reduced. A harvester discharges straw, chaff and spilt grain in a track. When the straw is pressed, chaff and spilt grain are left in the output track. Outside the output track, the density of grain is extremely low. The density of spilt grain was recorded in plots within the output tracks. For each field, grain density was recorded in 10-15 randomly selected plots (each being 0.16 m^2) inside output tracks and in up to 10 plots outside output tracks (but not in all fields).

The total amount of spilt grain available per field was calculated from the densities of grain inside and outside output tracks. The size of the areas with and without output tracks were estimated from the width of output tracks and the distances between the output tracks (typical ratio was 1:2.7). Based on the densities of spilt grain in the selected fields, the total amount of spilt grain available on 1 September was calculated for the entire study area. In most years, both harvested and unharvested fields were available on 1 September. For harvested fields with known harvesting date, the grain density on 1 September was estimated from repeated measurements of grain densities. For fields recorded as unharvested in early September it was assumed (if not directly measured) that the density of spilt grain right after harvest was similar to other newly harvested fields.

The calculation of the total amount of grain available in the study areas is sensitive to the area defined as used by the geese. The area delineation was conservatively defined by the areas in which geese had been observed regularly during August-October, also including previous knowledge of goose use of the sites (Madsen 1986, J. Madsen, unpubl. data). In the Nissum, Stadil Fjord and Fiil Sø areas, 11 km^2, 16 km^2 and 12 km^2, respectively, were defined as being used by greylag geese.

Results

Shooting intensity

Shooting intensity, expressed as the proportion of days with shooting in the core feeding area, was highest at Nissum (95% of all observation mornings; N = 21), intermediate at Stadil Fjord (72%; N = 32) and lowest at Fiil Sø (42%; N = 38). Furthermore, based upon the mapping of the distribution of hunters, the density of hunters was highest at Nissum (Area 1), intermediate

