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Meadow bird conservation on modern commercial dairy farms in the western peat district of the Netherlands: Possibilities and limitations

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Citation
Kruk, M. (1993, January 1). *Meadow bird conservation on modern commercial dairy farms in the western peat district of the Netherlands: Possibilities and limitations*. Retrieved from https://hdl.handle.net/1887/8073

Version:	Corrected Publisher's Version
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MEADOW BIRD CONSERVATION ON MODERN COMMERCIAL DAIRY FARMS IN THE WESTERN PEAT DISTRICT OF THE NETHERLANDS: POSSIBILITIES AND LIMITATIONS

WEIDEVOGELBESCHERMING OP MODERNE COMMERCIËLE MELKVEEHOUDERIJBEDRIJVEN IN HET WESTELIJK VEENWEIDEGEBIED VAN NEDERLAND:
MOGELIJKHEDEN EN BEPERKINGEN

(met een samenvatting in het Engels en Nederlands)

PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD VAN DOCTOR
AAN DE RIJKSUNIVERSITEIT TE LEIDEN,
OP GEZAG VAN DE RECTOR MAGNIFICUS
DR. L. LEERTOUWER,
HOOGLERAAR IN DE FACULTEIT DER GODGELEERDHEID,
VOLGENS BESLUIT VAN HET COLLEGE VAN DEKANEN
TE VERDEDIGEN OP DONDERDAG 10 FEBRUARI 1994
TE KLOKKE 16.15 UUR

DOOR

MAURICE KRUK

GEBOREN TE RIDDERKERK IN 1963

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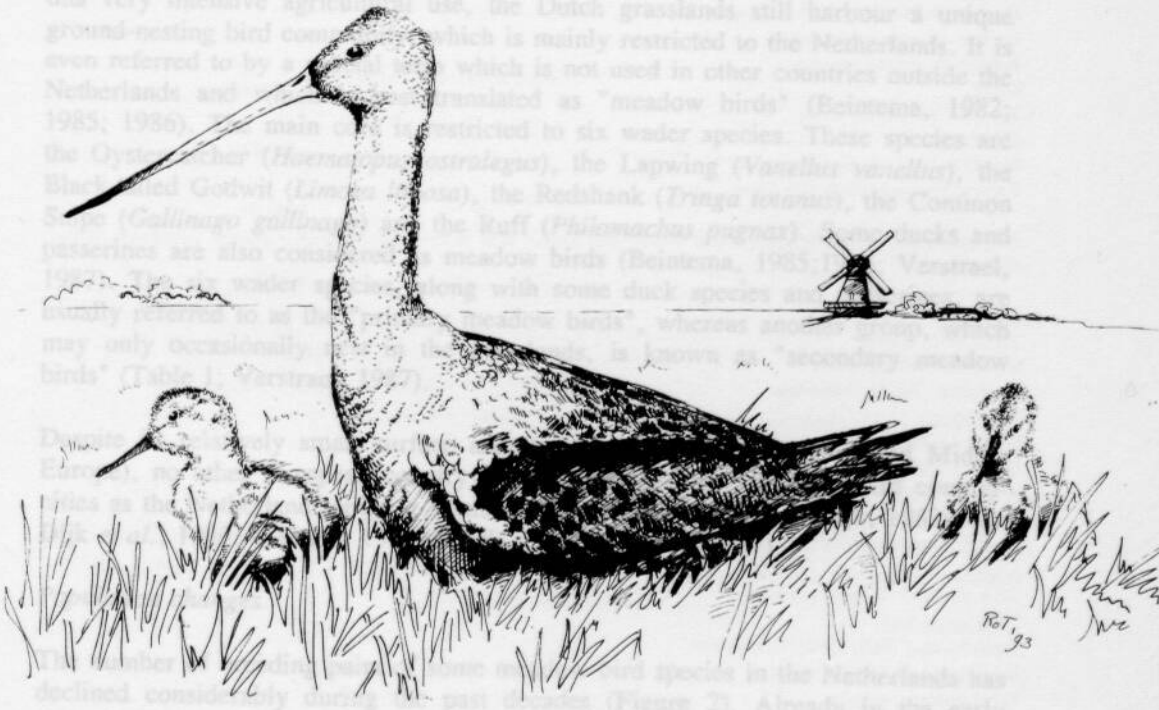
voor iedereen die aan dit proefschrift
een bijdrage heeft geleverd

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Chapter 1

Introduction and outline of the thesis



"*On intensively managed land, there are many ways of ensuring that the business and conservation aspects can co-exist, without damaging one another and with only a small cost or sometimes even a benefit to the land manager*" (Tait *et al.*, 1988).

INTRODUCTION.

The meadow bird community in the Netherlands represents a considerable part of the total West and Middle European populations. Meadow birds are increasingly threatened by modern intensive grassland management. If the process of intensification continues, this will lead to a severe reduction in numbers; on a local scale, possibly even to extinction. Since the greater part of the meadow bird populations nest in the intensively exploited grassland areas, measures increasing the breeding success at these sites are most desired. At the same time, however, such measures should not interfere too much with the dairy-farming practice, as only in that case will farmers be prepared to implement them. The possibilities and limitations of such meadow bird management on conventional commerical dairy farms will be discussed in this thesis.

Meadow birds in the Netherlands.

In the Dutch grassland polders, dairy farming is the most common form of land use. Dairy farming in the Netherlands is the most intensive in the world. Despite this very intensive agricultural use, the Dutch grasslands still harbour a unique ground-nesting bird community, which is mainly restricted to the Netherlands. It is even referred to by a special term which is not used in other countries outside the Netherlands and which is best translated as "meadow birds" (Beintema, 1982; 1985; 1986). The main core is restricted to six wader species. These species are the Oystercatcher (*Haematopus ostralegus*), the Lapwing (*Vanellus vanellus*), the Black-tailed Godwit (*Limosa limosa*), the Redshank (*Tringa totanus*), the Common Snipe (*Gallinago gallinago*) and the Ruff (*Philomachus pugnax*). Some ducks and passerines are also considered as meadow birds (Beintema, 1985;1986; Verstrael, 1987). The six wader species, along with some duck species and passerines, are usually referred to as the "primary meadow birds", whereas another group, which may only occasionally nest in the grasslands, is known as "secondary meadow birds" (Table 1; Verstrael, 1987).

Despite its relatively small surface area (about 1% of Northwestern and Middle Europe), no other European country has so well-developed meadow bird communities as the Netherlands (Figure 1; also see Beintema, 1982; Van Dijk, 1983; Van Dijk *et al.*, 1989; Piersma, 1986; Rooth, 1989; SOVON, 1987).

Population changes.

The number of breeding pairs of some meadow bird species in the Netherlands has declined considerably during the past decades (Figure 2). Already in the early fifties, Braaksma (1954), for example, estimated the number of breeding pairs of the Ruff at about 6,000. This has now been reduced to 870-1,050 pairs (Van Dijk *et al.*, 1989). Numbers of Black-tailed Godwit decreased from 125,000 pairs in the

sixties to 75,000-95,000 in the mid-eighties (SOVON, 1987). In contrast to the decrease in numbers of these species, there is an increase in numbers of others, such as the Lapwing, Curlew (*Numenius arquata*) and Oystercatcher.

TABLE 1.Meadow bird species in the Netherlands (Source: Verstrael, 1987).

A. "Primary" meadow birds (birds of which a significant part of the popualtion nests in the agriculturally exploited grasslands of the Netherlands)

Ducks.
Mallard, *Anas platyrhynchos*
Garganey, *Anas querquedula*
Shoveler, *Anas clypeata*
Tufted Duck, *Aythya fuligula*
Oystercatchers.
Oystercatcher, *Haematopus ostralegus*
Plovers, lapwings.
Lapwing, *Vanellus vanellus*
Sandpipers and alies.
Ruff, *Philomachus pugnax*
Snipe, *Gallinago gallinago*
Black-tailed Godwit, *Limosa limosa*
Curlew, *Numenius arquata*
Redshank, *Tringa totanus*
Larks.
Skylark, *Alauda arvensis*
Pipits, etc.
Meadow Pipit, *Anthus pratensis*
Yellow Wagtail, *Motacilla flava*

B. "Secondary" meadow birds (birds which only locally nest in the agriculturally exploited grasslands of the Netherlands)

Ducks.
Teal, *Anas crecca*
Gadwall, *Anas strepera*
Shellduck, *Tadorna tadorna*
Partridges.
Grey partridge, *Perdix perdix*
Quail, *Coturnix coturnix*
Rails and galineceous birds.
Corncrake, *Crex crex*
Coot, *Fulica atra*
Avocets.
Avocet, *Recurvirostra avocetta*
Gulls and terns.
Black-headed Gull, *Larus ridibundus*
Black tern, *Chlidonias niger*
Tern, *Sterna hirundo*
Wheatears, etc.
Whinchat, *Saxicola rubetra*
Stonechat, *Saxicola torquata*
Buntings.
Corn bunting, *Emberiza calandra*

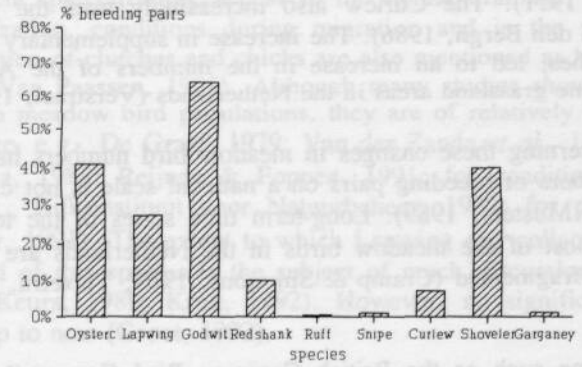


FIG. 1.Percentage of the Northwestern and Middle European populations of a number of wader and duck species (meadow birds) breeding in the Netherlands. Sources: Rooth (1989); Van Dijk *et al.* (1989).

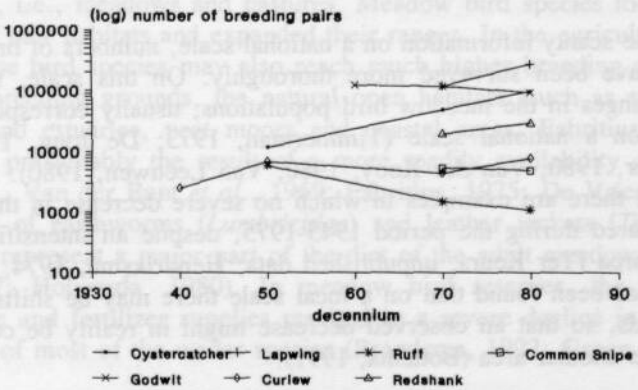


FIG. 2. Population trends of some meadow bird species in the Netherlands 1940-1990. Sources: Teixeira (1979); Piersma (1986); SOVON (1987); Van Dijk *et al.* (1989); Rooth (1989).

Lapwing numbers increased from 120,000 breeding pairs in the seventies to 275,000 in the eighties (Texeira, 1979; SOVON, 1987). The Oystercatcher extended its original breeding area along shores to almost every type of grassland inland (Hulscher,

1972; Heppleston, 1971). The Curlew also increasingly uses the grasslands as a nesting habitat (Van den Bergh, 1986). The increase in supplementary drainage, resulting in muddy ditches, led to an increase in the numbers of the Avocet (*Avocetta recurvirostra*) in some grassland areas in the Netherlands (Verstrael, 1987).

Some remarks concerning these changes in meadow bird numbers have to be made. The change in numbers of breeding pairs on a national scale is not clearly documentated (Weinreich & Musters, 1989). Long-term time series of the total numbers of breeding pairs of most of the meadow birds in the Netherlands are lacking, as the existing material is fragmented (Cramp & Simmons, 1983; Teixeira, 1979; SOVON, 1987).

A monitoring scheme such as the British Common Bird Census (Marchant, 1983; Marchant *et al.*, 1990) has been operative in the Netherlands only since 1984 (SOVON, 1987). Furthermore, in contrast to the generally accepted numbers as given above, the most recent data of this SOVON country-wide breeding bird monitoring project over the period 1984-1990 surprisingly show a significant decrease in Lapwing and a significant increase in Black-tailed Godwit and Common Snipe populations, whereas there is no significant change in numbers of Redshanks and Oystercatchers (Verstrael *et al.*, 1991).

In contrast to the scanty information on a national scale, numbers of breeding pairs on a local scale have been surveyed more thoroughly. On this scale, there are many examples of changes in the meadow bird populations, usually corresponding with the alleged trends on a national scale (Timmerman, 1973; De Jong, 1980; Fabritius, 1980; De Gelder, 1980; Van der Kooy, 1980; Van Leeuwen, 1980). However, on a local scale also, there are examples in which no severe decrease in the meadow bird populations occured during the period 1945-1975, despite an intensification of dairy farming in the area (Ter Keurs, unpublished data; Hendriksma, 1974; Visser, 1987). In addition, it has been found that on a local scale there may be shifts in the nesting areas of the birds, so that an observed decrease might in reality be compensated for by an increase in another area (Bottema, 1991).

In summary, however, it can be stated that there is no doubt that, on balance, the Dutch meadow bird community in many locations is becoming less rich in species and numbers of breeding pairs.

Causes of population changes.

The decreases in numbers are largely attributed to developments in agriculture, especially in dairy farming (Beintema, 1983a; Beintema & Van den Bergh, 1976; Teixeira, 1979; Jongsma & Van Strien, 1983; Musters *et al.*, 1986; Verstrael, 1987; SOVON, 1987). These developments concern both farm management (increased nitrogen supplies, higher cattle density, earlier and more frequent mowing, etc.) and

land development (parcelization, access to the fields, drainage, etc.). Other factors such as urbanization, conditions during migration and in the wintering areas and increased predation of clutches and chicks are also mentioned as having contributed to the decreases (Van Paassen, 1985). Although many studies show negative effects of these factors on meadow bird populations, they are of relatively less importance (for urbanization, see, e.g., De Graaf, 1979; Van der Zande *et al.*, 1980; Musters *et al.*, 1986; Brandsma, 1988; Reijnen & Foppen, 1991; for conditions in the wintering areas, see, e.g., Rijksinstituut voor Natuurbeheer, 1983; for predation, see, e.g., Groen & Buker, 1991). The extent to which Lapwing egg collecting has affected the population level of this species is the subject of much discussion in the Netherlands (Kruk & Ter Keurs, 1989; Kruk, 1992). However, no significant effect has been demonstrated up to now (Groot, 1992).

Agricultural developments.

Since the Middle Ages, woodlands have been turned into open lands for agriculture in the Netherlands. In the western and northern parts of the country, these were mainly marshy lands on peat soil. After the clearing, mainly arable farming was practised (vegetables and cereals). Due to shrinkage of the peat soil as a result of primitive drainage without pumps or mills, the areas soon became wetter. They were turned into grasslands, i.e., meadows and pastures. Meadow bird species took advantage of this creation of new habitats and expanded their ranges. In the agriculturally exploited grasslands, these bird species may also reach much higher breeding densities than in their original breeding grounds, the natural open habitats (such as steppes, tundras, river valleys and estuaries, peat moors and coastal areas; Fabritius, 1975; Voous, 1965). This is presumably the result of a more readily availability of food, notably soil fauna (e.g., Van der Bunt *et al.*, 1969; Fabritius, 1975; De Vries, 1971) such as several species of earthworms (*Lumbricidae*) and leather jackets (*Tipulidae* larvae). These animals represent a major part of the diet of the adult meadow birds (Green & Cadbury, 1987; Holwerda, 1980). In meadow bird reserves, the absence of any organic manure and fertilizer supplies resulted in a severe decline in the numbers of breeding pairs of most of the wader species (Brandsma, 1992; Groen & Buker, 1991; Zijlstra, 1990).

