Exposure of spring-staging pink-footed geese Anser brachyrhynchus to pesticide-treated seed

Author: Madsen, Jesper

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Jesper Madsen

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The Svalbard population of pink-footed geese *Anser brachyrhynchus* is concentrated in western Jutland, Denmark, from early March to early May. During spring, the geese shift feeding habitat from grasslands and stubble fields to new-sown fields. To avoid crop damage, grain bait is provided at five sites. The aim of this study was to quantify the exposure of geese to, and the ingestion rates of, pesticide-treated seeds, and to evaluate the potential effects at the individual and the population level. During spring 1994, approximately 7% and 1% of the total number of goose-days were spent on new-sown cereal fields and new-sown pea fields, respectively. After the commencement of sowing, about 25% of all goose-days were spent in new-sown fields. Late-departing individually marked geese made more frequent use of new-sown fields than early-departing individuals ($P < 0.001$). Geese foraged intensively in new-sown fields early in the morning and sometimes late in the evening. Due to high feeding profitability of the new-sown grain compared to grass, the geese obtained half or more of their daily energy intake by feeding on new-sown cereal fields, even where bait grain was provided. Spring-sown barley is treated with the fungicide Imazalil and peas are usually treated with Thiram. The daily Imazalil ingestion rate by an 'average' goose was estimated at 9-15 mg active ingredient (a.i.), or 3-5 mg a.i./kg body mass, which is two orders of magnitude below reported LD_{50} values for various species of test birds. Imazalil may have sub-lethal effects, especially on geese using the new-sown cereal fields for consecutive days, but the low toxicity and high mobility of the compound suggest that effects are minor and short-lived. The daily Thiram ingestion rate by the geese was not quantified, but it is calculated that a goose would have to eat about 100 g of peas to reach a level of Thiram ingestion (200 mg/kg diet), which could have sub-lethal effects on reproductive parameters. A goose foraging on new-sown peas can accomplish this within less than one hour. Special management precautions should be taken to deter geese from exploiting new-sown pea fields.

Key words: pink-footed goose, fungicide, Imazalil, Thiram, feeding ecology

Jesper Madsen, National Environmental Research Institute, Department of Coastal Zone Ecology, Kalø, DK-8410 Rønde, Denmark

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The Svalbard breeding population of pink-footed geese *Anser brachyrhynchus* numbers 27,000-34,000 individuals (Madsen & Mitchell 1994) and is concentrated on staging areas in western Jutland, Denmark, from early March to early May (Madsen 1982, 1984). There, geese put on weight (Madsen 1985, unpubl.) in preparation for their long-distance migration to and reproduction in Arctic breeding grounds. Geese forage on new growth of grass on pastures and salt marshes, but they also feed on newly sown cereal fields where they take the grain on or below the surface of the soil. In spring, the geese gradually shift from grassland to new-sown fields (Madsen 1984) where they attain much greater daily energy intake rates (Madsen 1985).

The increasing use of newly sown fields has raised several concerns. Farmers have complained about damage to their cereal crops caused by geese; to mitigate these problems, the National Forest and Nature Agency of the Ministry of the Environment and Energy has provided bait grain at an increasing number of sites in order to distract geese from the new-sown fields. Furthermore, geese are exposed to pesticides through the ingestion of new-sown grain.

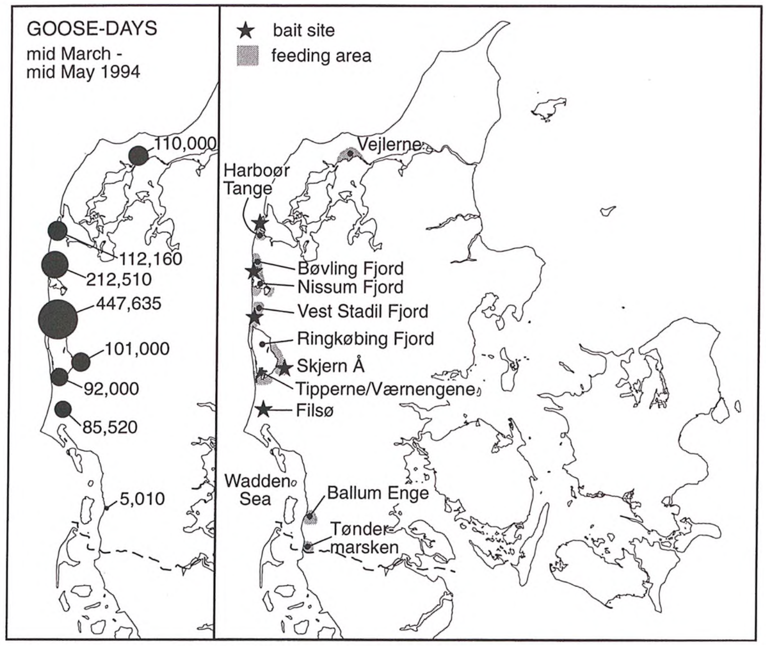

Figure 1. Site names referred to in the text (right), and distribution of pink-footed geese in western Jutland, expressed as the number of goose-days from mid March to mid May 1994 (left).