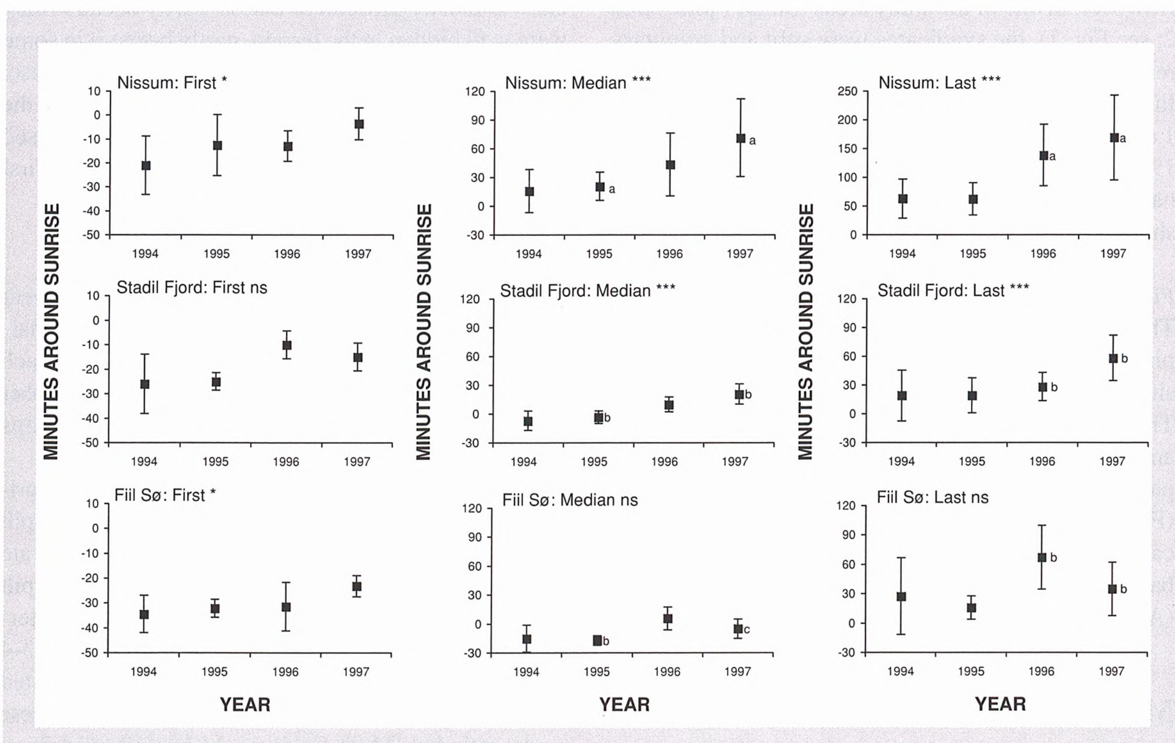

Figure 2. Timing of morning flights from the roosts to the feeding fields by greylag geese in the three study areas during 1994-1997, expressed by the average time of departure (± 95% confidence limits) of the first (outer left column), the median (middle column) and the last (outer right column) departing geese. Each data point represents 4-8 observation days. Statistically significant changes are shown by asterisks (Spearman rank correlation; *: $P < 0.05$; **: $P < 0.01$; ***: $P < 0.001$; ns: non-significant). Letters show significant differences between sites within years (Kruskal-Wallis test; $P < 0.05$).

at Stadil Fjord, and lowest/most concentrated at Fiil Sø (Area 1).

Roost flight

In 1994, there were no significant differences in the time of departure between the three study areas (Fig. 2). The departure from the roosts started on average 27 minutes before sunrise; 50% of the geese had left the roost one minute before sunrise and the last flock had left 34 minutes after sunrise. At Fiil Sø, there was a significant delay in the first departure (from 1994 to 1997 on average 12 minutes), but no change in the median and last departure. At Stadil Fjord, there was no change in time of the first departure, but a delay in the median and last departure; from 1994 to 1997 on average 28 minutes and 39 minutes, respectively. At Nissum, there was a significant delay in the time of the first, the median and the last departure; from 1994 to 1997 on average 17 minutes, 55 minutes and 106 minutes, respectively (see Fig. 2).

During September 1982 and 1983, the time of departure was recorded on five mornings at Fiil Sø (J. Madsen, unpubl. data). The first departure was on average 35 minutes before sunrise, the median 14 minutes before sunrise and the last departure 30 minutes after sunrise. The small data set suggests that there was no change in the time of departure between the early 1980s and 1994.

Goose numbers

The occurrence of greylag geese varied greatly between sites and years during 1994-1997 (Fig. 3). The highest

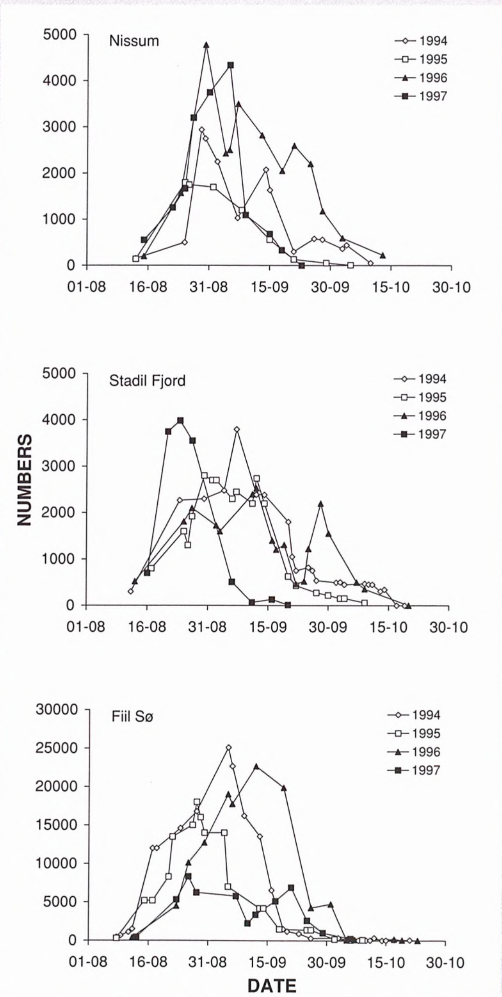

Figure 3. Numbers of greylag geese counted in the three study areas during August-October, 1994-1997.