Intensification of dairy farming on the one hand increases biomasses of soil fauna, resulting in greater numbers of birds (cf Mulder & Phillipona, 1986, for a similar process in Iceland). On the other hand, it has a negative effect on the bird numbers by changing the habitat (which becomes less attractive to breed in) and reducing the breeding success by earlier and more frequent grassland operations. It is difficult, however, to separate factors affecting habitat choice and breeding success, because they partly have a common cause, notably the intensification of dairy farming.

This intensification of dairy farming methods after the second World War comprises several factors. The lowering of the water table is frequently mentioned as an

important and crucial factor in the process of intensification (e.g., Beintema, 1986; Williams & Bowers, 1987). Water tables were (and still are) lowered in order to increase the bearing capacity of the soil and consequently to enable the farmers to start farm operations such as manuring, grazing and mowing earlier in the season. Subsequently, grassland productivity has been increased by higher input of fertilizers and as a result higher stocking rates were possible. Reallotments have played a significant role in this intensification of land use. As a result, average grassland production at present is 10-15 tonnes dry matter per hectare per annum, which is harvested in at least three, though mainly four to five, cuts a year. Nitrogen input at present has reached a level of about 330 kg N per hectare per annum. The number of dairy cattle per hectare of grass increased from 1.19 in 1960 up to more than 1.5 per hectare in the eighties (Dijkstra, 1991).

According to current opinions, drainage and intensive use have affected the suitability of grasslands as breeding areas. In many cases, this would have led to lower breeding densities of the birds (Beintema & Van den Bergh, 1976; De Jong, 1977; Timmerman Azn., 1973). A critical analysis of available literature by Jongsma & Van Strien (1983), however, shows that the effects of drainage as such on the densities are ambiguous. Furthermore, habitat preferences may change and in any case do not completely overlap with habitat requirements. The term "preference" usually refers to the observed utilization of available possibilities. If these possibilities change, the utilization may also change, so that it is impossible to speak about "requirements". In the nineteen fifties, Klomp (1959), for example, described the habitat "requirements" of Lapwing as brownish-grey blue grasslands, which have rapidly disappeared since then. Nevertheless, numbers of Lapwing increased (SOVON, 1987) and at present this species may nest in different habitats, including arable land (which is quite common outside the Netherlands; for Britain see, e.g., Shrubb & Lack, 1991). Even Black-tailed Godwits and Redshanks sometimes also nest on arable land in the Netherlands (Verstrael, 1987).

In addition to the changes in habitat, the intensification of dairy farming methods resulted in more damage to nests and offspring due to the more frequent successive grassland operations and earlier cutting dates. The study of Musters *et al.* (1986) has proved that the breeding densities of meadow birds in the Netherlands are largely affected by factors within agriculture rather than by external factors (the presence of, e.g., buildings or highways). The most crucial factors were those concerning grassland management such as the stocking rate, the mowing date and the grazing system. It is not clear how these factors could directly affect breeding densities. They can only affect the breeding densities via the breeding success. Thus, today in the Netherlands, the carrying capacity of the grassland area (in terms of food availability or suitbale nest sites) does not determine breeding densities; but, these are dependent on factors affecting the recruitment (Beintema & Müskens, 1981). This recruitment is of great importance to the population level. If the recruitment is below a required level, the so-called required recruitment, population levels will inevitably decline. The required

recruitment is the level at which the number of births exactly compensates for the mortality (Beintema & Müskens, 1981). This makes it plausible that measures increasing the breeding success will benefit meadow bird populations.

Such an increase in the breeding success is desired, as otherwise the numbers of breeding pairs will inevitably decline. Of course, one could ask whether current population levels should be maintained or if some lower levels are also acceptable. This is of course a "political" choice. For the province of Zuid-Holland, the maintenance of current population levels and an increase in numbers of the rarest species is part of the provincial policy (Provincie Zuid-Holland, 1992). In the Environmentally Sensitive Areas-scheme, the maintenance or development of meadow bird populations is also part of the policy (Bruggink, 1992). For this reason, it seems desirable to enhance the breeding success of the meadow birds in order to fulfill these policy aims. The question now is how the breeding success of meadow birds could be enhanced.

Conservation strategies.

In general, the relationship between agricultural intensity and a particular conservation value for wildlife has the form of an optimum curve. In many ecological studies, such a relationship is found between an environmental factor and species richness (Begon *et al.*, 1990; for agricultural factors, see also Green, 1989). The stocking rate (as a measure for agricultural intensity) and breeding density of Lapwings (as a measure for the conservation value of wildlife) shows, corrected for other factors, the same kind of relationship (Figure 3).

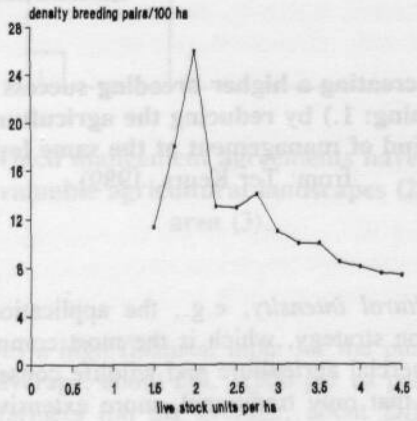


FIG.3. The relationship between stocking rate (as a measure of agriculture intensity) and breeding densities of the Lapwing (as a measure for the conservation value of wildlife). Source: Parmentier (1987).

This relationship results from two mechanisms working opposite to each other. The first is an increase of food abundance due to the intensifaction of the agricultural use, resulting in higher densities of breeding birds. The second is a decrease in numbers, caused by a reduction in breeding success due to the intensification of the agricultural use (Beintema, 1991). The curve describing this relationship of course is drawn as an average out of the noise. Assuming that the factors constituting the relationship are not determined by coincidence or factors other than agricultural management (and this has been made plausible by the study of Musters *et al.*, 1986), this kind of relationship gives way to two main methods of enhancing the breeding success of meadow birds (Figure 4):

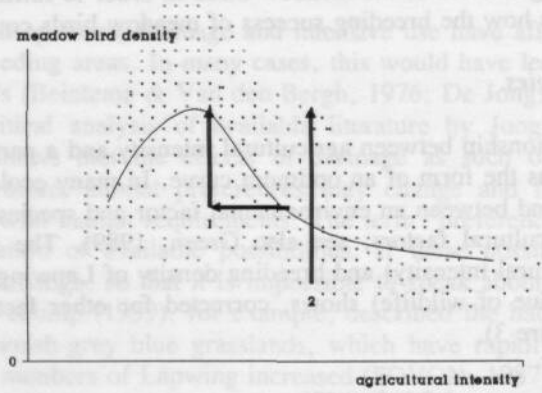


FIG.4.Two ways of creating a higher breeding success of meadow birds in conventional dairy farming: 1.) by reducing the agricultural intensity; and 2.) by practicing a different kind of management at the same level of intensity. (derived from: Ter Keurs, 1989).

1). Reducing the agricultural intensity, e.g., the application of traditional farming methods. This conservation strategy, which is the most common, is usually described as "segregation" of commercial agriculture and wildlife conservation. The approach is based on the assumption that only traditional, more extensive farming practices will benefit wildlife. The starting point is that modern agriculture and nature conservation are fundamentally conflicting activities (Jongsma & Van Strien, 1983; Reyrink, 1988) and therefore have to be separated from each other. After 1975, the Dutch government policy has been based on this concept and concentrated on measures within the framework of the so-called Policy Document on Agriculture and Nature Conservation (in Dutch: Relatienota; Minister van Landbouw & Visserij *et al.*, 1975). Meadow bird

reserves are set aside and, due to the high costs, only in a limited area (1991: 1% of the cultivated area; figure 5) farmers are financially compensated for losses due to *restrictions* on farm management for the sake of the meadow birds. The areas in which this kind of conservation takes place are called "Relatienotagebieden", which can be translated as the English equivalent Environmetally Sensitive Areas (ESAs). The prescribed measures usually create an undisturbed "window" of time in which the birds can breed. Early cultivation and manure spreading must be carried out before 1 April (or up to 10 April in some areas). The earliest dates for mowing or grazing are restricted to 1, 8 or 15 June, depending on the species of meadow birds present and/or the usual agricultural practices in the area (Ministry of Agriculture, 1987; De Boer & Reyrink, 1988). This kind of meadow bird conservation has been implemented in other European countries such as Germany and Great Britain (for the latter, see Mathers & Woods, 1989).

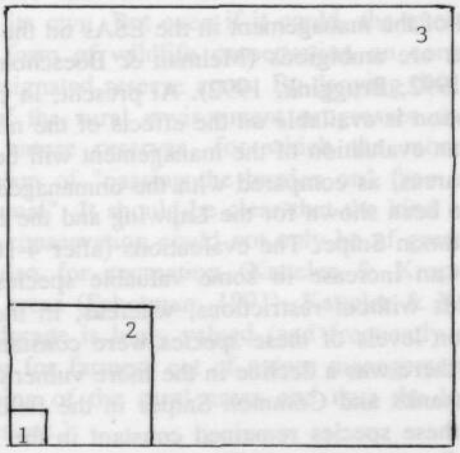


FIG.5.The area on which mangement agreements have been concluded (1) in relation to the area of valuable agricultural landscapes (2) and the total cultivated area (3).

The ESA scheme requires a high financial input for the purchase and management of nature reserves (on the average, about Dfl. 1,800 per ha per year) as well as financial compensations for the farmers (on the average, about Dfl. 1,100 per ha per year; Beintema & Rijk, 1988). Costs of the total scheme (in 1991, 12,744 ha of nature reserves and 20,397 ha of management areas; Commissie Beheer Landbouwgronden, 1992) can therefore be estimated at at least about Dfl. 45 million per annum. These costs will increase each year by several tens of millions, as the number of participa-

ting farmers has rapidly increased during the last few years (Melman & Boeschoten, 1991; Commissie Beheer Landbouwgronden, 1992).

Despite this increasing number, the enthusiasm of farmers to conclude management contracts is low as compared with other countries such as Great Britain (about 30% versus about 50%-70%; Kruk, 1991). During recent years, it has increased less than might be expected on the basis of milk quotas and other factors within agriculture which make additional income attractive (there is a constant growth, not an increasing one; Kruk *et al.*, 1991). One of the main reasons why farmers conclude a management contract is because of poor environmental conditions on their land, such as high water levels (Kruk *et al.*, 1991). Most of these kinds of less favoured areas, however, have already been designated. Farmers in the new designated areas will probably be less willing to conclude a management contract.

Studies on the effect of the management in the ESAs on the meadow bird populations, show that the results are ambigious (Melman & Boeschoten, 1991; Directie Beheer Landbouwgronden, 1992; Bruggink, 1992). At present, in only six of the present 180 ESAs (3%), information is available on the effects of the management on the meadow bird densities. Such an evaluation of the management will be made in 30 ESAs (Bruggink, 1992). In two areas, as compared with the unmanaged fields, positive effects of the management have been shown for the Lapwing and the Black-tailed Godwit and in one area for the Common Snipe. The evaluations (after 4-10 years; average 6 years), however, also show an increase in some valuable species such as Redshanks and Shovelers in the fields without restrictions, whereas, in the fields with management restrictions, population levels of these species were constant or even decreased (two areas). In two areas, there was a decline in the more vulnerable species such as Black-tailed Godwits, Redshanks and Common Snipes in the fields with restrictions, while population levels of these species remained constant in the fields without restrictions (Directie Beheer Landbouwgronden, 1992). This means that it has not yet been proven that the ESA scheme, in terms of "profit" for wildlife, has been very sucessful. This even more because the figures are for a very small area.

2). *Using the "scope" within the agricultural practice for the sake of meadow birds as much as possible, i.e., "fine tuning" of grassland operations in both space and time at the same level of agricultural intensity.* This conservation stategy is usually referred to as "interweaving" or "integration" of agricultural and meadow bird management (Van der Weijden *et al.*, 1984). Such an approach has already been proposed with respect to managing partridges (Sotherton *et al.*, 1989) and for the management of the flora on dairy farms (Melman, 1991; Van Strien, 1991).

There is a vigorous debate in the environmental movement as to which strategy would maximize wildlife benefits. Each of these has its own specific advantages and disadvantages. A major advantage of the policy of segregation is the fact that species-specific management is possible. Such extensive management, however, is possible

only on a small percentage of the total area. Eventually, only about 10% of the cultivated area will be designated as an ESA. The management also can only be slowly introduced on a large scale (in particular during economical recessions), as it is expensive and meets with resistance from farmers (Kruk *et al.*, 1987&1991; Van Schaik & Wingens, 1988; Schotman, 1991; Schröder & Van der Weijden, 1983; Van Strien *et al.*, 1988). Furthermore, the strategy carries the risk that many farmers will become estranged from nature management, since nature management increasingly "per definition" is put on a par with limitations to agriculture. Because there is a fixed level of compensation for those who comply with the restrictions, there is no incentive for doing conservation well or better. Doing well means keeping to the restrictions, not in all cases automatically increasing the conservation value. In addition, the surrounding area strongly influences abiotic conditions in the reserves and due to the small size of reserves and their isolation, populations risk extinction. This strategy of segregation cannot therefore halt the overall decrease in the grassland breeding meadow bird numbers on its own. But even if it could, the question arises as to why there should not be any form of wildlife conservation on conventional commercial dairy farms outside the designated reserve areas. By denying that such possibilities are present, the detoriation of the rural environment progresses and thus there will be even more demand for nature reserves, for which the money again is lacking. Furthermore, the mechanism of "passing the burden on" from agriculture on to the environment remains "normal". It should be clear that the kind of conservation which integrates agriculture and conservation could not only be of great importance to many aspects of nature, but also for recreation (Katteler & Kropman, 1977) and the development of the rural areas (Schotman, 1991). Katteler & Kropman (1977), e.g., show that the polder landscape is higly valued (and frequently visited) by recreating people. Additional income for farmers out of nature management compensations may partly prevent the emptying of the rural areas and thus the loss of many facilities (shops, banks, post-offices etc.).

In meadow bird studies, however, in comparison with the former strategy, relatively little attention has been paid to such ways of modifying dairy farming for the benefit of meadow birds (Jongsma & Van Strien, 1983; Joosten *et al.*, 1986; Van Kessel & Parmentier, 1984; Van Paassen, 1985; Verstrael, 1986&1987; Vloedgraven *et al.*, 1986). Not imposing severe limitations on agricultural farm management is less expensive, since it implies no withdrawal of areas from agriculture. It is attractive for farmers, since they can maintain or improve the land's conservation value in principle without drastically affecting the farming interests. Nevertheless, the strategy also has important limitations. Margins in farm management may change over the course of the years, which may limit the possibilities for wildlife conservation. A major disadvantage of a total rejection of nature reserves is that species which from an agricultural point of view already have extreme demands concerning the grassland management (e.g., the Ruff) are not very easily protected within this strategy.

Because of the advantages and disadvantages of both strategies, a balanced combination of these strategies may therefore be necessary. In this thesis, however, I will place the emphasis on the strategy of interweaving the interests of dairy farming and meadow bird conservation as much as possible.

QUESTIONS AND AIM OF THE STUDY.

Beintema & Müskens (1981;1987) developed a population dynamic model on the survival of meadow bird clutches in relation to grassland management. Variations have been included in this model concerning mowing dates, mowing regimens, manure application, grazing, effects of predation and the extent of replacement of clutches in case of losses. The model predicts the chance of breeding success per year for each concerned species and each concerned field. The main conclusion of this model is that the current intensive grassland management as a whole does not enable the maintainance of the current meadow bird populations. This is because the number of births does not compensate for the mortality, i.e., the recruitment was below that required. Other studies have led to a similar conclusion (Reyrink, 1988). For this reason, also in other European countries where the same process of intensification has taken place (Cramp & Simmons, 1983), the main conservation strategy has been a local reduction in agricultural intensity in order to enhance the breeding success of the meadow birds.