The amounts and types of pesticides ingested have not been addressed. The aims of this study, which was carried out in spring 1994, were 1) to quantify the utilisation of newly sown fields, 2) to record the types of pesticides used as seed dressings, 3) to estimate daily intake rates of pesticides, and 4) to evaluate the potential effects at the individual and the goose population level.

Study area

Areas used by the geese

During spring, the pink-footed geese use 12-14 sites in western Jutland, distributed from Tøndermarsken in the south to Vejlerne in the north (Fig. 1). They feed in salt marshes, rough and cultivated pastures, stubble fields, winter cereal fields, newly sown cereal and pea fields, and baited fields. In the new-sown cereal fields (mostly barley), the geese primarily eat the ungerminated grain on the surface and in the upper 2-3 cm of the soil immediately after sowing (Lorenzen & Madsen 1986) and usually abandon an area once grain has sprouted.

Baiting, time of sowing and pesticide use

The National Forest and Nature Agency started to provide bait grain at one site, Vest Stadil Fjord, in the early 1970s. Because of the increasing goose damage conflict with farmers, bait has been provided at Bøvling Fjord in the Nissum Fjord area, at Skjern Å east of Ringkøbing Fjord and at Filsø since 1990, and at Harboør Tange since 1991 (see Fig. 1). Approximately 300 kg of unsprayed barley is spread daily at each site, and, at Vest Stadil Fjord, often 600 kg. Vejlerne remains the only larger area where bait is not provided. The period of baiting in 1994 is shown in Table 1.

March 1994 was unusually wet and in western Jutland, the spring sowing of barley was delayed by approximately one to two weeks compared to normal. In western Jutland, the time of sowing varied locally (see Table 1).

According to local grain suppliers (Superfos, Ringkøbing, and Shell LandbrugsService I/S, Lemvig) who supply seed grain to farmers in the areas used by

Table 1. Commencement of spring cereal grain sowing in 1994 in six areas in western Jutland, Denmark, of relevance for pink-footed geese, and periods of grain baiting to alleviate the goose damage to cereal fields.

Area	Time of sowing	Period of baiting[a]
Filsø	10 April - 14 April	11 April - 17 April
Southern/eastern Ringkøbing Fjord	12 April - 20 April	7 April - 9 May
Stadil Fjord	24 April - 7 May	20 March - 10 May[b]
Nissum Fjord	15 April - 25 April	12 April - 9 May
Harboør Tange	15 April - 25 April	12 April - 9 May
Vejlerne	14 April - 16 April	no baiting

[a] information supplied by the National Forest and Nature Agency;
[b] baiting started a little earlier than usual to attract geese for capture.

geese, the only pesticide regularly used on spring-sown barley grain is the fungicide Fungazil. Imazalil is the active ingredient (a.i.) of Fungazil, usually used at a dosage of 50 mg a.i./kg grain. The pesticide Thiram (a fungicide) is used on spring-sown peas, applied at approximately 2 g a.i./kg seed. However, in some years seed dressing is not applied to seed peas. In 1994, peas were untreated in the Nissum Fjord area but treated in the Filsø and Skjern Å areas.

Methods

Counts and habitat distribution mapping

Field work was carried out from mid March to mid May 1994 by four observers, who had divided the sites among them. On average, four counts were carried out each week, recording the number of geese in each habitat within a site. Counts were made from cars using telescopes and were evenly distributed throughout the daylight hours. Eleven habitat types were distinguished: salt marsh, rough pasture, cultivated pasture, stubble, undersown stubble, set aside fields, winter cereals, winter rape, new-sown cereals, new-sown pea and cereal bait. From the daily count results, the number of goose-days per habitat type was calculated for ten-day periods and for the spring season as a whole.

Individual-based habitat use

To describe individual variation in the utilisation of newly sown fields, birds carrying neckbands with individual codes were recorded at all sites and habitats during the daily counts. Each spring since 1990, the National Environmental Research Institute has caught and marked pink-footed geese with blue neckbands with individual codes in order to measure individual life histories and migratory strategies within the population. Approximately 360 marked individuals, of which 37 were first-winter birds, were alive in the spring of 1994 (Madsen unpubl.). Under good weather conditions with no haze, fog or strong winds, neckbands can be read at a distance of 400-700 m with a telescope (20-60 x magnification).

Activity budgets

To describe the diurnal pattern in activity and habitat utilisation, single flocks of geese were followed from arrival on the feeding grounds in the morning to departure to the roost sites in the evening. Because of the long daylength, the day was split over two observation days. At intervals of 15 minutes, the activity of the flock was scanned (method after Altmann 1974), and the number of individuals engaged in different activities was counted. The following activities were distinguished: resting, feeding, walking, flying, aggression, and others. The habitat was recorded each time.