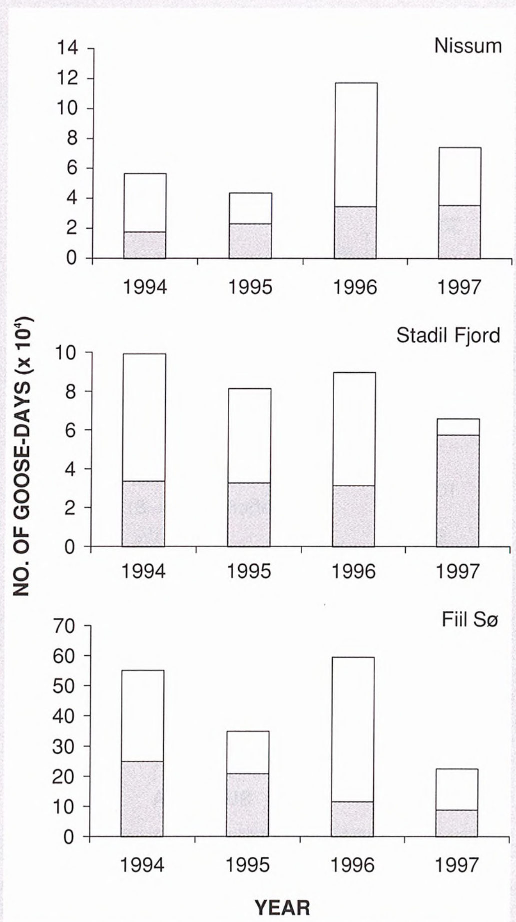

Figure 4. Number of goose-days spent by greylag geese in the three study areas during 1994-1997 for August (▒) and September-October (☐).

numbers were recorded at Fiil Sø with peaks between 8,500 and 25,000 individuals, followed by Stadil Fjord with peaks between 2,500 and 4,000, and Nissum with peaks between 1,800 and 4,800. At all three sites, greylag geese started to arrive in significant numbers from the middle of August, and numbers peaked during late August - early September. By late September, the majority of geese had left the sites, although with great between-year variation in the time of mass departure (see Fig. 3).

The variation in numbers and length of stay was reflected in the number of goose-days spent in the three sites (Fig. 4). Overall for all years and sites, 40% of the goose-days were spent in August, the rest during September-October. There was less variation in the number of goose-days spent in August than in September-October; hence, the coefficient of variance on the August numbers for Nissum, Stadil Fjord and Fiil Sø was 32, 32 and 46% and on the September-October numbers 59, 57 and 51%, respectively.

Daily redistribution of geese

During August, the greylag geese at Nissum foraged almost exclusively in Area 1, and there was no significant difference in the usage of the area between mornings and afternoons (Fig. 5). During September, geese mainly used Areas 2-4, both during mornings and afternoons, whereas Area 1 was only used during afternoons. Shooting intensity was high in Area 1, but low in Area 3 (and 4; see Fig. 5).

During August, the majority of geese at Stadil Fjord foraged in Area 2, but shifted to Area 1 in September (Fig. 6). Areas 3 and 4 were not used in August and only marginally in September. During August, there was no significant difference between morning and afternoon usage of the areas; during September, significantly more geese occurred in Areas 2 and 4 during afternoons than during mornings (see Fig. 6). Shooting was most intense in Area 2, followed by Area 1 and Area 3.

At Fiil Sø, greylag geese foraged exclusively in Area 1 both during August and September; during September,

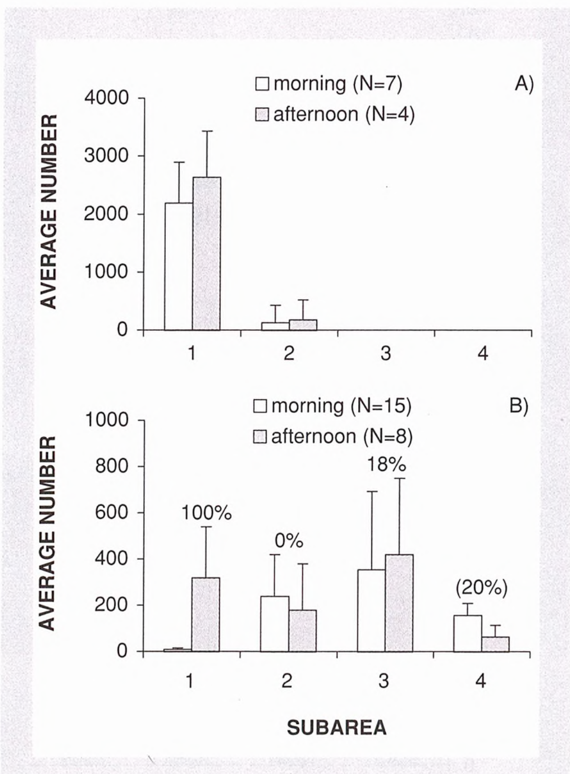

Figure 5. Average numbers (± 95% confidence limits) of greylag geese in the four Nissum subareas (1-4) during mornings (□) and afternoons (□) in: A) August, and B) September-October. N gives the number of observation days for mornings/afternoons. In B) the proportion of mornings with shooting in September-October is given (in brackets for subarea 4 due to small sample size).