However, for protecting meadow bird populations outside the designated areas, this knowledge is not sufficient for conservation measures. It also does not explain why meadow bird populations in some of these grasslands are still maintained at a fairly high level. Management regimens that favour grassland breeding birds without severely restricting dairy farming practice therefore need to be developed. This makes it necessary to quantify dose-effect relationships per grassland operation or aspects of it (dose), in terms of the breeding success of the meadow birds instead of considering dairy farming as one complex. A farmer does not have unlimited freedom in the way he can adapt his grassland management, as he also has to earn a living as a farmer. For this reason, the study reported in this thesis will focus on factors affecting both grassland operations and meadow birds. This will enable farmers to "fine tune" their grassland management for the benefit of breeding sucess requirements of meadow birds. This will make it possible for them to make choices for changes in their grassland management per grassland operation instead of more or less giving up their farm by going back to traditional methods.

Recent studies have already contributed to partial answers to the question of how this could be done (Van Paassen, 1981; Van Kessel & Parmentier, 1984; Joosten *et al.*, 1986; Vloedgraven *et al.*, 1986). Most of these studies concern the relationship between agricultural activities and breeding success, in particular the fates of clutches. The results of these studies as well as the remaining questions will be discussed here.

Rolling and Harrowing.

Rolling and harrowing have a disastrous negative effect on clutches present at the time of carrying out these activities (Beintema & Müskens, 1981). It is still unclear, however, as to what extent these activities are performed and the time at which they are carried out. Hence, the proportion of clutches which is confronted with these activities is in fact unknown. In order to take any possible measures, it is also necessary to know more about the factors affecting the extent and the dates of these grassland operations.

Manuring.

Fertilizer does almost no damage itself, although it speeds up the growth rate, increasing the possibility of earlier grazing or cutting. If possible, fields known to be good for meadow birds should receive the latest and lightest applications, so that they will be cut late in the season (Van Paassen, 1985).

Farmyard manure (FYM) can attract meadow birds to an area because of it's camouflage potential as well as the invertebrates which it attracts. Spreading of the manure can be used to bring birds into a field or range of fields where they are at least risk, i.e., plots which are going to be cut last (Van Paassen, 1985). The positive effect, however, is probably not due to the manure itself; it may be related to the extensive grassland management which is usually coupled with the use of this type of manure (Van Berkel & Hoffman, 1986). In the case of superficial slurry spreading, any eggs present can be protected with a bucket lid or similar shield to prevent them from being covered up (Van Paassen, 1985). New manuring legislation is now being developed in order to reduce ammonium emissions which cause acid rain and to reduce the leaching of nitrogen to the soil and surface water. For these reasons, the legislation comprises a ban on spreading slurry during the winter as well as the recommendation of new slurry spreading techniques which apply the slurry to the soil more directly, e.g., by means of injection. Although this may greatly benefit the environment, the question arises as to what effects these developments may have on the Dutch meadow bird populations and whether any and what kind of measures should be taken.

Grazing.

Meadow birds will hardly ever start nesting on plots which are being grazed, although they may have started before grazing or may come in after grazing (mainly Lapwings and Oystercatchers). Eggs are at great risk from trampling, especially by young stock (Beintema *et al.*, 1984). The risks of trampling are dependent on the number of "cattle days"', i.e., the number of cattle multiplied by the number of days the grazing takes place (Beintema & Müskens, 1987). Chicks are rarely harmed, however, and especially those of the Lapwing may benefit from the presence of grazing animals

(due to the shorter grass to feed in and the presence of invertebrates attracted by the cattle). Because of the risks of the trampling of eggs, plots rich in meadow birds should not be grazed in the nesting season or should be left at least until the end of April or grazed before the beginning of April, then left and mown in June, leaving an undisturbed period between those dates (Van Paassen, 1985; Vloedgraven *et al.*, 1986). In general, this means that, in pastures, the prospects for integration of the modern farming practice and meadow bird management are broadly known. Furthermore, the area of pastures is much smaller than that of meadows and breeding densities are lower; so, this habitat is relatively less important. For this reason, the focus in this thesis will be mainly on meadows (i.e., fields mown in the first cut).

Mowing.

Grasslands which are mown in the first cut comprise about 65-90% of the grassland area, so that the greater part of the meadow bird population breeds in these mown fields. Mowing generally takes place later than grazing; so, fewer eggs are at risk. As there is a tendency towards earlier mowing dates, however, it is expected that fewer clutches will hatch before mowing (Reyrink, 1988). The effects of mowing on the nesting success of meadow birds in the present situation, however, is not quite clear. In particular, factors affecting both mowing dates and timing of nesting have not yet been studied. In addition, the survival chances of chicks may be negatively affected by mowing activities. In intensively exploited grasslands, especially chicks of the Black-tailed Godwit (*Limosa limosa*) are thought to be extremely vulnerable to mowing activities (Buker & Groen, 1989). The Lapwing and the Oystercatcher take their young to forage on shorter grass nearby soon after hatching, so they will not face any mowing risks; but, broods of the Black-tailed Godwit are found mainly in tall grass. Buker & Winkelman (1987) have studied the survival of Black-tailed Godwit chicks in a nature reserve and grassland management area. In intensively exploited grasslands, however, the fates of Black-tailed Godwit chicks in relation to grassland management are virtually unknown.

AIM AND SCOPE OF THE STUDY.

The aim of the study described in this thesis was to find measures for meadow bird conservation on conventional commercial dairy farms, using the "scope" in the grassland operations as much as possible. The starting point was that these methods should interfere with farm management as little as possible. Such methods may include:

(1) protection of clutches (and chicks) without any changes in farm management (by marking clutches and the protection of chicks during grassland operations; Hendriksma, 1964; Fokkema & Wiltenburg, 1982; Van der Meer, 1984; Van Paassen, 1985);

(2) changes in the way the grassland operations are carried out. An example is to mow from the centre of a field instead of the other way round, in order to give chicks a greater chance of escaping (Verstrael, 1987);
(3) reducing the damage due to grassland operations at "sensitive" sites, i.e., fields rich in meadow birds;
(4) reducing the damage due to grassland operatations during "sensitive" periods, i.e., during the breeding season, which may vary;
(5) a combination of methods as described above.

GENERAL DESCRIPTION OF THE STUDIED MEADOW-BIRD AREAS.

Of the two million hectares of cultivated land in the Netherlands, 1.1 million hectares are grassland. About 300,000 hectares are situated on peat soils and clay covered peat soils (<50 cm layer of clay). These peat grasslands are the most characteristic elements of the Dutch polder landscape. They are mainly situated in the holocene western and northern parts of the country, notably in the provinces of Friesland, Overijssel, Utrecht, Noord-Holland and Zuid-Holland (for their locations, see Terwan, 1988). The polders are generally one or two metres below sea level and have relatively high water tables. They were reclaimed from A.D. 1000 onwards (Van der Linden, 1982). The peat polders consist of long and narrow fields intersected by an extensive network of ditches and canals. Often, one or more shallow furrow drains are present in the fields. Together, the fields form a very open landscape with only a few trees.

In the peat areas, the possibilities of modifying dairy farming for the benefit of meadow bird protection are greater than on the clay and sandy soils (albeit meadow bird conservation would also be possible on these soils). Farming in the peat areas is less intensive due to the limitations posed by the wetness of the soil. In these areas, meadow birds also represent the most characteristic value of wildlife and relatively high numbers may still be found there. Therefore, the greater part of the study was concentrated on these types of areas.

OUTLINE OF THIS THESIS.

The chapters in this thesis will follow the order of the grassland operations usually carried out on dairy farms. First, in Chapter two, however, a description of the main methods used for the study described will be given. The more specific methods will be described in each separate chapter.

In Chapter three, a study on the effects of rolling and harrowing on the nesting success of the grassland breeding birds in intensively exploited grasslands along with

possible measures for lessening the negative effects without significantly affecting the farming itself will be discussed.

The possible effects of new manuring techniques on the nesting success of meadow birds and their food supply are discussed in Chapter four.

Chapter five concerns the dates of nesting and mowing in different fields in order devise more flexible measures concerning mowing dates in different fields.

In Chapter six, the relationship between nesting and mowing dates in different years is described. The variation in these dates is also considered to be of importance for establishing more flexible sets of rules for meadow bird management.

Chapter seven is concerned with the effects of mowing on the survival of Black-tailed Godwit chicks as well as a possible means to diminish the negative effects.

The thesis ends with Chapter eight, in which the main conclusions will be presented and the prospects for the meadow bird populations in the Netherlands will be discussed.

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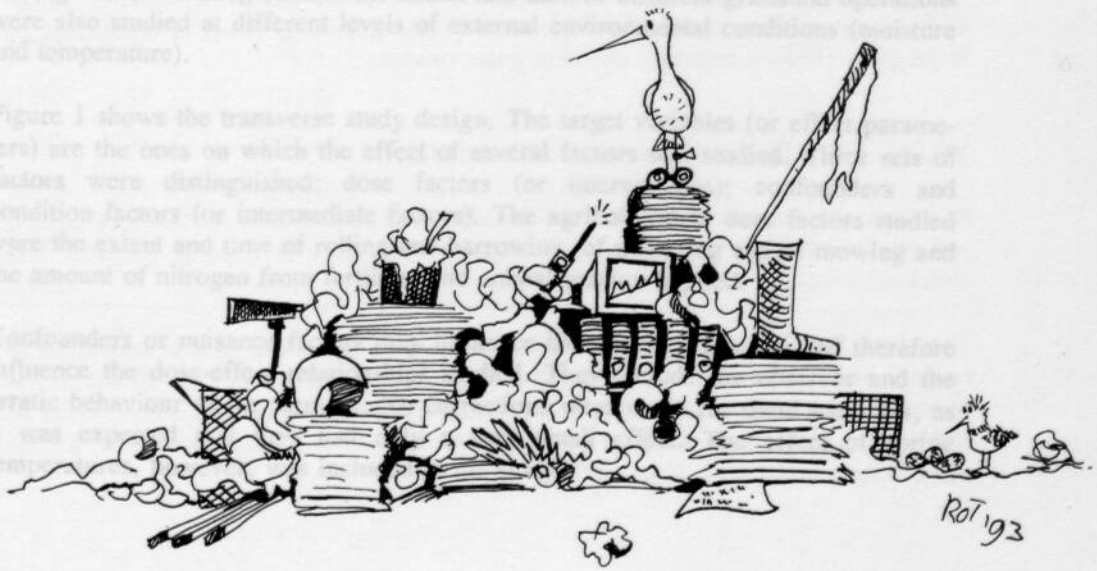
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Chapter 2

Study design, study area and methods of collecting and analyzing data



INTRODUCTION.

The general study design and methods for collecting and analyzing data used for most of the studies decribed in this thesis will be given in this chapter. More specific information on study design and methods will be given in each separate chapter.

STUDY DESIGN.

Transverse study design.

The study design used for most of the studies is a descriptive-analytical and not an experimental one. Non-experimental or descriptive analytical studies can be transverse, in the case of *ceteris paribus* comparison of different areas in space, or longitudinal, in the case of comparing one area at different points in time, before and after the intervention (Ward, 1978; Verstrael, 1987; Van Strien, 1991).

I have used both methods in the study for this thesis; however, the transverse design was mainly used. A transverse set-up has the advantage - apart from several others (Van Strien, 1991) - that relationships can be found in a relatively short time. This was necessary, as the study was confined to only four and one half years. The longitudinal study consisted of research on the timing of nesting and grassland operations in relation to spring temperatures and precipitation. The transverse study consisted of spatial, simultaneous comparisons within one year of the date of nesting and the nesting success at different levels of agricultural activity. In order to be able to explain the effects of the grassland operations on the timing of nesting and the nesting success the extent and time of different grassland operations were also studied at different levels of external environmental conditions (moisture and temperature).

Figure 1 shows the transverse study design. The target variables (or effect parameters) are the ones on which the effect of several factors was studied. Three sets of factors were distinguished: dose factors (or interventions); confounders and condition factors (or intermediate factors). The agricultural or dose factors studied were the extent and time of rolling and harrowing, of manuring and of mowing and the amount of nitrogen from fertilizer and animal manure applied.

Confounders or nuisance factors may influence the effect parameters and therefore influence the dose-effect relationships studied. They include the observer and the erratic behaviour of the farmers. No corrections were made for these variables, as it was expected that they had only a very small effect. The effect of spring temperatures, however, was included in the study.

Condition factors are those which operate in the black-box system such as soil type, the water level in the ditches, the ground water level, vegetation height and food availability (soil fauna). The soil type in most of the studies was peat. In one study, three types were distinguished: sandy, clay and peat soil. The other factors were taken into account to by collecting data on these factors.

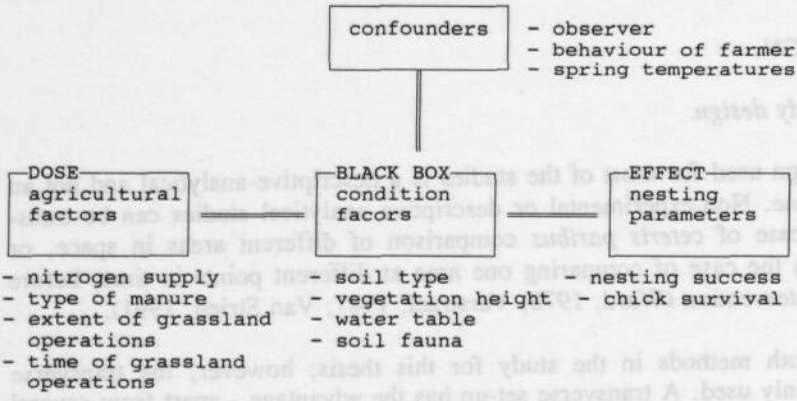


FIG.1. Study design used in this thesis.

The effect parameters/target variables used were the nesting success and the survival of chicks.

The study was carried out mainly on meadows, i.e., fields mown for silage in the first cut, and to a lesser extent on pastures, i.e., fields grazed in the first cut (9-25% of the studied area). The vegetation in the grassland fields is dominated by Reye grass (*Lolium perenne*) and *Poa* grass species.

STUDY YEARS, STUDY AREA AND FIELDS.

Research was carried out from 1987 to 1991. Additional data on times of nesting and some grassland operations (provided by volunteers monitoring meadow bird clutches) were available from 1984-1986.

The greater part of this study was done in the grassland areas of Ade (northeast of Leiden) and Duivenvoorde (southwest of Leiden), located in the peat district of the province Zuid-Holland in the western part of the Netherlands near Leiden. From an agricultural point of view, these areas may be considered as representatieve for the western peat area (Kruk *et al.*, 1987).

In addition, in 1989, volunteers made observations in intensively exploited grasslands on different soils (clay, peat and sand) in Friesland.

In 1991, a study was carried out in the Bovenkerker polder, near Amstelveen, on the effects of manure injection to prevent ammoinia emissions on the numbers and biomass of soil fauna. This intensively exploited area has mainly peat soil, with some clay.

The study on the effects of mowing on the survival of chicks was carried out in a part in the Ade area, but mainly in the grassland area of Oenkerk (1990 and 1991), located in the province of Friesland in the northern part of the Netherlands (both sandy and peat soil). In this grassland polder, both intensive an extensive grassland management occurred.

The total area studied for Ade and Duivenvoorde in 1987-1991 changed each year (Table 1).