The method, however, turned out to be difficult to apply, because geese often flew long distances between new-sown fields, bait sites and other habitats, thus making it impossible to track the same birds throughout a day. Only in Vejlerne, where there were no baited sites, was the method applied successfully on two full days. At all other sites in western Jutland, the method had to be modified. To do this, the entire flock of geese utilising the baited site at Bøvling Fjord and the surrounding field feeding grounds was scanned at different times each day during a four-day period (5-8 May). At four-hour intervals (at 6, 10, 14 and 18 hrs, respectively), the observer surveyed the entire potential feeding area, and for each flock encountered, the habitat used and the activity of the flock was scored. From this, a crude habitat-based activity budget could be established.

Daily intake rates

To estimate daily food and energy intake rates, feeding time in each habitat type, pecking rates, ingestion rates

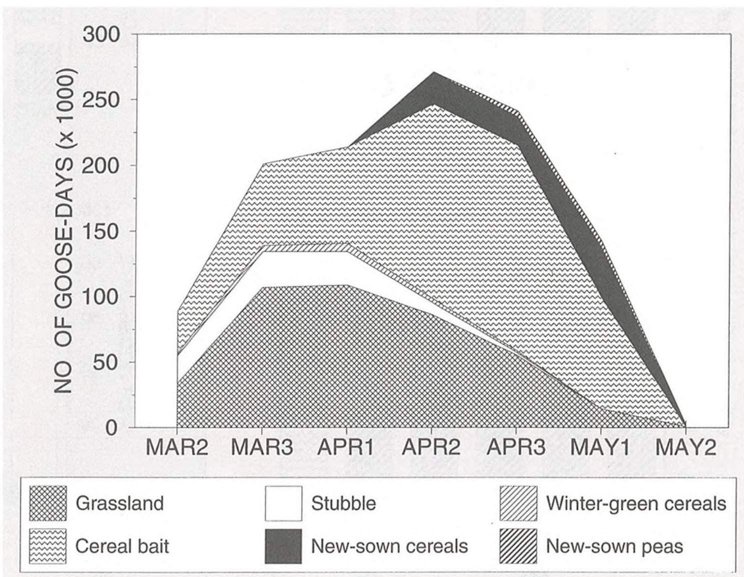

Figure 2. Habitat use by pink-footed geese in all of western Jutland, mid March to mid May 1994, expressed as the total number of goose-days spent in each habitat type per 10-day period.

and, energy retention rates need to be quantified. In a previous study (Madsen 1985) pecking, ingestion and retention rates of pink-footed geese feeding in pastures and new-sown cereal fields were described. From the habitat based activity budgets, the daily foraging time in each habitat could be calculated. Pecking rates on new-sown cereal and pea fields were measured as the time it took a goose to make 25 pecks (timed on a stop watch). Daily food and energy intake rates were then calculated, using ingestion and retention rates from the above-mentioned study.

However, in the baited sites, it was difficult to discriminate between geese pecking grain and shoots of grass. To estimate crudely the daily energy intake of an 'average' bait-feeding goose, the intake was calculated from the known daily amount of grain provided and the number of geese present in the area.