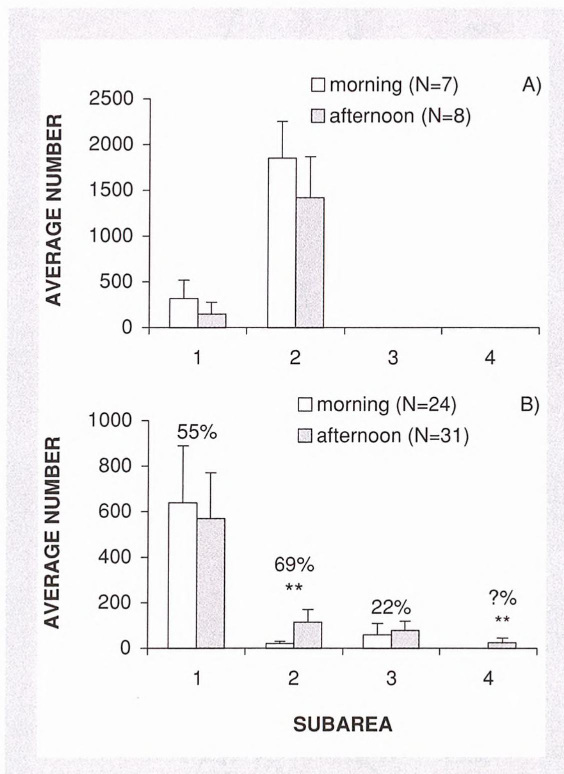

Figure 6. Average numbers (± 95% confidence limits) of greylag geese in the four Stadil Fjord subareas during mornings (□) and afternoons (□) in: A) August, and B) September-October. N gives the number of observation days for mornings/afternoons. In B) the proportion of mornings with shooting in September-October is given for subareas 1-3, but for subarea 4 it is unknown. **: P < 0.01 (Mann-Whitney U test).

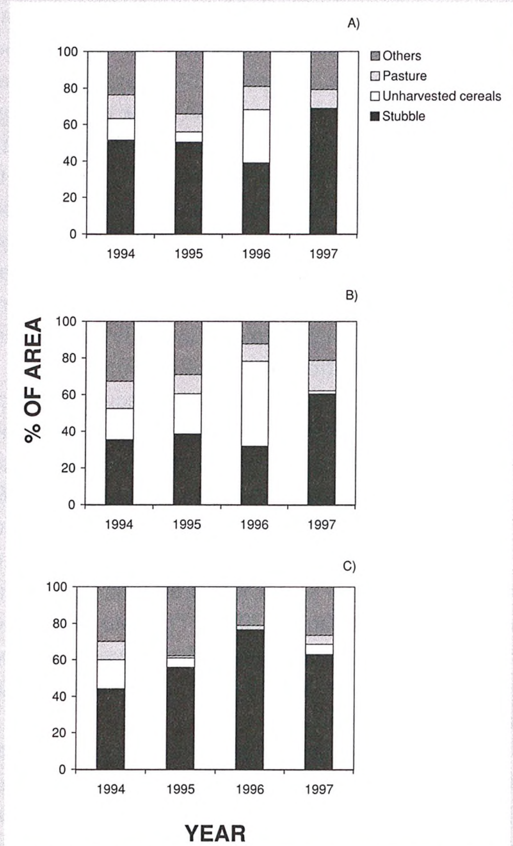

Figure 7. Crop types available expressed as % of total area used by geese in the study areas Nissum (A), Stadil Fjord (B) and Fiil Sø (C) during early September 1994-1997.