TABLE 1. The number of fields studied and the studied area of meadows, pastures and unknown (grassland) use (in ha) in the study years 1984-1991. Data of 1984-1986 were collected by volunteers marking nests.

year	number of fields	area of meadows (ha)	area of pastures (ha)	area with unknown use (ha)
1984	12	26.6	9.0	9.6
1985	13	14.0	10.9	2.3
1986	43	40.3	24.0	16.0
1987	108	141.3	26.7	31.0
1988	203	252.0	24.9	12.1
1989	219	292.9	46.7	26.1
1990	188	218.9	79.3	16.7
1991	95	88.2	38.8	46.0
total	871	1074.2	260.3	159.8

DATA ON NESTS AND CHICK SURVIVAL.

The study was focussed on the species which on a European scale are relatively abundant in the Netherlands, i.e., the Lapwing (*Vanellus vanellus*), the Black-tailed Godwit (*Limosa limosa*), the Oystercatcher (*Haematopus ostralegus*) and the Redshank (*Tringa totanus*). The Shoveler (*Anas clypeata*) should also be included. For this species, however, no sufficient data could be obtained in all years, so that it was excluded.

Data on nests were collected weekly throughout the nesting season from the end of March until the beginning of June. Nests were found by either systematic walks through the fields searching for clutches (early in the season) or by locating incubating birds and adults returning to the nest site (later in the season). The fate of nests was recorded as successful (hatched), preyed upon, destroyed by grassland operations or deserted since the last visit. All clutches were marked with a garden cane placed upright into the ground at three to four meters from the nest. For each nest, the date on which the first egg of the clutch was laid was estimated by one of two methods:

(a) If the clutch was found prior to the last egg being laid, the first egg date was calulated on the assumption that the laying interval between successive eggs was one day plus one extra day per clutch.
(b) If complete clutches were found, the incubation stage was determined by using the degree of flotation of the eggs in water (Joosten *et al.*, 1986; Van Paassen *et al.*, 1984). For very few clutches, a first egg date could not be calculated. These clutches were not included in the analysis.

The method of collecting data on chick survival will be described in more detail in Chapter 7.

DATA ON DOSE AND OTHER FACTORS.

Grassland operations.

The dates and extent of the grassland operations were obtained by means of a questionnaire distributed among the farmers and by personal observations of the grassland operations in the field. In addition, volunteers monitoring clutches provided several data on mowing dates. If there was any difference between these sources, the average date was taken.

Water levels.

Most of the fields in the Dutch peat areas have an oblong, rectangular form, with ditches on all four sides. One or more furrow drains or "grips" (very small and shallow ditches) may also transect a field. In 1988, 1989 and 1990, the ditch water table was measured as a parameter for the moistness of the field. It was measured on two fixed, randomly chosen edges of a field at every visit. The ditch water table is the vertical distance between the ground level and the water surface. As the ground water table was supposed to be a much better measure for moistness per field, the ground water table was also measured in both 1989 and 1990. From the end of March until the first of May, ditch water tables and ground water tables were measured weekly. Thus, in total, four to five measurements were made. Ground water tables were measured by means of one dip well (perforated plastic tube) per field which was placed in the centre of the field between two ditches or between the ditch and a grip. This position of the dip well was considered to give the most reliable estimation of the ground water table of the field independent of the width of a field. In the period of February-May, the ground water table at this point is virtually constant (Melman *et al.*, 1990). The average of the measurements from March to May was used as a measure for the ground water table of a field.

DATA ON CONDITION FACTORS.

Vegetation height.

To obtain data on vegetation growth, vegetation height was measured from the end of March until the day on which the field under study was mown. In order to make a comparison between fields, the vegetation height was taken on the date on which the first of all studied fields was mown (1988, 5 May; 1989, 3 May; 1990, 10 April).

Soil fauna.

In the last two weeks of March, 1990, in the Ade and Duivenvoorde areas, data were collected on *Lumbricidae* and *Tipulidae* larvae in order to determine the effects of diferences between fields on the timing of nesting. Earthworms and Leatherjackets represent the major part of the diet of the adult meadow birds in early spring and are of great importance for egg formation. Fields were selected on the basis of similarity in soil type (peat), moisture (ditch water level), permanent use as grassland for at least five years, no use (in the studied year) of sprays against *Tipulidae* larvae and differences in moisture; 31 fields (about 40 ha) were sampled twice.

To compare the effects of manure injection on soil fauna with those of the current surfacial application, in 1991, a study was also carried out on 30 fields in the peat area of the Bovenkerker polder in the province of Noord-Holland, near Amstelveen and Nes aan de Amstel.

In each field, four sod samples of 20x20 cm square and 10 cm deep were selected along a diagonal over the fields. The number of *Lumbricidae* and *Tipulidae* larvae was determined by sorting out each sod sample by hand (Edwards & Lofty, 1977), which is a reliable method for finding >90% of earthworms present (Nelson & Satchell, 1962). No distinction was made between different species, as there are no indications that the meadow birds select their prey items. Biomasses were determined by placing the *Lumbricidae* or the *Tipulidae* larvae in a measuring glass filled with water. Each cm^3 difference from more than the original water volume was considered to be 1 gram of biomass. Total numbers and biomasses in the four sod samples per field were calculated by adding the numbers and biomasses of all separate samples.

Weather conditions.

Data on temperatures and precipitation were provided by the National Weather Forecasting Institute, KNMI. For the Ade and Duivenvoorde areas, data of one weather station (Valkenburg) at about 10 km from the study area were used.

Analysis techniques.

Two main methods for analyzing data were used: 1.) simple correlation; 2.) multitvariate techniques. By means of multivariate techniques, the independent effect of several factors can be established. For this purpose, multiple regression and ANOVA were used.

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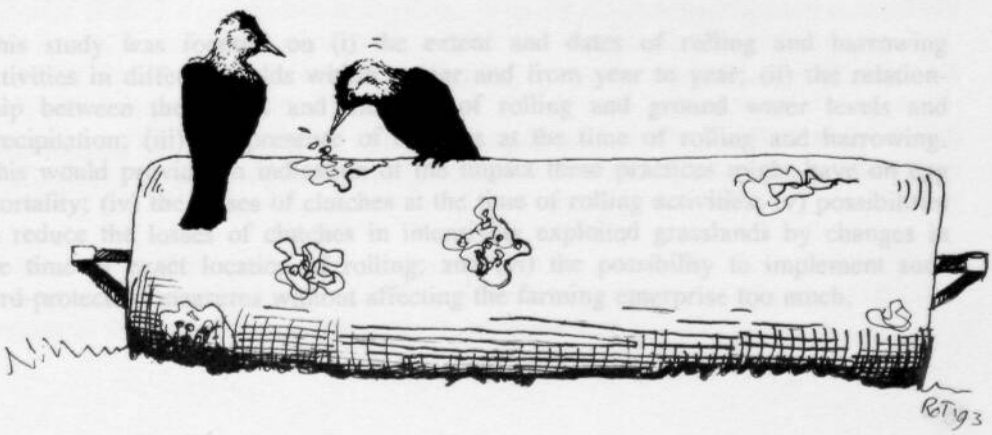
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Chapter 3

Effects of rolling and harrowing on the nesting success of meadow birds birds in intensively exploited grasslands in the Netherlands

Maurice Kruk, Carola Alsemgeest-van den Broek and Martien Kooyman



SUMMARY

(1) The effects of rolling and harrowing on the nesting success of four species of meadow birds, the Oystercatcher (*Haematopus ostralegus*), Lapwing (*Vanellus vanellus*), Black-tailed Godwit (*Limosa limosa*) and Redshank (*Tringa totanus*) in an intensively exploited grassland area in the western peat district of the Netherlands were studied in 1987-1991.

(2) The portion of the area in which rolling and harrowing activities took place as well as the (median) date of these activities varied each year; the latter was positively correlated with the amount of precipitation in March.

(3) Within a year, the higher the ditch or ground water table, the later the date of rolling of a field; the higher the water tables, the greater the extent of rolling activities.

(4) Rolling and harrowing was most risky for Lapwing nests; on the average, 13% (range 0-34%) of all Lapwing clutches could be damaged as a result of these activities.

(5) By rolling and harrowing one week earlier in the season, the percentage of destroyed nests of the Lapwing could be significantly reduced by 59%. Total nest losses were decreased to 8% on the average. This apperently may occur without significantly affecting the farming enterprise.

(6) Lapwings showed a preference to nest along furrow drains and ditches. The percentage of nests destroyed therefore could also be reduced to a total of 9% by leaving a strip of 2 m along furrow drains and ditches. This presumably would affect the farming even less.

(7) To reduce the necessity of rolling, it is recommended that any trampling of the soil by cattle be prevented during the autumn in the wetter fields by driving the cattle out from such fields.

INTRODUCTION

At the start of the breeding season in March and April, egg-incubating meadow birds may be threatened by rolling and harrowing activities. Both of these processes negatively affect the breeding success because they damage the clutches present at the time (Beintema & Müskens, 1981; De Jong, 1977; Buker & Reyrink, 1989).

The Dutch Government has designated special areas in which measures are taken to protect the clutches and chicks from harmful farming activities (De Boer & Reyrink, 1988; Ministry of Agriculture, 1987; cf Mathers & Woods, 1987). In the management regulations, there is a ban on the rolling and harrowing after a certain date (varying between 15 March and 6 April) in order to decrease losses due to these activities. The greater part of the meadow bird community, however, nests in the non-protected areas. It is therefore worthwile to also pay attention to measures which protect the birds in these non-protected areas. To increase the acceptance of bird-protecting measures by farmers, such measures should affect the farming enterprise as little as possible.

To establish whether restrictions on rolling and harrowing may be effective, the main question is which part of the bird community is confronted with these activities. Some estimations have already been made (Van der Werf, 1974; Vermeer, 1981; Brandsma, 1988). These, however, are very scarce and usually concern small areas and only a single year and may no longer be valid for the present situation. They also do not afford any possibilities for "fine tuning" these grassland operations for the sake of the meadow birds. If necessary, two different methods could be applied in parcels rich in meadow birds (Van Paassen, 1985). One is to take account of the location of clutches in the field; the other is to carry out the rolling and harrowing activities earlier in the season, when fewer clutches are present.

To determine to what extent these measures could be implemented, factors affecting the extent and date of rolling, particularly water levels and precipitation were studied.

This study was focused on (i) the extent and dates of rolling and harrowing activities in different fields within a year and from year to year; (ii) the relationship between the extent and the date of rolling and ground water levels and precipitation; (iii) the presence of clutches at the time of rolling and harrowing. This would provide an indication of the impact these practices might have on egg mortality; (iv) the losses of clutches at the time of rolling activities; (v) possibilities to reduce the losses of clutches in intensively exploited grasslands by changes in the time or exact location of rolling; and (vi) the possibility to implement such bird-protecting measures without affecting the farming enterprise too much.

METHODS.

The study area, data on grassland operations, water levels, precipitation and nests were collected as described in Chapter two.

The location of each nest in the field was determined by measuring the distance from the center of the clutch to the nearest grip (shallow furrow drain) or ditch. To determine if the birds prefered to nest in the neighbourhood of ditches or grips, the number of clutches within a strip of 0-1, 1-2 and 0-2 metres alongside the ditches and grips was determined. This number was compared with the expected number of nests if there was no site preference. Therefore, for each field, the number of grips and the distances between them and between the ditches were recorded. The total area of each field was estimated from maps (scale 1:5000) or in the field with a measuring tape. The maximum width of the strips was fixed at 2 metres, i.e., about the width of the roll. That width was assumed to be acceptable for farmers to exclude it from rolling and harrowing.

RESULTS

The part of the area rolled and harrowed

The total fraction of the area rolled varied significantly from one year to another, between 0% and 37% (χ^2 test; $P<0.05$; fields where dates of rolling and harrowing were unknown were excluded from the analysis). On the average, 21% of the fields were rolled.

More fields were rolled than harrowed (χ^2 test, $P<0.05$). In the study area, only in three of five years was a number of the meadows and pastures harrowed. This fraction of fields harrowed also showed a great variation between years: between 0% and 49% of the total area studied was harrowed (average, 12%).

In 1987, harrowing occurred more often in meadows than in pastures (χ^2 test, $P<0.05$). No significant differences were found between meadows and pastures for the fraction of harrowed fields (χ^2 test, $P>0.05$).

Factors affecting the extent of rolling activities.

In wet fields, rolling occurred less frequently (Table 1). Rainfall in the autumn was negatively correlated with the extent of rolling activities ($r=-0.94$; $P<0.01$;$n=5$ years)

TABLE 1.The fraction of fields rolled in situations with high and low water levels (i.e., higher or lower than the average).

	high water levels	low water levels	N
year	fraction of fields rolled	fraction of fields rolled	
1988	47%	18% *	73
1989	56%	19% *	60
1990	27%	15% N.S.[1]	31

[1] N.S. = not significant; Fisher's exact-probability test, $P>0.05$
* χ^2-test, $P<0.05$

The date of rolling and harrowing.

There was a considerable variation in the dates of rolling and harrowing in different years. Median rolling dates varied between the third and sixth week after 1 March. Median harrowing dates varied between the second and fourth week after 1 March. Most of the rolling and harrowing took place at 3-5 weeks after 1 March.

The drier the field, the earlier it was rolled (1989: $r=-0.63$, $P<0.01$; 1990: $r=-0.88$, $P<0.05$). No significant correlations were found between rolling dates and ditch water levels (apart from 1990, where $r=-0.88$, $P<0.05$).

Precipitation in March determined the median rolling date for a given year ($r=0.995$, $P=0.005$; $n=4$ years; Spearman Rank Correlation).

The presence of clutches during rolling and harrowing.

In 1987, 34% of all Lapwing clutches in all meadows studied, and 39% in all pastures studied were present at the time of rolling/harrowing (Figure 1). In 1988, this was 22% and 58%, respectively. In the other years, it was 10% or less. The other species usually started nesting after the fields were rolled and harrowed. In all years except one year, 5% or less of the clutches was present during these grassland operations. Only in exceptional cases (in the extremely wet spring of 1988, for instance), was a considerable number of Black-tailed Godwit clutches present at the time of rolling or harrowing (in meadows, about 20%).

In most years, the number of Lapwing clutches present at the time of rolling/harrowing usually rapidly increased during 22-28 March, with a maximum of 50-60% present in the period from 29 March - 4 April onwards.

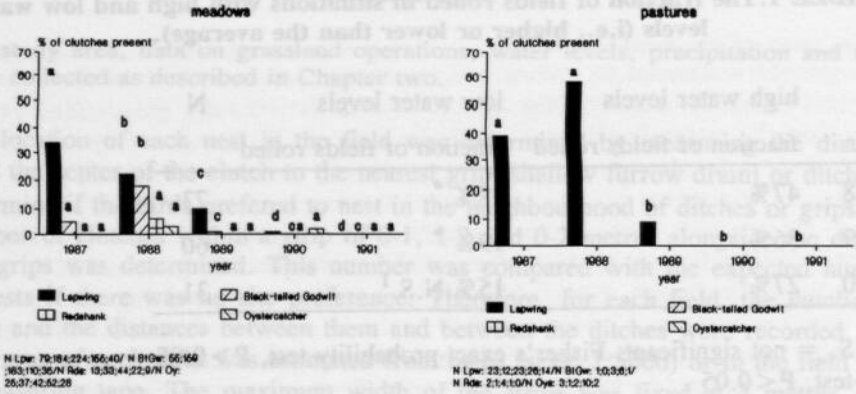


FIG.1.The percentage of clutches present in meadows and pastures at the time of rolling/harrowing. Different characters represent significant differences between years (χ^2-test, $P<0.05$).

Because rolling started later in wet fields, it was expected that clutches laid in the wetter fields had a greater risk of being damaged by rolling activities. The first eggs of the Lapwing were also laid later in wet fields, but the effect of the ground water table on egg laying was less than on rolling. As a result, the period between rolling and nesting was shorter in wet fields. Very wet fields were rolled after the first eggs were laid. In 1988, in the fields with a ditch water table higher than the average in that year, 27% of all Lapwing clutches (n=52) was threatened by rolling activities, in 1989, 5% (n=83), in 1990 0% (n=24) and in all years combined 11% (n=159), whereas in the drier fields, this was 0% for all the years. The differences were significant for 1988 only and for the three years combined (Fisher's exact-probability test and χ^2 test, $P<0.05$).