The daily intake of seed dressing pesticides was esti-

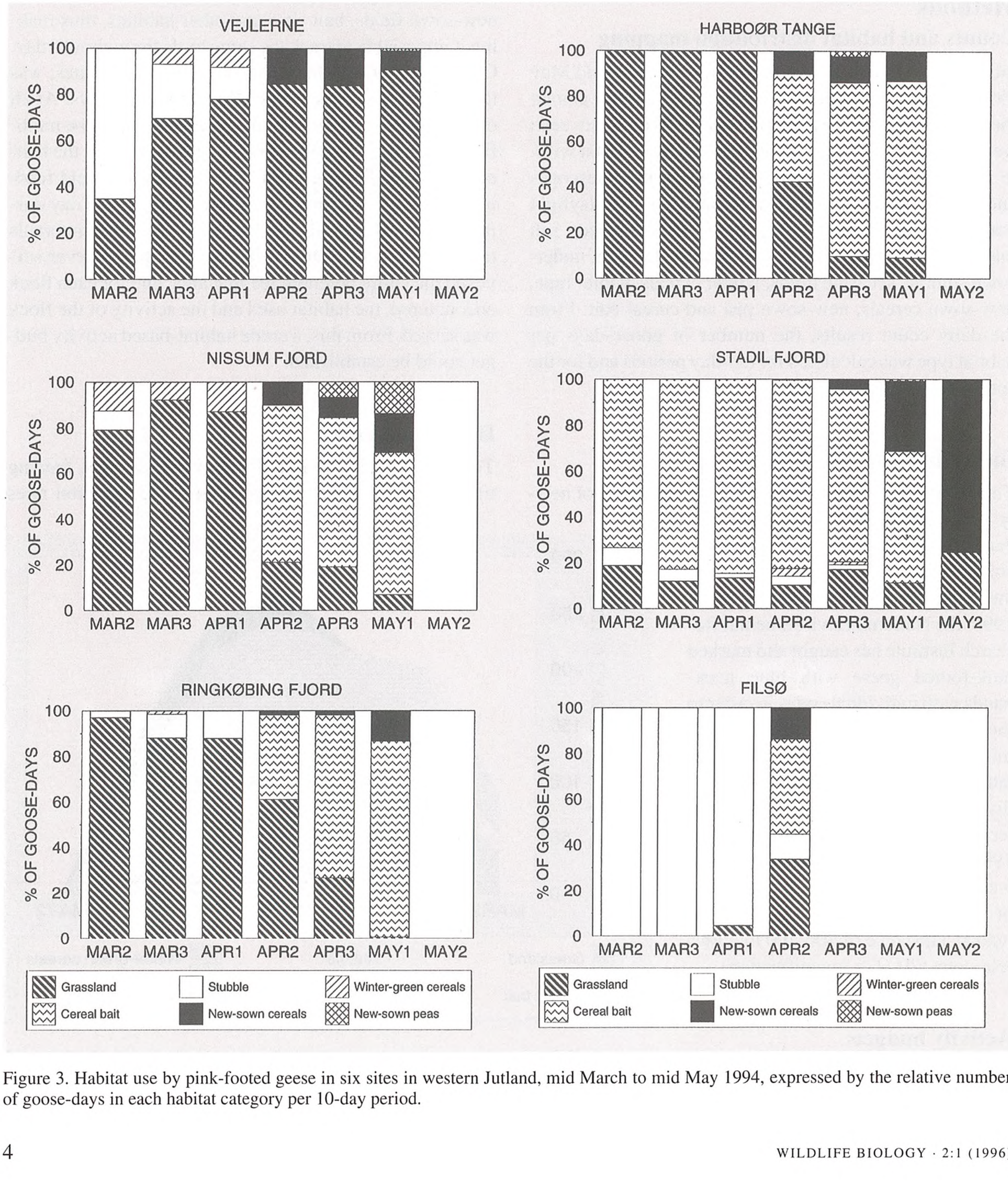

Figure 3. Habitat use by pink-footed geese in six sites in western Jutland, mid March to mid May 1994, expressed by the relative number of goose-days in each habitat category per 10-day period.

mated from the daily intake of grain in the new-sown fields and the known concentration of a.i. of the pesticide in the applied formulation of seed dressing. Weights of barley grain and peas as well as formulations of seed dressings used were supplied by local grain suppliers.

Results

Habitat utilisation

From mid March to mid May 1994, the pink-footed geese were concentrated at seven major sites in western Jutland, with the largest concentrations at Vest Stadil Fjord and Nissum Fjord (see Fig. 1). In western Jutland, pink-footed geese used different habitats in sequence (Fig. 2): From mid March to early April 1994, the majority of geese foraged on grassland, followed by stubble, cereal bait and to a minor degree, winter cereals. From mid April to early May, most geese were observed on bait; remaining stubble fields had been ploughed and thus lost importance. Use of grasslands likewise decreased. In all, the geese made little use of new-sown cereal fields and new-sown pea fields. By mid May, when the majority of the population had emigrated, most geese foraged on new-sown cereal fields. For the spring as a whole, bait supported nearly 50% and grassland 35% of all goose-days, whereas only 7% and 1% of goose-days were spent on new-sown cereals and peas, respectively.

A high degree of variation in local habitat use reflected local differences in feeding opportunities (Fig. 3). In Vejlerne, where no baiting was carried out, geese primarily fed on stubble fields at first, and later primarily on grassland. After the start of sowing, geese also foraged on new-sown fields. In the other areas, bait attracted the majority of geese. At all sites, geese were also observed foraging on new-sown fields. Only at Nissum Fjord did new-sown pea fields play a role.

Individual variation in use of new-sown fields

Of approximately 360 neck-banded individuals, the 347 observed more than twice in April 1994 were included in the analysis. Single individuals were observed up to 13 times feeding on new-sown fields; however, 181 individuals (52%) were never observed on new-sown fields. There was no difference in use of new-sown fields between first-winter and older birds (dividing the number of times an individual was observed on new-sown fields into four categories (0, 1, 2, >2 times); $\chi^2 = 2.293$, df = 3, $P > 0.05$). The frequency of use of fields by individuals increased with time (Fig. 4; $r_s = 0.533$, N = 347, $P < 0.001$) as well as with the time for the last observation (which is an approximation of the time of departure) of an individual in western Jutland ($r_s = 0.484$, N = 347, $P < 0.001$). There was no difference between the time of departure of first-winter birds versus older birds (dividing the period 1 April to 15 May into four periods; $\chi^2 = 6.261$, df = 3, $P > 0.05$).