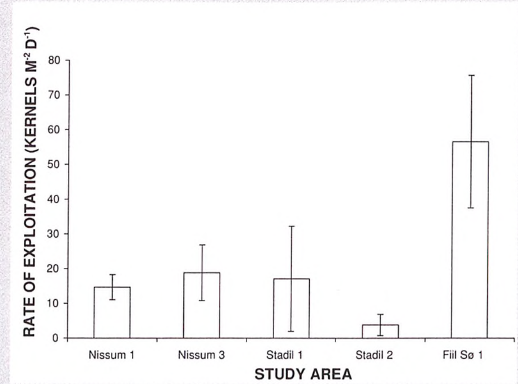

Figure 8. Daily rate of exploitation of spilt grain (average kernels $m^{-2}d^{-1}$ ± 95% confidence limits) in newly harvested cereal field in the three study areas (two subareas shown for Nissum and Stadil Fjord). For each area the sample size was 4-9 fields, in which 10-15 plots were sampled in the harvester output tracks at approximately two-week intervals.

an average of 64 and 13 geese were observed in area 2 during mornings and afternoons, respectively. The difference between morning and afternoon numbers was not significant (Kruskal-Wallis test; $P > 0.05$).

Exploitation of resources

At all three sites, greylag geese preferred to feed in stubble fields; hence, at Nissum, Stadil Fjord and Fiil Sø, an average of 97, 91 and 91% of all goose-days, respectively, were spent in stubble fields.

Table 1. Densities of grain (kernels m^{-2}) in straw output tracks in newly harvested cereal fields during 1994-1997 for the three study areas combined. Each year, three fields were sampled in each study area.

Year	Average density	(± 95 % c.l.)
1994	672.5	(224.7)
1995	203.9	(104.7)
1996	283.2	(125.7)
1997	356.2	(76.8)

In none of the three sites was there a change in crop composition during 1994-1997 which could have affected goose usage. However, a high degree of variation in the timing of harvest between years and sites was reflected in the proportion of harvested and unharvested field area around 1 September in the three study areas (Fig. 7). In particular, the harvest in 1996 was especially late at Nissum and Stadil Fjord, despite being early at Fiil Sø.

From early September to early October the available stubble field area decreased due to ploughing and sowing of new crops. At Nissum, the area of stubble plus unharvested cereals (which were harvested during Sep-

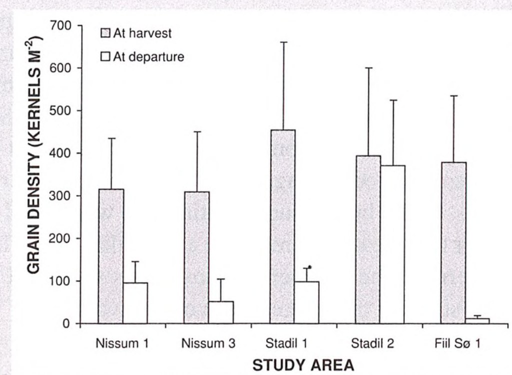

Figure 9. Densities of spilt grain (average kernels m^{-2} ± 95% confidence limits) in the harvester output tracks in stubble fields at harvest and at the time of mass departure of greylag geese from the study areas (two subareas shown for Nissum and Stadil Fjord).

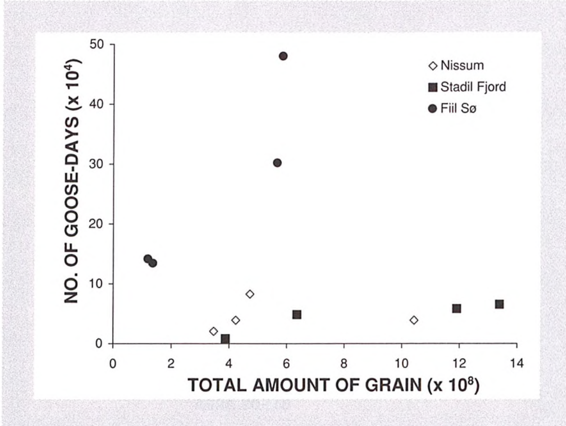

Figure 10. Relationship between the total amount of spilt grain (kernels x 10^8) available and the number of greylag goose-days (x 10^4) spent in the three study areas during September-October 1994-1997.

tember) decreased from an average of 63 to 25% of the area, at Stadil Fjord from 65 to 39% and at Fiil Sø from 69 to 40%.

The density of spilt grain in the straw output tracks immediately after harvest did not differ between areas (Kruskal-Wallis test; $\chi^2 = 3.03$, df = 2, $P > 0.05$) but varied between years ($\chi^2 = 12.43$, df = 3, $P < 0.001$), with the highest densities present in 1994 (Table 1). The rate of disappearance of the grain measured during the two-week period following harvest was highest at Fiil Sø (Fig. 8). By the time of mass departure of greylag geese, arbitrarily defined as the day when 90% or more of peak numbers had left the area (see Fig. 4), the grain resource had been almost completely depleted at Fiil Sø, whereas grain was still available in the other areas, and with the highest remaining concentrations in stubble fields in Area 2 at Stadil Fjord (Fig. 9).