The effect of rolling and harrowing earlier in the season.

The percentage of clutches threatened by rolling and harrowing activities, showed that, in meadows, the percentage of Lapwing clutches present in two of four years was significantly lower if these activities would take place one week earlier (χ^2 test, $P<0.05$). Maximum losses under these conditions would have been reduced by 59%. This means that on the average there were 7% (range 0-18%) fewer losses. Total nest losses would have decreased from 13% to 8% on the average.

The effect of leaving rolling-free and harrowing-free strips along grips and ditches.

Of 237 Lapwing nests found (1988 and 1989), 45% was situated within two metres from the nearest grip or ditch. Only 31 clutches (13%), however, were present during rolling activities. Of these 31 clutches, even a larger fraction (71%) was found within a strip of two metres along the nearest grip or ditch. There was no relationship between first egg dates and distances from the nearest grip or ditch (χ^2 test, $P>0.05$). Not rolling/harrowing these strips then would have saved 71% of the clutches present or 9% of all Lapwing clutches present during the breeding season.

Rolling and harrowing are usually done when the vegetation is still very short (i.e., less than five cm). Nearly one-half of all Lapwing nests in vegetation less than five cm high (21 of 43; 49%) were found within two metres from the nearest grip. In vegetation taller than five cm, slightly more than a quarter of the nests was found in this zone (13 of 47; 28%; $\chi^2 = 3.43$, $0.1<P<0.05$).

DISCUSSION

Factors affecting the extent and time of rolling and harrowing.

The proportion of the cluchtes of meadow birds which will be damaged by rolling and harrowing is largely determined by: (1) the the part of the area rolled; (2) the time of rolling.

Although there is some variation, only a small fraction of all fields is usually rolled or harrowed (in meadows, on the average, 21% was rolled and 7% was harrowed). Vermeer (1981) found a higher percentage (42%) in the peat area of Midden Delfland. In the peat/clay area of Bleiswijk/Pijnacker, a slightly lower percentage of 19% was found (G. de Hoog & C. Noorman, unpublished data).

Heavy autumn rainfall (in September-October) leads to less rolling in the following year. This is in contrast with what one might expect, as heavy rainfall in the autumn will cause more damage to the soil by cattle. Presumably, the cattle are turned out of the pasture early in the autumn when there is much precipitation, so that trampling is avoided.

The fraction of fields rolled and the time of rolling are largely determined by water tables. This may be explained by the vulnerability of the wetter soils to trampling and frost, which may increase the need for rolling. In addition, the high water tables lead to a diminished bearing capacity of the soil, which leads to a later time of rolling and harrowing. In addition, heavy precipitation in March, to which wet soils are the most vulnerable, also leads to later rolling times.

Vloedgraven *et al.* (1986) found that 96% (in 1982) and 90% (in 1984) of the fields were rolled. However, exact data on ground water levels in that study area (Waterland, North of Amsterdam), which is considered to be much wetter than other peat areas, are not available. Therefore, it cannot be determined whether the differences between the areas can indeed be explained in this way.

Loss of clutches present.

How many of the clutches present are actually lost as a result of rolling or harrowing depends on the procedure. Observations have shown that farmers may not roll a part of the field surface, so that clutches at field edges may escape destruction. Other farmers, however, roll only along grips and ditches. Clutches which were threatened by rolling activities were without exception partly or completely destroyed. The farmer, however, may find some of the clutches present during rolling and save them. In addition, lost Lapwing clutches are usually followed by replacement clutches. The number of clutches present during rolling and harrowing is therefore a maximum estimation of losses due to these activities.

The significance of conservation.

The effects of rolling and harrowing are usually considered to be detrimental to grassland breeding birds. The results found in this study show that the negative effects of these activities are usually not relevant to most of the grassland breeding bird species, except in some years for Lapwings. Although, for this species also, total losses of nests are limited to only 13% on the average. Van der Werf (1974) reported losses of 0-6% of all clutches of all species present during the breeding season as a result of spring grassland activities. Vermeer (1981) found that 11% of Lapwing clutches was present during rolling and harrowing activities (and 4% of Black-tailed Godwit). Brandsma (1988) reported losses of about 10% due to rolling and harrowing activities. These figures are all within the range found in this study and also suggest limited losses.

Lowering of water tables and subsequent grassland management intensification are usually considered to have a negative effect on wetland waders (Williams & Bowers, 1987). This study shows, however, that as far as rolling and harrowing activities are concerned, the nesting success of waders, in particular Lapwings, is less affected in the drier fields. This means that high water tables as such are not a guarantee for a greater breeding success.

As nest losses due to rolling and harrowing are small, measures for reducing losses of clutches will have only small effects. However, they may still be of significance for the Lapwing, especially in those years when the rolling and harrowing activities are carried out on a large scale and at a late time. Three measures are possible to reduce negative effects on nests of the Lapwing.

1). rolling and harrowing should be done as early as possible, preferably before the 22nd of March. However, farmers roll and harrow as soon as the land can bear the weight of the machines, so there seems to be not many possibilities in this direction; Rolling and harrowing one week earlier in the season than current dates could reduce losses to on the average 8%. To what extent this is feasible, however, is not clear;

2). taking into account the location of nests, i.e., not rolling or harrowing a strip of 2 m width along grips and ditches could save a considerable number of the clutches present (71%). This would mean that only 9% of the total number of clutches present during the entire breeding season would be damaged;

3). wet fields are rolled more often than the drier ones. To avoid the necessity of rolling in these fields, the access of cattle to them could be restricted, particularly in the autumn and winter when the soil is wet.

Recent developments in the Lapwing population indicate an increase since the seventies (Van Dijk *et al*, 1989), although there was a decline in the period of 1984-1990 (Verstrael *et al.*, 1990). This is possibly the result of an increasing number of Lapwings nesting on arable land, whereas numbers in traditionally good grassland habitats are declining (SOVON, 1987; Verstrael *et al.*, 1990). Measures designed to save this species in the grasslands therefore may certainly contribute to maintaining the population level.

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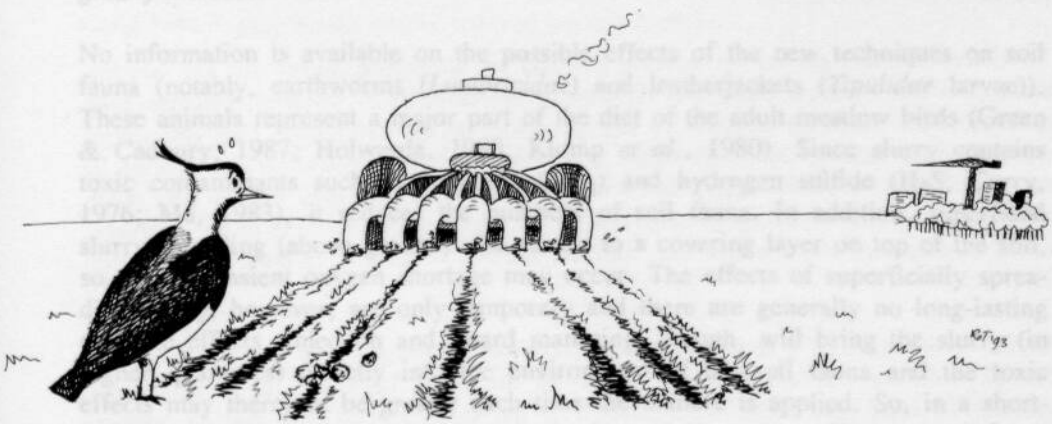
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Chapter 4

Cattle slurry spreading by injection techniques in relation to soil fauna and the nesting success of meadow birds in the Netherlands

Maurice Kruk, Karin A. Hofman and Marcel A.W. Noordervliet



SUMMARY

(1) Potential side-effects of manure legislation, which places a ban on spreading manure during the winter and the obligation to use slurry injection techniques, on the nesting success of meadow birds and on soil fauna were studied.

(2) Since there will be a ban on spreading slurry during the winter from 1994 onwards, manure will be spread in the spring. In addition, slurry has to be injected with heavy machinery in order to avoid ammonium emissions.

(3) The nesting success of all meadow bird species can be expected to be severely diminished, depending on the new time of manuring. No negative effect on soil fauna, the most important food source for meadow birds, could be demonstrated.

(4) Possible measures for reducing the negative effects on the meadow - bird populations are discussed.

(5) It is recommended to develop slurry spreading techniques which can be applied before the breeding season starts so as to save the clutches of the birds (if necessary, in combination with an extra ban on slurry spreading during the nesting season).

INTRODUCTION

Agricultural grasslands in the Netherlands are among the world's most intensively exploited. In addition to an extensive use of artificial fertilizers, manure is usually spread in the form of a slurry and in large quantities as a result of a large number of livestock units per hectare. Total average nitrogen input is about 400 kg N per hectare per annum (Van Strien, 1991).

The high N input leads to considerable emissions of nitrogen to water and the air. In order to diminish these negative effects on the environment, manure application laws have been enacted. From 1992 onwards, the spreading of slurry is forbidden on the Dutch dairy farms on sandy soils from October until February. Some other measures will also be gradually introduced. These will be designed to prevent leaching of nitrogen as much as possible. On peat-grassland soils, the ban on the spreading of manure during the winter and the additional measures will be effective from 1994 onwards. Farmyard manure will be excluded from the new regulations. The ban will be valid during the winter months, during which risks of N leaching and run-off are highest (Commissie Stikstof, 1991; Hendriks & Ter Keurs, 1992). To avoid high ammonium emissions during the months in which manure is allowed to be spread, new techniques are being introduced for the spreading of the slurry. The best developed techniques are "slurry injection" and "sward manuring". Slurry is pumped into the soil in ploughed furrows of about 10 cm depth and at about 15-25 cm distance from each other.

The introduction of these environmental measures may greatly benefit the environent. There is, however, an important potential drawback. The ban on spreading manure during the winter, along with the required heavy machinery, will result in a shift to a later time of slurry application in the season, when most of the meadow birds are nesting. As a consequence, the damage to meadow bird clutches may greatly increase.

No information is available on the possible effects of the new techniques on soil fauna (notably, earthworms (*Lumbricidae*) and leatherjackets (*Tipulidae* larvae)). These animals represent a major part of the diet of the adult meadow birds (Green & Cadbury, 1987; Holwerda, 1980; Klomp *et al.*, 1980). Since slurry contains toxic contaminants such as ammonia (NH_3) and hydrogen sulfide (H_2S; Curry, 1976; Ma, 1983), it reduces the numbers of soil fauna. In addition, superficial slurry spreading (above ground) also results in a covering layer on top of the soil, so that a transient oxygen shortage may occur. The effects of superficially spreading slurry, however, are only temporary and there are generally no long-lasting negative effects. Injection and sward manuring, though, will bring the slurry (in higher quantities) directly into the environment of the soil fauna and the toxic effects may therefore be greater each time the manure is applied. So, in a short-term period (i.e., one or several weeks in the spring), severe effects on soil fauna

can be expected. However, the number of times that manuring takes place will probably decrease (Vloedgraven, 1990). Long-term effects, i.e, a reduction in the numbers or biomass of soil fauna over the years may persist. A decrease in soil fauna may have a severe negative effect on the ability of female birds to establish (replacement) clutches.

The questions studied here are: 1). what will be the effect of the inroduction of the injection techniques on the nesting success of meadow birds and on the soil fauna in comparison with the current methods of slurry spreading; 2). What measures can be taken to reduce any possible negative effects. As the measures have not yet been introduced and new techniques have been used only on a very small and experimental scale, it was not possible to make a comparison between areas with and without slurry injection techniques. For this reason, an empirical study design for the greater part was not possible and estimations had to be made on the basis of existing data on slurry application and nesting times.

This Chapter therefore is focused on: (i) the current pattern of slurry spreading on grasslands and its effects on meadow birds' nests; (ii) an estimation of the effects of a ban on spreading slurry along with the new slurry spreading injection techniques on meadow bird clutches and soil fauna; and (iii) suggestions for modifications which may be favourable to the birds, but will not negate the positive effects on N emissions and will affect the farming enterprise as little as possible.

METHODS

Current slurry spreading method.

The study was limited to meadows, i.e., fields to be mown in the first cut, since most information was available on these types of fields. The effect on pastures will probably not differ much.

To determine the effects of current method of spreading slurry on the nesting success of the meadow birds, the fraction of the clutches of different meadow bird species which could be affected by slurry spreading was estimated. This estimation was based on data collected for other purposes on slurry application and nesting in the period of 1987-1989. Only fields in which the date of slurry supply was more or less exactly known (with an accuracy of 1-7 days) were involved in the analysis. For a description of the study area and the method of collecting data, see Chapter 2.

As the water table of a field may affect the time at which slurry spreading can be carried out, the effects of water tables on the dates of slurry application was studied. In 1988 and 1989, on a portion of the studied area (106 and 87 hectare

respectively), also ditch water levels (1988) and ground water levels (1989) were measured weekly. For the methods used, see Chapter 2.

The effects of the current pattern of spreading slurry on nesting success.

The method of collecting data on nests was as described in Chapter 2. The estimation of the minimum number of clutches which could be lost due to the current methods of slurry spreading was based on estimations of Beintema & Müskens (1981). According to these authors, about 15% of all clutches present will be destroyed by the tractor's wheels. That is a minimum estimation of losses, since clutches may also be covered by a crust of slurry and consequently not hatch. Clutches may in addition be preyed upon by gulls (*Laridae*) and crows (*Corvidae*) during or shortly after manuring (Brandsma, 1987). The number of clutches present were considered to represent maximum potential losses. As lost clutches may be followed by replacement nesting, the time period between the spread of slurry and mowing was also determined. This period must be long enough for replacement clutches to successfully hatch (at least six to seven weeks; Vloedgraven *et al.*, 1986).

Estimation of the effects of a ban on spreading manure during the winter and the use of injection techniques on clutches.

An estimation of effects of injection was made by assessing the number of clutches which would be present at the time of application. The effect of the delay in the time of slurry spreading, which is expected because of the necessity of a higher bearing capacity, however, is unknown. Therefore, estimations were made of damage to nests if slurry spreading by injection would occur at the same time or one to four weeks later than by current methods. Minimal losses of clutches present at the time of slurry spreading by injection were estimated to be 85%, as it was expected that about 15% of the field surface (i.e, strips of about 3 meters along field edges) would not be covered by this method.

The effects of injection on soil fauna.

In order to compare the effects of manure injection on soil fauna with current effects of superficial application, a study was carried out in 1991 on 30 fields in the peat area of the Bovenkerker polder in the province of Noord Holland, near Amstelveen and Nes aan de Amstel. In this area, farmers cooperated in a government experimental project which studied the effects of the new slurry techniques on the farming industry.

Fields were selected that had the same soil type (peat) and moisture (ditch water level), grassland use for the last 5 years and had not been sprayed against leatherjackets (*Tipulidae* larvae). Fifteen fields were injected at between 26 and 28 March

and fitfteen were subjected to the current method of slurry spreading at between 5 and 15 March. All fields were sampled weekly in 6 sampling rounds at between 28 February and 17 April for numbers and biomasses of earthworms (*Lumbricidae*) and leatherjackets (*Tipulidae* larvae). The method of sampling for soil fauna was as described in Chapter 2.