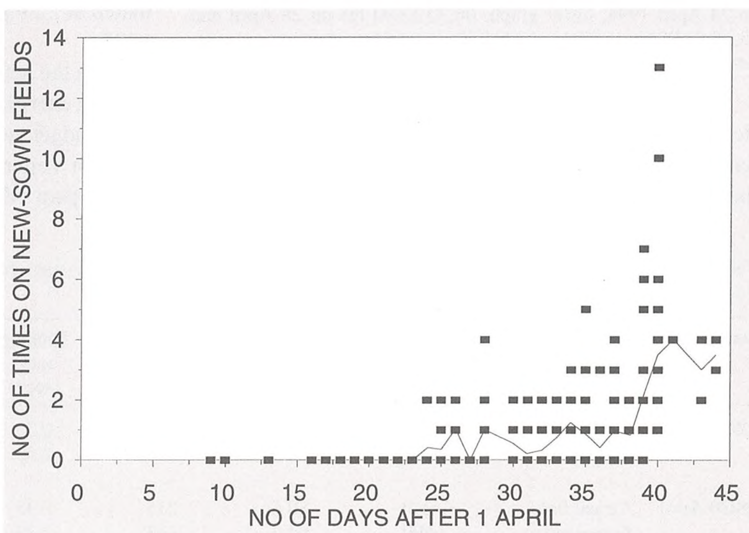

Figure 4. Relationship between date and the number of times individual neck-banded pink-footed geese were observed on new-sown fields in spring 1994. Line gives the average number of times.

Activity budgets

From Vejlerne, two full diurnal activity budgets can be pieced together, both from the second half of April when sowing of spring cereals had commenced (Fig. 5). Supplementary observations indicated that these activity budgets were representative of the daily routines of the goose flocks present there. In the morning, the geese started to feed on new-sown cereal fields and foraged intensively for 2-3 hours. Then they moved to grassland (either salt marsh or cultivated pasture) where they stayed during most of the day, feeding less intensively and spending most of the remaining time roosting. On one of the two observation days, the geese returned to the new-sown fields in the evening, to feed intensively for ca 2 hours before flying to the roost site. This bi-modal feeding on new-sown fields was observed in two out of four evening observations.

In the Bøvling Fjord area, where bait was spread in the morning (usually between 08.00 and 09.00 hrs), geese

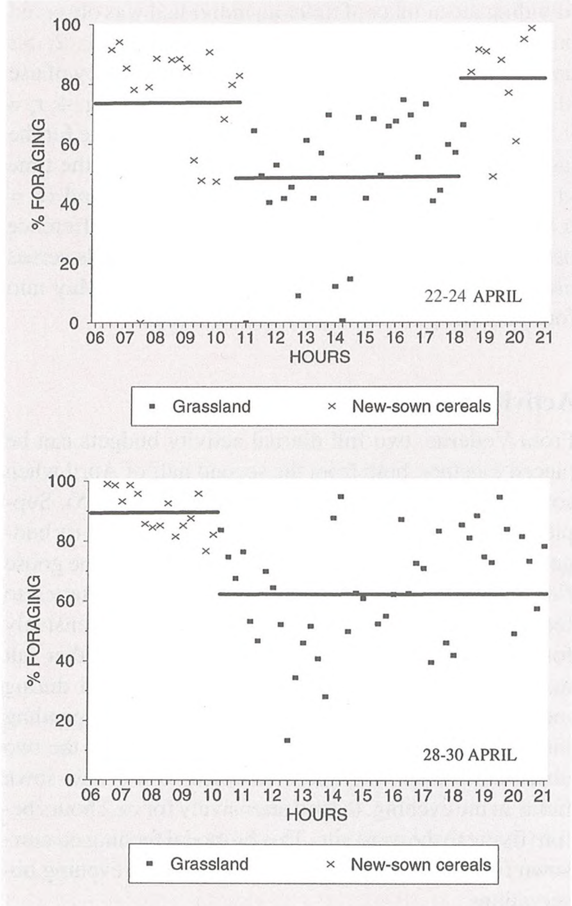

Figure 5. Diurnal foraging activity of pink-footed geese shifting between new-sown cereal fields and grasslands during the day at Vejlerne. The data shown in each graph was combined from two days. Upper graph: 06.00-12.30 hrs on 22 April and 12.45-21.00 hrs on 24 April 1994; lower graph: 06.30-13.00 hrs on 28 April and 13.15-21.00 hrs on 30 April 1994. Horizontal bars show average values.

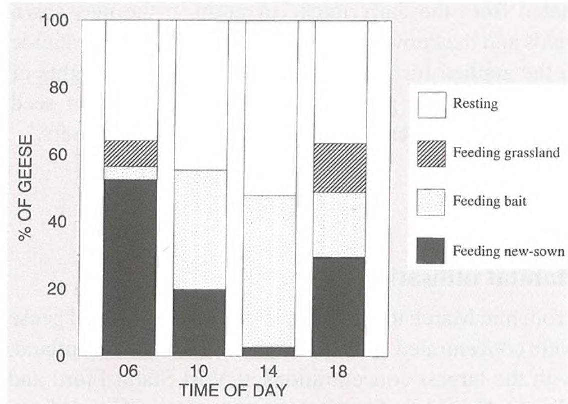

Figure 6. Foraging and resting activity of pink-footed geese at Bøvling Fjord, shifting between new-sown cereal fields, a bait site, and grasslands. Scans were made four times during the day and average values are shown from four observation days, 5-8 May 1994.

flew to new-sown fields in the early morning, foraged intensively for 2-4 hours after which the majority moved to the bait site (Fig. 6). On the bait site, geese usually fed for short periods (ca 30 minutes) and then roosted; if the geese resumed feeding later on, they foraged on grass (K. Essendrop, pers. comm.). By noon, few geese fed on new-sown fields, but by evening, flocks returned to feed before roosting. Grassland outside the bait site was only used in the mornings and evenings.