On a site scale, the relationship between the total spilt grain resource available on 1 September and the number of goose-days spent by greylag geese during September-October differed greatly (Fig. 10). At Fiil Sø, there was a linear relationship between the amount of resources and goose usage ($y = 000.57x + 63011$; $r = 0.91$; $P < 0.05$), but no such relationship was found in the other two areas. At a resource availability of 5 x 10^8 grain kernels, the number of goose-days spent at Fiil Sø was six-fold the usage of the other two sites.

Discussion

Behavioural adjustments

The study showed that over the four study years greylag geese gradually delayed their morning roost flight at the two most heavily hunted sites, whereas there was only a minor change at the site with the lowest shooting intensity. Hence, it appears that greylag geese adjusted their behaviour in response to the diurnal regulation at sites with high levels of disturbance or high risk of predation. However, in none of the sites was the delay 'perfectly' timed to the time of the diurnal shooting ban. Even in the last year of the study, the vast majority of geese departed from the roosts at a time when shooting was still allowed. Possibly over a longer run of years, geese might eventually have delayed their time of departure until after the end of hunting.

The gradual delay suggests that geese gained experience from, or habituated to, the new regulation. Based on resightings of geese carrying neckbands (marked in Norway by NINA-NIKU), it was shown that at least 30% of neckbanded individuals returned to Fiil Sø from year to year, and at least 35% to Stadil Fjord; at Nissum the data were too scarce to allow a similar analysis (Madsen, Jørgensen & Hansen 2000). This site-faithfulness gives the individual an opportunity to gain the necessary experience of available feeding opportunities and relative predation risks.

When the shooting season opened on 1 September, greylag geese avoided the most heavily hunted areas at Nissum and Stadil Fjord; the redistribution was abrupt and not related to depletion of food supplies. At Nissum, geese returned to the core area (Area 1) in the afternoons, which was the clearest example of a diurnal redistribution that could be ascribed to the diurnal shooting regulation. In the other areas, there was either no diurnal redistribution, or only a marginal effect. The reason why geese redistributed at Nissum probably was that flocks sampled feeding opportunities and predation risks in the core area as they flew to and from more distant feeding areas used in the morning (Areas 3 and 4).

To respond behaviourally to the diurnal regulation, geese must be able to detect a change in diurnal levels of disturbance. In the farmland study areas, most of the shooting was targeted towards geese, and in none of the areas was shooting recorded in the afternoons (but some duck shooting may have occurred in the evenings). It is generally known that before 1994, goose shooting also took place in the afternoons and evenings (Madsen et al. 2000), but no specific knowledge exists from the study areas.

Numbers of greylag geese

In the case of Fiil Sø, greylag geese were able to deplete the grain resource, and the number of greylag geese during the hunting season, expressed in terms of goose-days, was primarily determined by the amount of resource. Although the study was only based on data from four years, the results comply with the rules of simple ideal free distribution theory, i.e. that consumers fill up habitats according to resource availability (Pulliam & Caraco 1984).

In the other two sites, the rate of exploitation of the resources was more variable, and despite some behavioural adjustments, greylag geese left the sites while resources were still plentiful. The observations showed that disturbance from shooting was the major cause redistributing geese, and large areas were left unused or were underused after the opening of shooting. Compared to Fiil Sø, the level of unused resource represents a quantification of the trade-off between feeding preference and predation risk (*sensu* Milinski 1985, Madsen 1988, Gill, Sutherland & Watkinson 1996). It is estimated that in an 'average' year, Nissum and Stadil Fjord could accommodate 4-5 times as many geese as observed during 1994-1997.

From 1998 onwards, most of Area 1 and the western part of Area 2 at Stadil Fjord became a wildlife reserve with a shooting ban in most of the area and very limited shooting in the rest. Most of Area 1 was restored as a wetland area, whereas Area 2 remained a farmland area. During the autumns of 1998 and 1999, the numbers of greylag geese more than doubled compared to 1994-1997, despite the fact that the area of stubble was nearly halved (NERI, unpubl. data). This 'natural' experiment supports the inference that 1) shooting disturbance reduced goose use during 1994-1997, and 2) greylag geese can quickly respond to a change in predation risk. Furthermore, the observation that the refuge immediately attracted more geese indirectly shows that the rather weak reaction to the diurnal regulation was not due to a lack of behavioural flexibility in response, but reflected the fact that staying and adjusting to the diurnal regulation was not an attractive option compared to moving on to less disturbed sites (in The Netherlands).