The numbers and biomasses were log transformed. The question was to what extent differences in numbers and/or biomasses could be explained by differences in the method of slurry application. An ANOVA (Sokal & Rohlf, 1981; Anonymus, 1988) was used to test these effects. However, date of sampling, sampling round and field effects may also affect the soil fauna. Therefore, an extended model was used for the analysis. The following was the model used:

$\log Y_{ptml} = \mu+\alpha_m+\beta_p+\alpha\beta_{pm}+D_{ml}+E_{pt}+\xi_{ptml}$, with Y being the number or biomass of soil fauna.

In this model, p represents the time period; t, the sampling round; m, the method of slurry application and l, the field; μ is the mean; α_m, the effect of the method of slurry application (current method or by injection); β_p, the effect of the three time periods (1]. before slurry application: sampling round 1, 2]. after superficial slurry application and before slurry injection: sampling rounds 2 and 3, 3]. after slurry application: sampling rounds 4, 5 and 6); $\alpha\beta_{pm}$, the interaction term of method of slurry application and periods; D_{ml}, field effects nested in the method of slurry application (2x15 different fields); this was to detect possible differences between fields for one method of slurry spreading. Differences between fields differing in the method of slurry application were excluded by the selection of fields; E_{pt} is the effect of the six sampling rounds nested in the three time periods, this was because a correction for seasonal effects is relevant per time period; and ξ_{ptml} is the residual. At the end, a serial correlation between residuals was investigated in order to determine whether fields which started with large numbers had any effect on the analysis of variance.

RESULTS

The current spreading of slurry.

Slurry was spread on 38-65% of the fields studied. For some of the fields (about 30-50%), however, it was not known whether slurry had been spread.

There was a considerable variation in the time of slurry spreading, both within one year and between years (Figure 1).

In fields with a high ditch or ground water level, the time of slurry application was later in the season (1988: r=-0.59, $P<0.01$; 1989: r=-0.42, $0.05<P<0.10$). The

difference in manuring dates between 1988 and both 1987 and 1989 can be explained by rainfall in winter and early spring, which was very heavy in 1988. This is in accord with the correlation found with the water levels.

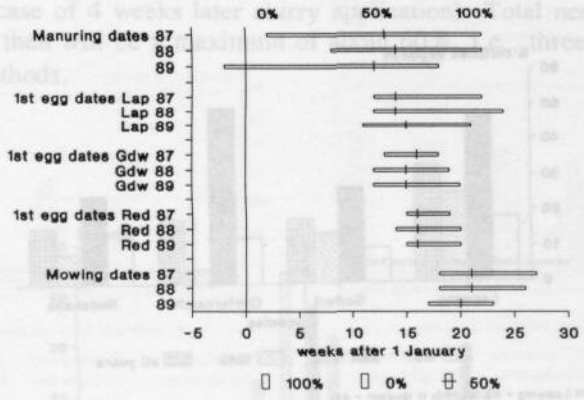


FIG.1. The week in which 1, 50 and 100% of the total area of meadows in Ade and Duivenvoorde (1987-1989) was manured (slurry), in which 1, 50 and 100% of Lapwings, Black-tailed Godwits and Redshanks had laid their first eggs and in which 1, 50 and 100% of the total area was mown.

The pattern of first egg laying dates of meadow birds.

The median first egg dates of meadow birds showed differences of a maximum of 5 days between years. The differences in dates of slurry spreading were much greater (several weeks). In 1987, most species started nesting somewhat later than in 1988 and 1989 (Figure 1). If more years are taken into account, the median first egg laying dates varied by up to 17-18 days between years and were correlated with spring temperatures (see Chapter 5).

Losses of clutches during the current slurry spreading methods.

The pattern of egg-laying dates and dates of slurry spreading together determined the number of clutches exposed to the manuring (Figure 2). Except for Redshanks, the percentage of exposed clutches in 1988 was significantly higher than in the other years (χ^2 test, $P<0.05$). In that year, birds nested early and slurry spreading was late due to heavy rainfall. The Lapwing had the significantly highest proportion of exposed nests, on the average 33%, whereas this was 16-18% for the other

species (χ^2 test, $P<0.05$). Minimal losses due to superficial slurry spreading, i.e., 15% of clutches present during the time of spreading slurry, meant that about 0-10% of all clutches present during the nesting season could be destroyed. The maximum possible losses, i.e., all clutches present on the day of slurry spreading, however, could be considerable (up to 50%).

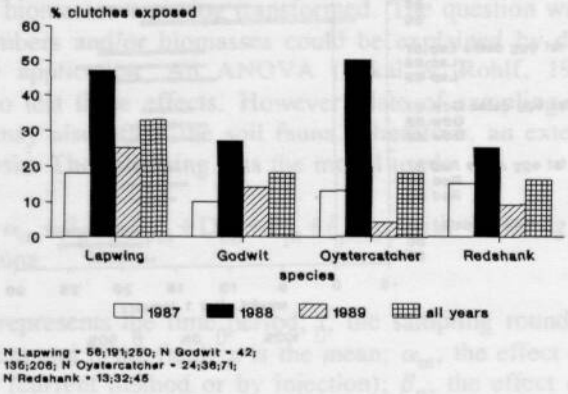


FIG.2.The maximum percentage of clutches present in the study area at the time of superficial spreading of slurry in 1987-1989.

A complication is that clutches lost due to the spreading of slurry can be compensated for by a successful replacement clutch. Whether the birds successfully breed again depends on the time left until mowing. The length of the latter period ("resting period"; see Van Paassen, 1985) varied between one and twelve weeks, while at least six to seven weeks are required for breeding success (Vloedraven *et al.*, 1986). In 1987-1990, on, respectively, 77, 33 and 54% of the fields (Figure 3), the time period between the spreading of slurry and mowing was six weeks or more. This means that about half of all replacement clutches could hatch before mowing. Therefore, total nest losses would be about 5-20%, i.e., a maximum of 10-40% losses of which 50% could be compensated for by means of replacement clutches.

Losses of clutches as a result of injection techniques.

The percentages of clutches present at the time of slurry application by the new injection techniques for all species would increase if these techniques should be used at the same time as the current date of superficial slurry spreading or 1-4 weeks later. Estimated losses due to new manuring techniques would therefore increase substantially as compared with current manuring. Minimum losses when

slurry was injected would vary between 0% and 67%, depending on the species considered, the year and the date of slurry application in comparison with the current time of superficial slurry application (Figure 4). The chance of successful replacement clutches would be smaller if the slurry was spread later in the year. Instead of about 50% successful replacement clutches, this may become at worst about 10% (in case of 4 weeks later slurry application). Total nest losses with the new techniques then will be a maximum of about 60%, i.e., three times as high as with current methods.

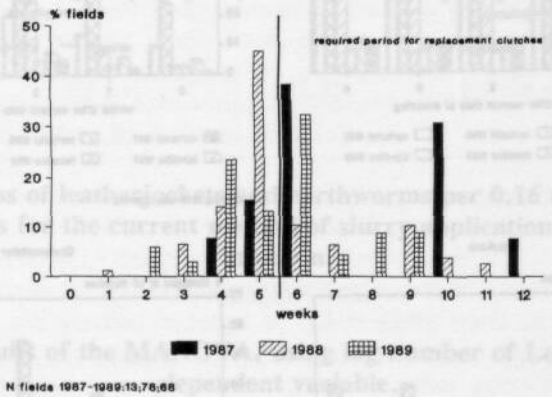


FIG 3.The percentage of fields with a certain time period (in weeks) between manuring and mowing in the peat areas of Ade and Duivenvoorde in 1987-1989.

Effects of injection techniques on soil fauna.

Numbers and biomass of soil fauna appeared to be highly and significantly correlated with each other ($r=0.75$, $P<0.001$ and $r=0.87$, $P<0.001$). The numbers and biomasses of leatherjackets and earthworms varied greatly at the different sampling rounds (Figure 5). After the first one, superficial slurry spreading took place and the injection after the third round. Differences in number and biomass were due mainly to both field and season effects; no effects of the method of slurry aplication were demonstrated (Tables 2a and 2b).

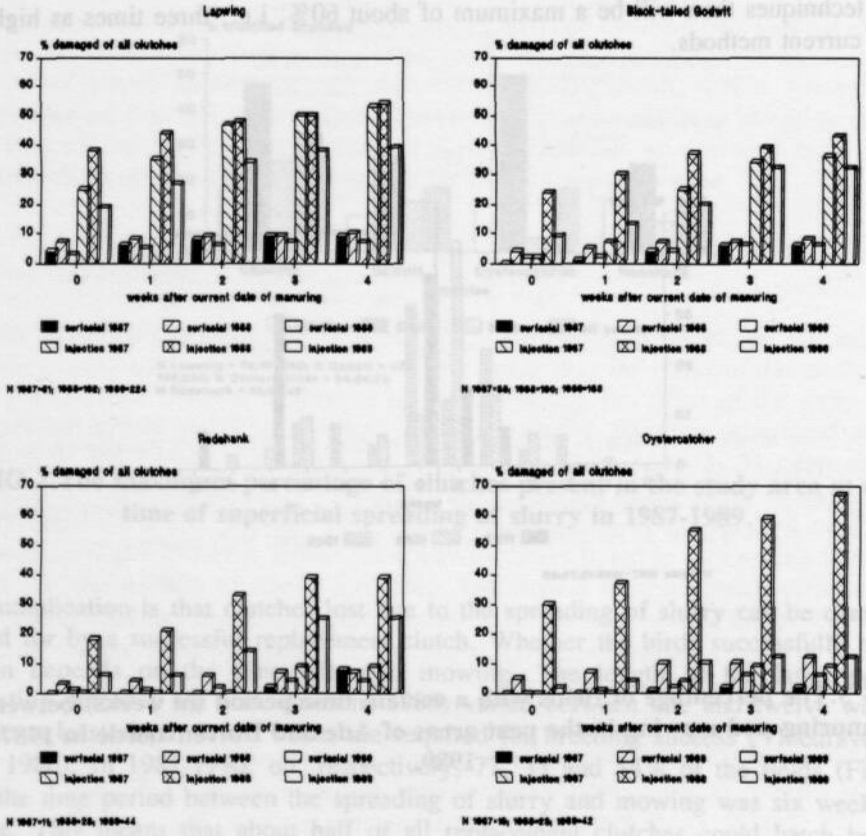


FIG.4. Minimum percentage of losses of all meadow bird clutches per species in the nesting period within the present method of superficial slurry application and in the case of a 0-4 weeks delay in the spreading of slurry by means of injection techniques.

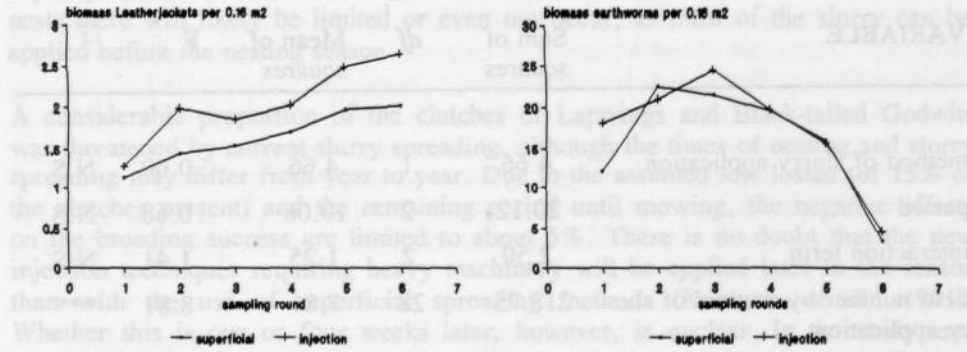


FIG.5. Biomass of leatherjackets and earthworms per 0.16 m^2 at different sampling rounds for the current method of slurry application and with slurry injection.

TABLE 2a. Results of the MANOVA, using log number of Leatherjackets as a dependent variable.

VARIABLE	Sum of squares	*df*	Mean of squares	F	
method of slurry application	1.37	1	1.37	0.94	N.S.
period	2.04	2	1.02	1.80	N.S.
interaction term	0.23	2	0.12	0.65	N.S.
field number by method of slurry application	40.55	28	1.45	8.02	***
sampling round by period	1.70	3	0.57	3.14	*
residuals	25.84	143	0.18		

*: $P<0.05$; **: $P<0.01$; ***: $P<0.001$)

TABLE 2b. Results of the MANOVA, using log number of earthworms as a dependent variable .

VARIABLE	Sum of squares	*df*	Mean of squares	F	
method of slurry application	4.66	1	4.66	0.60	N.S.
period	20.12	2	10.06	0.68	N.S.
interaction term	2.50	2	1.25	1.41	N.S.
field number by method of slurry application	218.75	28	7.81	8.81	***
sampling round by period	44.59	3	14.86	16.76	***
residuals	126.83	143	0.89		

*: $P<0.05$; **: $P<0.01$; ***: $P<0.001$)

DISCUSSION

The effect of new manure legislation on the meadow bird populations.

If the new manure legislation should become effective, a shift in the date of slurry application as well as the use of heavy machinery can be expected and consequently significantly greater losses of meadow bird clutches. The increase will depend on the species considered, the year and the time of slurry application in comparison with the current time of superficial slurry application. On a short-term basis, there will be no negative effects on food supply for the birds.

The effects on the clutches were estimated on the basis of times of nesting and (assumed) times of slurry spreading on meadows in two peat areas as well as assumptions about the losses due to injection techniques. The effects of injection on clutches in pastures will probably be the same, as there are usually no significant differences in times of slurry application between meadows and pastures. Other areas, however, may be different from the study areas as concerns soil moisture, slurry storage capacity , times of nesting of birds, etc. When comparing the agricultural factors of the study area with some other peat areas in the western part of the Dutch peat district, no great differences are found (Bischoff *et al.*, 1987). Times of slurry application and nesting may well differ due to differences in moisture, e.g., as compared with the peat area of Waterland north of Amsterdam (Vloedraven *et al.*, 1986). Water levels affect both times of slurry application and

nesting times (Chapter 5), so that effects of earlier or later times of slurry application on nests will probably be the same. In sandy soils, however, the bearing capacity of the soils is much higher as compared with the peat areas. Losses of nests there will likely be limited or even not occur, as most of the slurry can be applied before the nesting season.

A considerable proportion of the clutches of Lapwings and Black-tailed Godwits was threatened by current slurry spreading, although the times of nesting and slurry spreading may differ from year to year. Due to the assumed low losses (of 15% of the clutches present) and the remaining period until mowing, the negative effects on the breeding success are limited to about 5%. There is no doubt that the new injection techniques requiring heavy machinery will be applied later in the season than with the use of superficial spreading methods (Korevaar *et al.*, 1991). Whether this is one or four weeks later, however, is unclear. In the study area Bovenkerker polder, slurry spreading by injection was 11-23 (average 17) days later than superficial slurry spreading. Estimations of losses 2-3 weeks after the current time will therefore be the most reliable.

The losses of clutches present during the slurry spreading by injection techniques were estimated at 85%. Others, however, state that these losses may even be higher, up to 90-100% (Vloedgraven, 1990; Korevaar *et al.* ,1991). Data on the distance of nests from furrow drains and ditches, however, show that about 45% of Lapwing clutches are situated in strips of 1-2 m along these fields edges (Chapter 3). Therefore, it can be concluded that damage to nests of this species will be less than 85% if field edges are spared, whereas, for other species, this may be 90-100% as they avoid the field edges. However, this will not lead to great differences in the general pattern of losses due to injection.

No negative effects of injection techniques on the soil fauna were found. Other models were tested in order to determine to what extent the model influenced the results. For example, in an alternative model, the sampling rounds were not nested in the time periods, but tested as such. These other models gave about the same results as those presented in this thesis. An important shortcoming of the study may be that it was limited to one year and one area only. Long-term effects of the injection techniques on the soil fauna may occur. In combination with the reduction in the breeding success, this may increase the negative effect on the bird populations. A severe reduction in earthworms will also have negative effects on grassland production, whereas a reduction in leatherjackets for this purpose may be positive (Van Rijn, 1987). There may also be differences in soil fauna between areas. But, it is not to be expected that the effects of the injection will be different in different areas with the same soil type.