Daily food and energy intake rates

Average pecking rate for geese foraging uninterruptedly on new-sown cereal fields was 0.35 pecks/second (SD = 0.09, N = 47). For geese foraging on new-sown peas, average pecking rate was 0.20 pecks/second (SD = 0.15, N = 14). The pecking rate of grass feeding geese was estimated at 2.29 pecks/second in a previous study (Madsen 1985).

From the activity budgets, pecking rates and published feeding energetics parameters (Madsen 1985), a daily energy budget can be derived for the flocks of pink-footed geese in Vejlerne (Table 2). On the two observation days, geese spent 48% and 27% of the day available for feed-

Table 2. Daily energetics of an 'average' pink-footed goose foraging on both new-sown cereal fields and grassland during a day of observation at Vejlerne in April 1994.

Date	Type of habitat	Time spent in habitat (min)	% foraging	Feeding time (min)	Pecking rate[a] (sec^{-1})	Total no of pecks	Energy intake/ peck[b] (J)	Total energy intake (kJ)
22/24 April	Cereal field	450	77.6	349	0.35	7,270	219	1,592
	Grassland	445	48.8	217	2.29	29,884	14	418
								sum: 2,011
28/30 April	Cereal field	240	89.6	215	0.35	4,477	219	980
	Grassland	690	64.2	443	2.29	60,961	14	853
								sum: 1,834

[a] pecking rates in grassland habitat from Madsen (1985)
[b] from Madsen (1985).

Table 3. Daily energetics of an 'average' pink-footed goose foraging on both new-sown cereal fields, grassland, and bait grain during a day of observation at Nissum Fjord, 5-8 May 1994.

Type of habitat	Feeding time[a] (min)	Pecking rate[b] (sec^{-1})	Total no of pecks	Energy intake/ peck[c] (J)	Energy intake (kJ)
Cereal fields	260	0.35	5,422	219	1,188
Grassland	225	2.29	21,572	14	442
Bait grain[d]	88	-	-	-	608
					sum: 2,238

[a] calculated from activity budgets (see text)
[b] pecking rates in grassland habitat from Madsen (1985)
[c] from Madsen (1985)
[d] energy intake calculated from daily bait dosage (see text).

ing in the new-sown fields, respectively. However, due to higher levels of feeding intensity and higher profitability of grain compared to grass, geese received 79% and 53%, respectively, of their daily energy intake from feeding on new-sown fields. The calculated energy budget on new-sown fields rests on the assumption that the geese pick a grain for each peck, which may lead to an overestimation of intake rates.

In the Bøvling Fjord area, the average daily spread of grain on the bait site was ca 360 kg (data provided by the Forest and Nature Agency). With an average of 3,250 geese in the area during the observation days, the geese on average achieved an intake of 111 g bait grain, equivalent to 608 kJ. On the new-sown fields, the geese on average ingested 217 g grain, equivalent to an intake of 1,188 kJ. The food intake on grassland can only be indirectly estimated. Assuming that the bait is depleted 2-4 hrs after having been spread (K. Essendrop, pers. comm.), i.e. at Bøvling Fjord by 12.00 hrs, birds still foraging at the bait site by 14.00 hrs all fed on grass. The daily energy intake from grass is thus estimated at 442 kJ. On a daily basis, geese thus obtained 53% of their daily energy intake from feeding on new-sown fields, although they only spent 32% of the day there (Table 3).

Daily intake of pesticides

Based on the estimated daily food intake rates, individual geese in Vejlerne took 179-291 g new-sown grain on the two observation days (Table 4). At Bøvling Fjord, where geese had access to bait, they ate on average 217 g grain from the new-sown fields. Given the concentrations of Imazalil in the Fungazil seed dressing, it is estimated that a goose daily ate 9-15 mg a.i. Imazalil (see Table 4). Because the calculations are based on the assumption that each observed peck represents an ingestion of a grain, these estimates are probably slight overestimates.

Only at Nissum Fjord did new-sown peas contribute significantly to the diet of geese. Because geese were so infrequently observed on new-sown peas, the food intake rates and, hence, the potential Thiram intake rates could not be properly quantified.

Discussion

The intensified use of bait in the 1990s has alleviated the goose damage problem in western Jutland and has also decreased the potential problem of exposure to pesticide-treated grain. In the 1980s, the pink-footed geese moved between sites, feeding on the most recently sown fields (Madsen unpubl.). Then, pesticide intake rates were, therefore, probably higher than they were in 1994. Furthermore, in a late season like 1994, geese had less time to exploit new-sown grain, whereas in earlier seasons, they may have better opportunities to shift among areas sown at different times. Hence, due to the late sowing season and the intensified baiting programme, the exposure of pink-footed geese to pesticide-treated grain was probably less in 1994 compared with previous years.