Since the early 1980s greylag goose numbers in Denmark have been monitored annually during mid-September (Jørgensen, Madsen & Clausen 1994, NERI, unpubl. data). Overall, numbers have increased from approximately 30,000 geese during the early 1980s to 40,000-65,000 during the late 1990s, with the most dramatic increases in the numbers of greylag geese staging in western Jutland (i.e. geese from the Norwegian breeding population). Year-to-year fluctuation in numbers in western Jutland has primarily been attributed to variation in numbers at Fiil Sø and hence, as shown above, driven by variation in food supplies. The diurnal shooting regulation has had no detectable effect on the numbers of staging geese, nor on new sites taken into use (Madsen et al. 2000).

Responses by pink-footed geese

Pink-footed geese occurred at Stadil Fjord and Fiil Sø, with annual peak numbers of 6,000-11,000 and 9,000-13,500, respectively, during 1994-1997. Nissum was not regularly used by pink-footed geese. At none of the sites did the geese show any significant change in the time of morning roost flight, and there was only a marginal (involving no more than few hundred geese), though significant, redistribution of geese between mornings and afternoons which could be ascribed to the diurnal shooting regulation. There was no trend in numbers, and at the time of mass departure of pink-footed geese from Stadil Fjord the spilt grain resource was still plentiful (Madsen et al. 2000). At one site, Skjern Å, 30 km south-southwest of Stadil Fjord, shooting stopped in 1996 (farmland areas purchased by the Danish Government for nature restoration purposes). Before 1996, this site had been irregularly used by less than 100 pink-footed geese during October, but in 1996 up to 5,000 geese stayed there. Likewise, when Stadil Fjord became a reserve in 1998, the numbers of pink-footed geese increased, with a peak number of 27,000 in October 1998 (NERI, unpubl. data).

The observations on the responses of pink-footed geese support the conclusions made for greylag geese. The low level of response to changes in hunting activity suggests that pink-footed geese have a lower tolerance threshold than greylag geese at which they decide to leave the sites.

The national goose bag

During 1988-1997, the national goose bag fluctuated without trend between 13,300 and 16,300 (average 15,300; Official Danish Bag Record, NERI, unpubl. data). Greylag and pink-footed geese constituted approximately 66 and 16% of the bag, respectively. Thus, the introduction of the diurnal regulation did apparently not affect the bag, which may suggest that Danish hunters effectively modified their shooting practise/behaviour to compensate for the restriction. However, coinciding with the introduction of the regulation, numbers of autumn-staging and wintering geese in Denmark were generally increasing. The stable goose bag may, therefore, also reflect the fact that the shooting intensity actually declined as a result of the diurnal regulation, but that this decline was compensated for by more geese being available for shooting. Furthermore, from 1994 onwards, shooting of greylag geese was postponed from 1 August to 1 September, and during the 1990s, the National Forest and Nature Agency established reserves for waterfowl at more than 40 wetland Special Protection Areas. Especially these measures may have had an effect on the greylag goose bag. Therefore, the specific effects of the diurnal regulation are difficult to unravel due to concurrent changes in population sizes and management measures.

Conclusions

In summary, the observations suggest that when geese flew out from their roosts in the morning to feed and were fired at when flying into the feeding areas, a shot-over feeding ground was in most cases perceived by the geese as being too dangerous to return to within the same day. At sites with intensive shooting, geese gradually delayed their morning roost flight, but never sufficiently to completely avoid shooting. Despite the introduction of the diurnal regulation, geese departed the general area prematurely, except for the site with the lowest shooting intensity, where spilt grain resources were fully exploited. Neither locally nor nationally, could any effects of the diurnal regulation on autumn-staging numbers of greylag geese and pink-footed geese be detected. It is concluded that the diurnal shooting regulation did not achieve the intended management objectives. The national goose bag remained stable from before to after the introduction of the diurnal regulation, but a specific effect of the regulation on the bag cannot be unraveled.

As a result of the weak effect of the diurnal shooting regulation, it was abandoned with the revision of the Danish Hunting and Wildlife Management Act in 2000.

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