In contrast to the detrimental effects mentioned above, slurry may be spread less often, i.e., on a smaller area, as more slurry can be applied per field at one time.

The maximum for the injection techniques is about 40 tonnes per hectare, whereas it is about 10-15 tonnes at present. Consequently, a smaller area in which the birds are nesting will be subjected to slurry spreading. In addition, it can be expected that the new techniques will be applied mainly on fields with a good bearing capacity. These are usually the fields near the farms, which harbour smaller number of birds. Futhermore, the question is whether the time of the slurry spreading will be detrimental to the birds in all cases. A certain spread in the operations may arise, because the new techniques will mainly be performed by contract workers, who cannot be present everywhere at the same time (see also Korevaar *et al.*, 1991). Therefore, a number of the fields may be manured even after the nesting season. Consequently, the eventual "damage" of the proposed injection techniques may be less than estimated.

Possible ways of reducing negative effects on the meadow bird populations: solutions and bottlenecks.

Measures designed to save the meadow-birds' populations should in the first place be directed to the reduction or prevention of damage to nests. Other harmful grassland operations such as rolling and harrowing also take place during the nesting season of meadow birds. However, the negative effects of the new slurry injection techniques on the nesting success are much greater (cf Chapter 3). Therefore means should be found which at least substantially reduce these negative effects. This should not lead to in increase of nitrogen emissions and should not burden the farmers too much.

Solutions might be found in four ways:

(1) the exclusion of specific areas from the obligation to use the new slurry spreading techniques, in particular those areas rich in meadow birds;
(2) the introduction of an extra ban on spreading manure during a part of the nesting season of the meadow birds;
(3) the introduction (or at least strong recommendation) of nest protecting measures;
(4) the development of other emission-poor slurry spreading techniques in combination with greater slurry storage capacities.

Combinations of these measures are also possible.

The exemption of specific areas from the obligation to use the new techniques.

Mitigation of the detrimental effects would be possible by exempting special areas from the use of the new slurry spreading techniques, in particular those areas rich in meadow birds which are not Environmentally Sensitive Areas (ESAs). Areas

which have already been designated as ESAs, are already excluded, as there is a ban on spreading manure in these areas during the breeding season.

In principle, such exemption of specific areas is possible. The legislation concerning the spread of manure is differentiated on the basis of soil types. This differentiation could also be used for pointing out areas rich or poor in meadow birds. However, such a division into richer and poorer areas will be not the same for each meadow bird species. Even with respect to the six wader species, available data show that the areas considered as nationally less important, harbour a substantial number of the internationally important Lapwing and Black-tailed Godwit populations (Van Dijk *et al.*, 1989; Vloedgraven, 1990).

Another disadvantage of the exemption of specific areas is that it will lead to a geographical and socio-cultural split between agriculture and nature. In one area, there will be extra restrictions on spreading slurry for the sake of wildlife; in others, there will be restrictions only for the sake of the environment, without anymore attention to nature values. Moreover, in addition to those mentioned above, another severe disadvantage is that, if the areas are large, nitrogen emissions will remain at an unacceptably high level; if the areas are small, the positive effects on the meadow bird populations will be limited. Therefore, it seems to be not desirable to exempt specific areas from using the new techniques in order to prevent damage to the meadow bird populations.

The introduction of an extra ban on spreading slurry.

The introduction of an extra ban on spreading slurry to prevent damage to clutches raises to two questions: (1) during which period should this extra ban be valid and should this period be the same for the entire country; and (2) should it be introduced for the entire country or may some areas be excluded?

The most rigorous, though perhaps not a very realistic solution, would be a national ban on the spreading of manure from October until 15 June, the date on which on the average most of the clutches of the meadowbird species will have hatched. From both an environmental and an agricultural point of view, however, this is a poor solution. If only the most abundant and early breeding species are taken into account, the ban could be lifted on until 15 may, the date on which about 50% of clutches of Lapwings and Black-tailed Godwits have hatched (Reyrink, 1988). However, this has disadvantages from an environmental point of view, as manure will be spread too late in the spring and whith less utilization of minerals than in the early spring period. Moreover, there are great disadvantages for the farmers, as they have to build larger storage tanks to store the slurry for many months. It would make relatively little difference in the disadvantages for the environment and the farmers if the banning period would end at the first cut instead of 15 may. The

conditions for the birds will perhaps even deteriorate, as the farmers may be stimulated to cut the grass earlier in the season.

The disadvantages of a very long banning period for the environment and the farmers may be diminshed or even prevented by the introduction of a shorter extra ban on the spreading of manure only during "the nesting season". This would allow the spreading of manure in early spring (February, March), as long as the bearing capacity of the soil is sufficient, so that there is utilization of minerals and the investments in slurry storage will be reduced. For the sandy soils, it has been calculated that, with the new techniques, 47-83% of the slurry could be applied before 1 April (Korevaar *et al.*, 1991). For the peat areas, this percentage probably would be much lower. At present, however, only 23% of the dairy farms has a storage capacity of 6 or more months, which conceivably would be necessary whith an extra ban on the spreading of manure (ITS, 1989). The question now is in which period should this extra ban be valid, as there is much variation in the starting and ending of the nesting season.

In general, the start of nesting (i.e., the date on which the first eggs are laid) for the earliest nesting species (i.e., the Lapwing) in the peat area of Ade falls at around 15 March, except for some extremely early clutches, so that this could be the start of the extra ban on the spreading of manure (figure 6). Others, however, base the start on data from other peat areas and therefore have advocated for a start of the extra banning period on the first of April (Korevaar *et al.*, 1991). In the study area from 1984-1991, at the fifth week starting from 1 March, the percentage of clutches present, was between 50 and 72%, which is obviously too high a percentage to start the banning period from. Therefore, it may be necessary to distinguish several regions.

The end of the nesting season is less clear. Clutches of late nesting birds can be found until the end of July or even the beginning of August. On land to be mown, however, nesting of many species ends in practice with the first cut, since clutches incubated after this period usually do not hatch before the next cut. The first cut usually takes place from 1 May onwards, so the extra ban could extend until this date. However, this may stimulate early mowing, as the manure can be applied after the mowing.

In pastures, the situation is more complicated. In the areas mentioned, grazing of cattle usually takes place from the third week of April; for young cattle, it occurs even earlier.

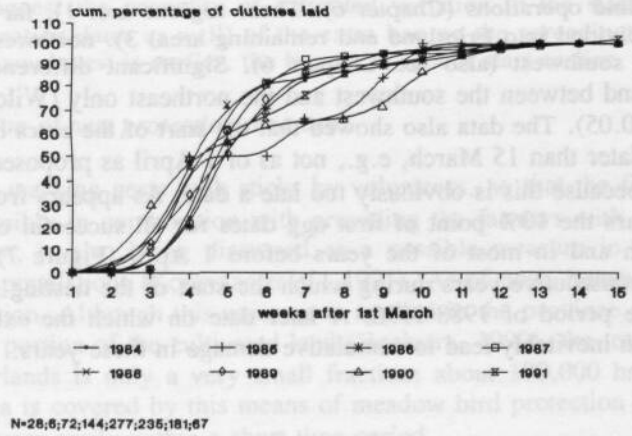


FIG.6. Cumulative percentage of Lapwing clutches laid in the peat area of Ade/Duivenvoorde in the years 1984-1991.

The losses of clutches due to grazing, in contrast to mowing, may be less. Losses due to trampling are dependent on the number of cattle and the time period of grazing (Beintema *et al.*, 1982) and are not always 100%, whereas losses of clutches due to mowing always reach this percentage (Beintema & Müskens, 1981). However, at the current cattle densities, the losses will probably also reach the 100% (Beintema & Müskens, 1981). If manuring takes place after grazing, clutches may still be destroyed due to the new techniques. Therefore, the date of 1 May as the end of the extra banning period seems plausible as concerns meadows, though not necessarily for pastures.

The question now is whether the starting and termination dates should be the same for the grassland all over the country, as there may be a variation in the starting and ending of the nesting season and/or grassland operations in different parts of the country. Another question is whether the extra ban on the spreading of manure should also apply to the whole country, even where meadow bird densities are low. As mentioned earlier, the exemption of specific areas has several disadvantages and is therefore undesirable.

In an attempt to answer the question of whether there should be any differentiation between regions in the period of the extra ban, national data on ringing dates of the Lapwing (1971-1988) were analyzed. The data were obtained from another study described in this thesis (Chapter 6). For this purpose, country was divided into several regions, which differ significantly in spring temperatures and so also in the

dates of grassland operations (Chapter 6). These regions are: 1). far northeast; 2). northeast (subdivided into Friesland and remaining area) 3). northwest; 4). middle; 5). south and southwest (also see Chapter 6). Significant differences in nesting dates were found between the southwest and the northeast only (Wilcoxon matched pairs test, $P < 0.05$). The data also showed that the start of the extra banning period should not be later than 15 March, e.g., not as of 1 April as proposed by Korevaar *et al.* (1991), because this is obviously too late a date. As appears from the ringing data, in all years the 10% point of first egg dates for all succesful clutches comes after 15 March and in most of the years before 1 April (Figure 7). In addition, there may be consecutive years during which the start of the nesting season is very early, e.g., the period of 1988-1990. A later date on which the extra ban would start would then inevitably lead to cumulative damage in these years.

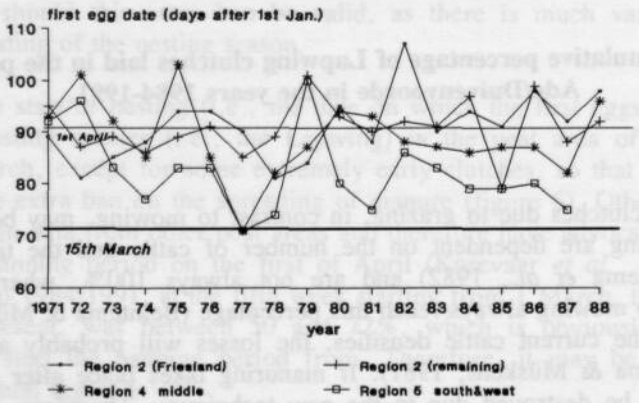


FIG.7.The date on which the first egg of 10% of all successful clutches of Lapwings was laid in four regions in the Netherlands during the years 1971-1988. Based on ringing data.

The end of the period may be the date on which most of the mowing takes place. An analysis of national first cut mowing dates in 1988 (Laboratorium voor Grond- en gewasonderzoek, undated) shows a synchronization of mowing dates throughout the country in that year. The start of the mowing activities was around the first of May, with a peak in the period from 10 until 15 May. No data were available for a wide range of years.

These data suggest the necessity of a limited variation in the starting dates (and perhaps termination dates as well) of the extra ban on the spreading of manure. As nesting in the southwest is earlier, the ban there should start earlier.

The introduction of nest protection measures.

Protection by marking nests with sticks by volunteers, so that the farmer can save the nests, possibly in combination with providing the farmers with information on nest protection, is also being discussed as a possible measure in order save the meadow bird populations (Korevaar *et al.*, 1991). As of now, however, it is not an effective solution. Although this measure is applied in the province of Friesland on a fairly large portion of the cultivated land (Hoekstra, 1990), the total area covered in the Netherlands is only a very small fraction: about 100,000 ha or 5% of the cultivated area is covered by this means of meadow bird protection and this cannot be increased very easily within a short time period.

The development of other techniques in combination with larger storage tanks.

A final possibility for avoiding any damage to the meadow bird populations may be found in the development of other slurry spreading techniques in combination with larger storage tanks. With a large storage capacity, dairy farmers may become more flexible in the timing of manure application. For that reason, the need to spread manure at a disadvantageous time for the birds will decrease. To increase the efficient use of minerals, new techniques should also be developed and tested for which a high bearing capacity of the soil is not necessary, so that they may be applied early in the spring. The development of these sorts of new techniques could be stimulated by subsidizing investments such as for wider tires, field path solidification and lighter machinery. Such measures would be favourable to the birds as well, as slurry then for a greater part can be spread before the breeding season. Furthermore, nitrogen emissions will still be limited. There would also be no severe disadvantages for the farmers. Such a new techniques are, e.g., the spreading of undiluted manure with the simultaneous use of sprinklers or the spreading of already diluted manure.

Of all possible measures for avoiding negative effects on the meadow bird populations, this solution therefore seems to be the best one, taking into account the interests of the environment and the farmers as well.

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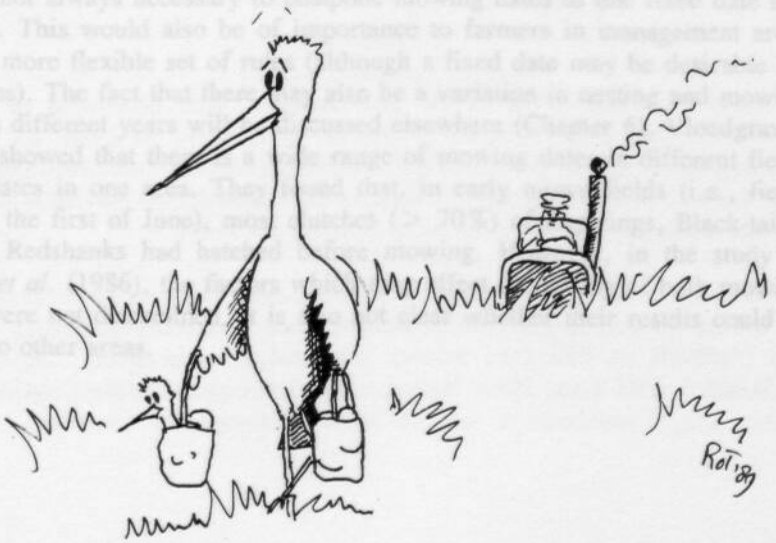
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Chapter 5

The relationship between mowing dates and egg-laying dates of meadow birds in intensively exploited grassland areas in the Netherlands: (1) in different fields

Maurice Kruk, Joslyn C.E.W. Hooijmeijer, Carola Alsemgeest-Van den Broek and Margot A. Heineman



SUMMARY

(1) The relationship between the mowing date and the nesting date of the Lapwing (*Vanellus vanellus*), the Black-tailed Godwit (*Limosa limosa*) and the Redshank (*Tringa totanus*) were studied.

(2) Mowing dates and nesting dates of a field were positively correlated for both the Lapwing and the Black-tailed Godwit.

(3) Both mowing and nesting dates were correlated with the same factor, namely, the date of fertilizer supply, which itself depended on the ground water table. Later dates of fertilizer supply were also correlated with a lower biomass of soil fauna, which represents the major part of the diet of meadow birds. No effect of the date of slurry supply was found.

(4) Because nesting dates were synchronized with mowing dates, the negative effect of early mowing on the nesting success was limited.

(5) The nesting success (number of clutches hatched) of the wader species may be enhanced up to a level which will lead to a stabilazition of the current population levels by postponing the mowing date of all the fields (in the study area, until about 1 June). For a large portion of the fields, however, this would be an unnecessary too late date. In these fields most nests already would have hatched long before this date.

(6) Postponement mowing dates in all fields until 1 June would mean that, in 98-100%, of all fields a sufficient percentage of the clutches would have hatched before mowing for maintaining current population levels. The same result (i.e., in 95-100% of all fields, the required percentage of clutches hatched before mowing) would be obtained if current mowing dates per field were postponed for 1-2 weeks.