Judging from the overall habitat distribution of pink-footed geese, the use of newly sown cereal fields appeared to be of minor importance and ingestion of pesticide therefore negligible. However, the diurnal habitat-based activity budgets showed that the geese flew to the newly sown fields for relatively short periods of the day, but foraged at high intensity and on a food resource of high profitability. At Vejlerne, where no bait was provided, the geese obtained half or more of their daily energy intake from the new-sown fields, and even in areas where bait was provided, the geese gained half of their daily energy intake on the new-sown fields. Hence, in terms of energy intake rates, new-sown fields were the most important habitat.

The study showed that it was the late departing geese which made most in-

Table 4. Estimated daily intake rates of Imazalil by an 'average' pink-footed goose feeding on new-sown cereal fields on two days of observation at Vejlerne and Nissum Fjord, 1994.

	Vejlerne 22/24 April	Vejlerne 28/30 April	Nissum Fjord 5-8 May
Daily no of kernels ingested[a]	7,270	4,477	5,422
Daily intake (g)[b]	291	179	217
Daily intake of Imazalil (mg)[c]	14.5	9.0	10.8
Intake/kg body weight (mg/kg)[d]	4.5	2.8	3.4

[a] based on values in Tables 3 and 4, assuming that each peck represents an intake of a kernel
[b] barley kernel weight: 0.04 g
[c] using a dosage of 50 mg a.i./kg^{-1} grain
[d] body weight in early May is 3.2 kg (population mean) (Madsen unpubl.).

tensive use of the fields and, hence, were most exposed to pesticides. In a late season such as 1994, early departing geese may not use new-sown fields at all. In the period from approximately 25 April to mid May 1994, the majority of geese remaining in western Jutland probably made daily feeding flights to the new-sown fields, and this is likely to resemble the situation for the majority of geese in a year with normal sowing conditions.

For Imazalil, toxicology tests on birds have shown LD_{50} (the acute oral dosage by which 50% of a test population dies; Hudson et al. 1984) values of >2,500 mg/kg body mass for mallard *Anas platyrhynchos* (Beavers & Fink 1979) and 2,000 mg/kg body mass for pheasant *Phasianus colchicus* (van Ravestyn & Marsboom 1986). For bobwhite quail *Colinus virginianus* and mallard, LC_{50} (the concentration in the food by which 50% of a test population will die; Heath et al. 1972) values of 6,290 and 5,620 mg/kg diet, respectively, have been reported (Anon. 1991). In a study on bobwhite quail, LC_{50} (22 weeks of exposure) exceeded 61.6 mg/kg diet per day, and with dosages of up to 61.6 mg/kg/day there were no observable effects on body condition, food intake rates, nor on egg production or chick survival (van Cauteren et al. 1988). Tests with rainbow trout *Salmo gairdneri* indicate that Imazalil does not accumulate in the organism but is metabolised/exchanged relatively fast (half-life 27-43 hrs) (Weytjens et al. 1989).

The daily ingestion rate of Imazalil by pink-footed geese feeding on new-sown cereal fields was estimated at 9-15 mg a.i., or 3-5 mg a.i./kg body mass. Intake rates were thus far below reported LD_{50} values. A worst case scenario is that the geese would exclusively cover their daily energy demands by feeding on new-sown cereals, which might in some areas have been the case before the intensified baiting programme began. In such a situation, the daily intake of Imazalil would amount to approximately 26-42 mg a.i., or 8-12 mg a.i./kg body mass, which is still more than two orders of magnitude below reported lethal dosages.

With an Imazalil dosage of 50 mg a.i./kg grain, a goose which feeds on new-sown cereal for just one day (i.e. an acute poisoning) obtains an ingestion which is two orders of magnitude below the reported LC_{50} values. If a goose feeds on new-sown cereal fields for 2-3 weeks (i.e. a more chronic poisoning), the pesticide ingestion is comparable to the above-mentioned test of reproductive effects on bobwhite quail. In the quail, the 50 mg/kg is within the range where sub-lethal effects could not be detected.

New-sown peas, which may be treated with Thiram, were only occasionally and locally used by the geese. Toxicity tests of Thiram on birds have shown highly varying LD_{50} values, viz., between 100 mg/kg body mass in passerines (Schafer et al. 1983) and >2,800 mg/kg body mass in mallard (Hudson et al. 1984). LC_{50} values of >5,000 mg/kg diet have been reported for pheasant and mallard (Heath et al. 1972). However, Thiram is known to have sub-lethal effects on reproductive parameters even in low concentrations; the 'no-effect' level has been estimated at between 10 and 350 mg/kg diet, depending on the test species (e.g. Riedel & Grün 1986, Elder 1964). Theoretically, if the 'no-effect' level for pink-footed geese is set at 200 mg/kg diet, and the dosage of Thiram in new-sown peas is 2,000 mg/kg, a goose has to ingest 100 g of peas to reach the 'threshold' level. With a pecking rate of 0.2 sec^{-1} and a seed weight of 0.27 g (and assuming that the goose takes a seed for each peck), this level will be reached after 31 minutes of uninterrupted foraging. If the geese are actively feeding, this can be accomplished within less than one hour of visiting a new-sown pea field. At Bøvling Fjord, flocks of geese were observed feeding in new-sown pea fields for up to two hours but seed dressing had not been applied in that area in 1994. However, in other areas and years, seed dressing is applied; then there may be some risk that geese are poisoned to an extent where sub-lethal effects will occur.

To conclude, after the commencement of spring sowing of barley and despite an intensive baiting programme to distract geese from the new-sown fields, new-sown cereals constitute the most important food for pink-footed geese during their stay in western Jutland. In some areas, flocks of geese also utilise new-sown pea fields. In a normal spring season, the entire population is likely to be exposed to Imazalil treated spring barley, and in some years a fraction of the population is exposed to Thiram-treated peas. Late departing geese are likely to make most use of new-sown fields and are, hence, most exposed to pesticides. It cannot be excluded that Imazalil may have sub-lethal effects on pink-footed geese, especially for birds utilising new-sown cereal fields for several consecutive days, but the low toxicity and high mobility of the compound and its metabolites suggest that effects are minor and short-lived. Thiram, however, may be ingested by geese in dosages which may have sub-lethal effects on reproductive parameters. Even though Thiram is apparently not used in all seed peas, special management precautions should be taken to deter geese from exploiting new-sown pea fields. More research is needed to quantify the exposure of the pink-footed goose population to Thiram-treated pea fields in order to evaluate potential impacts.

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References

Altmann, J. 1974: Observational study of behaviour: sampling methods. - Behaviour 49: 227-267.

Anon. 1991: The Pesticide Manual. 9th ed. - British Crop Protection Council.

Beavers, J.B. & Fink, R. 1979: Acute oral LD_{50} - mallard duck. Imazalil technical. - Final report. Wildlife Int. Ltd., Maryland, USA.

Elder, W.H. 1964: Chemical inhibitors of ovulation in the pigeon. - Journal of Wildlife Management 28: 556-575.

Heath, R.G., Spann, J.W., Hill, E.F. & Kreitzer, J.F. 1972: Comparative dietary toxicities of pesticides to birds. - U.S. Dept. of the Interior Fish and Wildlife Service, Special Scientific Report - Wildlife, No 152.

Hudson, R.K., Tucker, R.K. & Haegele, M.A. 1984: Handbook of toxicity of pesticides to wildlife. - U.S. Dept. of the Interior Fish and Wildlife Service, Publication, No 153.

Lorenzen, B. & Madsen, J. 1986: Feeding by geese on the Filsø farmland, Denmark, and the effect of grazing on yield structure of spring barley. - Holarctic Ecology 9: 305-311.

Madsen, J. 1982: Observations on the Svalbard population of Anser brachyrhynchus in Denmark: (a) numbers, distribution and breeding success 1980/81 and (b) population trends 1931-1980. - Aquila 89: 133-140.

Madsen, J. 1984: Numbers, distribution, and habitat selection of Pink-footed Geese Anser brachyrhynchus in Denmark 1980-1983. - Norsk Polarinstitutts Skrifter 181: 19-23.

Madsen, J. 1985: Relations between change in spring habitat selection and daily energetics of Pink-footed Geese Anser brachyrhynchus. - Ornis Scandinavica 16: 222-228.

Madsen, J. & Mitchell, C. 1994: Status of the pink-footed goose, 1990-1993. - IWRB Goose Research Group Bulletin 5: 8-11.

Riedel, B. & Grün, G. 1986: Die vogeltoxikologische Bewertung von Thiram, Carboxin und Carbendazim als Saatgutbeizmittel. - Nachrichtenblatt für den Pflanzenschutz in der DDR: 40(7): 147-151. (In German).

Schafer, E.W., Bowles, W.A. & Hurlbut, J. 1983: The acute oral toxicity, repellency, and hazard potential of 998 chemicals to one or more species of wild and domestic birds. - Archives Environmental Contamination Toxicology 12: 355-382.

van Cauteren, H., Coussement, W. & Vandenberghe, J. 1988: Reproduction study in bobwhite quails. - Janssen Pharmaceutica N.V., Beerse, Belgium, Exp. No 1822 (88.24.10).

van Ravestyn, C. & Marsboom, R. 1986: Acute oral toxicity study of ring-necked pheasants. - Janssen Pharmaceutica N.V., Beerse, Belgium, Exp. No 1601 (86.03.10).

Weytjens, D., Boonen, P., Gasparini, R., Leemput, L. van, Swysen, E., Woestenborghs, R. & Pauwels, C. 1989: The bioaccumulation of Imazalil (R 23979) in Rainbow trout (Salmo gairdneri). - Janssen Pharmaceutica N.V., Beerse, Belgium, R. R23979/BF/Sg.