INTRODUCTION

Based on the assumption that dates of egg laying and hatching are more or less fixed (Reyrink, 1988), the effect of early mowing in intensively exploited fields is considered to be detrimental to the breeding success of most of the meadow birds. Many farmers in the intensively exploited grassland areas are willing to take measures to protect the birds as long as these measures do not interfere too much with the farming industry. Possible measures for diminishing this negative effect on the breeding success of the birds should therefore be adapted to practical farm management and be as flexible as possible.

The Dutch government policy aimed at the protection of the birds, as described in the "Policy Document on Agriculture and Nature Conservation" (Relatienota), includes the designation of special areas (similar to the Environmentally Sensitive Areas in Great Britain; Mathers & Woods, 1989). Certain areas are set aside as nature reserves and farmers are encouraged to conclude management agreements with the government for the protection of wildlife (De Boer & Reyrink, 1988; Ministry of Agriculture & Fisheries, 1987). In the agreements, there is a ban on grazing, mowing, rolling and harrowing during a fixed period of the year. This period usually starts at between 1 to 6 April and ends at between 1 to 30 June. Many farmers in the Dutch management areas regard the current restrictions embodied in the management agreements as too rigid. As a possible result, fewer farmers may be willing to conclude management agreements. This would be disadvantageous from the point of view of nature conservation (Van Strien *et al.*, 1988). So, also here, a more flexible set of measures aimed at the protection of the meadow birds is desired.

In the opinion of the farmers, the dates of mowing and the start of the breeding season of meadow birds may vary from field to field. In fields which are mown early, the birds also start nesting earlier than in the later mown fields. Consequently, it is not always necessary to postpone mowing dates to one fixed date late in the season. This would also be of importance to farmers in management areas who desire a more flexible set of rules (although a fixed date may be desirable for control reasons). The fact that there may also be a variation in nesting and mowing dates between different years will be discussed elsewhere (Chapter 6). Vloedgraven *et al.* (1986) showed that there is a wide range of mowing dates in different fields and nesting dates in one area. They found that, in early mown fields (i.e., fields mown before the first of June), most clutches (> 70%) of Lapwings, Black-tailed Godwits and Redshanks had hatched before mowing. However, in the study of Vloedgraven *et al.* (1986), the factors which may affect the timing of both mowing and nesting were not determined. It is also not clear whether their results could be extrapolated to other areas.

Relevant questions are (i) what effect has the timing of mowing of a particular field on the nesting success of the meadow birds; (ii) is the timing of nesting correlated with the date of mowing; and (iii) what measures could be taken to enhance the nesting success without imposing too severe ones.

Several factors, such as the date of fertilization and the amount of fertilizer supplied, affect the mowing date of a particular field. It is unclear, however, which of these factors are of the greatest importance. It is not known whether these factors determine egg-laying dates as well, through the availability of food in the fields. For meadow nesting waders, earthworms (*Lumbricidae*) and leatherjackets (*Tipulidae* larvae) represent a major part of the diet, particularly during the early part of the breeding season in March/April (Green & Cadbury, 1987; Holwerda, 1980; Klomp *et al.*, 1980). Several studies have shown that differences in supply of food influence the dates of nesting (Galbraith [1988] and Högsted [1974] for the Lapwing and Thompson *et al.*, [1986] for the Greenshank *Tringa nebularia*). Beintema *et al.* (1985) have suggested that, since the beginning of this century, the laying dates of meadow birds, in particular the Lapwing and the Black-tailed Godwit, have changed as a result of intensified land management, probably associated with an increased supply of food, especially *Lumbricidae* (Green & Cadbury, 1987).

The study presented in this chapter is centred on the dates of mowing and nesting in different fields in one year and the factors controlling these dates.

STUDY DESIGN AND METHODS

The relationship between mowing and nesting dates in different fields was studied in two peat areas during three years. The assumed relationship between environmental factors and the dates of mowing and nesting is presented in Figure 1.

Study area.

The study was performed in the peat areas of Ade (northeast of Leiden, the Netherlands) and Duivenvoorde (southwest of Leiden). In 1988, 73 fields (about 106 hectares) were involved. In 1989, 60 fields (about 87 hectares) and in 1990, 31 fields (about 40 hectares) were included. The selection of the fields was based on expected differences in mowing dates between the fields.

To establish the relationship between mowing dates and nesting success in the same area during the period 1984-1990, data were also collected on nesting and mowing dates (methods as described below), comprising, respectively, 28.0, 4.8, 40.3, 141.3, 305.3, 292.9 and 218.9 hectares. All fields were cut for silage.

Data on nests.

Data on nests were obtained as described in Chapter 2.

Per field and per species, the median of all first egg dates of a species in a field was calculated. This was considered to give the most reliable estimate of the dates of egg laying in a field.

Soil fauna.

In the last two weeks of March 1990, data were collected on *Lumbricidae* and *Tipulidae* larvae. These data were collected as described in Chapter 2.

Water tables.

For the method on collecting data on water tables, see Chapter 2.

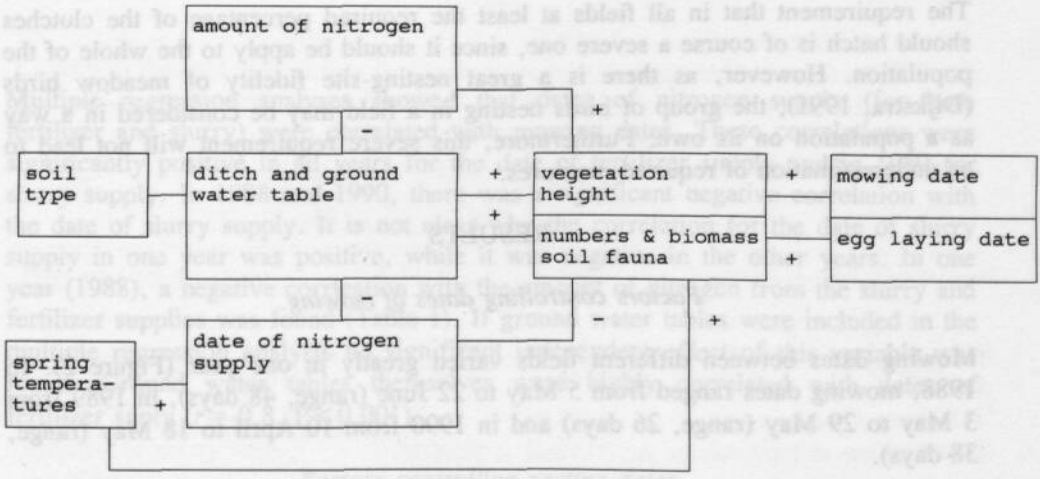


FIG.1.Hypothetical relationships between environmental variables and mowing dates and first egg laying dates of meadow birds in grasslands.

Grassland operations and vegetation height.

Data on grassland operations and vegetation height in all years were collected as described in Chapter 2. They were collected on date of fertilizer supply, date of

slurry supply (farmyard manure was not applied on any of the investigated fields), mowing date and amounts of fertilizer and slurry supplied. The quantities of slurry and fertilizer were converted into the amount of directly available nitrogen per hectare for the first cut (Pelser, 1984).

Effects of mowing dates on nesting success.

To assess the effect of mowing dates on the nesting success, the number of fields in which at least a required percentage of the clutches hatched before mowing was determined. According to Beintema & Müskens (1981), at least enough clutches so that mortality is outweighed and thus to maintain the population at the same level should hatch. This percentage is for the Lapwing, the Black-tailed Godwit and the Redshank respectively 87%, 63% and 40% (based on data on survival of chicks and adults as given by Beintema & Müskens, 1981; Beintema & Drost, 1986 and Beintema, 1991). Potential hatching dates were used, i.e., the first egg date plus the laying and incubation dates (31 days for the Lapwing and 29 days for the Black-tailed Godwit and the Redshank).

The requirement that in all fields at least the required percentage of the clutches should hatch is of course a severe one, since it should be apply to the whole of the population. However, as there is a great nesting-site fidelity of meadow birds (Dijkstra, 1991), the group of birds nesting in a field may be considered in a way as a population on its own. Furthermore, this severe requirement will not lead to an underestimation of required measures.

RESULTS

Factors controlling dates of mowing.

Mowing dates between different fields varied greatly in one year (Figure 2). In 1988, mowing dates ranged from 5 May to 22 June (range, 48 days), in 1989 from 3 May to 29 May (range, 26 days) and in 1990 from 10 April to 18 May (range, 38 days).

There appeared to be several significant correlations between grassland management variables such as the date of fertilizing and measurements of water levels. It is not useful to include two variables both with a high correlation in a multiple regression analysis. The value of this correlation is arbitrary. Correlations which were at least greater than 0.5 were chosen. In this study, therefore, only the dates and amounts of fertilizer and slurry supplies were involved.

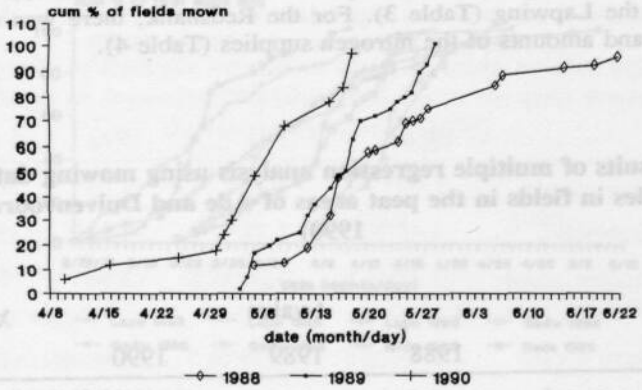


FIG.2. Mowing dates in fields in the peat areas of Ade and Duivenvoorde in 1988, 1989 and 1990.

Multiple regression analyses showed that dates of nitrogen supply (for both fertilizer and slurry) were correlated with mowing dates. These correlations were significantly positive in all years for the date of fertilizer supply and in 1989 for slurry supply. In 1988 and 1990, there was a significant negative correlation with the date of slurry supply. It is not clear why the correlation for the date of slurry supply in one year was positive, while it was negative in the other years. In one year (1988), a negative corrleation with the amount of nitrogen from the slurry and fertilizer supplies was found (Table 1). If ground water tables were included in the multiple regression analysis no significant independent effect of this variable was found. Ground water tables themselves were highly correlated with dates of fertilizer suply (r=-0.8, $P<0.001$).

Factors controlling nesting dates.

Median first egg dates varied greatly between fields. Differences for both the Lapwing and the Black-tailed Godwit were in the same order as those for mowing dates; for the Redshank, they were smaller (Figure 3).

For the Lapwing, median first egg dates were significantly positively correlated with dates of fertilizer and slurry supply (Table 2). Black-tailed Godwit median first egg dates were also significantly positively related with the date of fertilizer supply. In 1989 and 1990, a negative correlation of the date of slurry supply with the median first egg dates was found. Except for 1990 (when only a small number

of observations was included), the R-square for this species was low as compared with those for the Lapwing (Table 3). For the Redshank, there was no significant effect of dates and amounts of the nitrogen supplies (Table 4).

TABLE 1.Results of multiple regression analysis using mowing dates as dependent variables in fields in the peat areas of Ade and Duivenvoorde (1988 - 1990)

Factor	t-value			χ^{2} 1)
	1988	1989	1990	
Date of fertilizer supply	17.84**	4.62**	7.81**	-2**
Date of slurry supply	-4.24**	4.25**	-6.37**	- **
Amount of fertilzer supply (kg N/ha)	-2.86**	-0.58 N.S.	-0.52 N.S.	7.21 N.S.
Amount of slurry supply (kg N/ha)	-2.61*	1.18	2.04°	17.06*
R-square (adj. for d.f.)	0.93	0.63	0.76	
N (fields)	32	54	25	

N.S.: not significant, $P > 0.10$ o: $0.05 < P \leq 0.10$ *: $0.01 < P \leq 0.05$ ** $P \leq 0.01$

1) Fishers Omnibus test; * = $P \leq 0.05$ ** $P < 0.01$; 2) χ^2 could not be exactly calculated, as at least one of the P's was < 0.0001

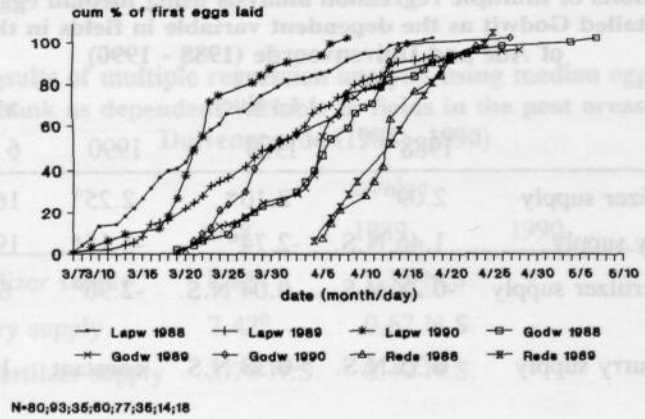


FIG.3. Cumulative first egg dates for the Lapwing, Black-tailed Godwit and Redshank in different fields in the peat areas of Ade and Duivenvoorde (1988-1990).

TABLE 2.Results of multiple regression analysis using median egg laying dates of the Lapwing as the dependent variable in fields in the peat areas of Ade and Duivenvoorde (1988 - 1990)

Factor	t-value			χ^{2} [1]
	1988	1989	1990	6 d.f.
Date of fertilizer supply	3.47**	3.02**	2.52*	28.63*
Date of slurry supply	4.07**	0.98 N.S.	1.09 N.S.	19.06*
Amount of fertilzer supply (kg N/ha)	-0.50 N.S.	-1.33 N.S.	1.46 N.S.	7.58 N.S.
Amount of slurry supply (kg N/ha)	0.51 N.S.	0.79 N.S.	-1.04 N.S.	4.85 N.S.
R-square (adj. for d.f.)	0.60	0.44	0.30	
N (fields)	22	30	12	

N.S.: not significant, P > 0.10 o: 0.05 < P ≤ 0.10 *: 0.01 < P ≤ 0.05 ** P ≤ 0.01

[1]) Fishers Omnibus test; * = P≤0.05 ** P<0.01

TABLE 3.Results of multiple regression analysis using median egg laying dates *of the Black-tailed Godwit as the dependent variable in fields in the peat areas* of Ade and Duivenvoorde (1988 - 1990)

Factor	t-value			χ^{2} [1)]
	1988	1989	1990	6 d.f.
Date of fertilizer supply	2.09°	2.10*	2.25°	16.91*
Date of slurry supply	1.46 N.S.	-2.74*	-3.15*	19.39*
Amount of fertilzer supply (kg N/ha)	-0.28 N.S.	0.04 N.S.	-2.96°	6.91 N.S.
Amount of slurry supply (kg N/ha)	0.35 N.S.	-0.38 N.S.	constant	1.31
R-square (adj. for d.f.)	0.10	0.18	0.60	
N (fields)	19	32	8	

N.S.: not significant, $P > 0.10$ o: $0.05 < P \leq 0.10$ *: $0.01 < P \leq 0.05$ ** $P \leq 0.01$

[1]) Fishers Omnibus test; * = $P \leq 0.05$ ** = $P < 0.01$

TABLE 4.Results of multiple regression analysis using median egg laying dates of the Redshank as dependent variable in fields in the peat areas of Ade and Duivenvoorde (1988 - 1990)

Factor	t-value			χ^{2} [1]
	1988	1989	1990	4 d.f.
Date of fertilizer supply	8.88°	1.38 N.S.	-	8.54 N.S.
Date of slurry supply	7.42°	0.67 N.S.	-	6.25 N.S.
Amount of fertilzer supply (kg N/ha)	3.74 N.S.	0.40 N.S.	-	4.31 N.S.
Amount of slurry supply (kg N/ha)	constant	0.52 N.S.	-	-
R-square (adj. for d.f.)	0.96	0.08	-	
N (fields)	5	15	no sufficient data	

N.S.: not significant, $P > 0.10$ o: $0.05 < P \leq 0.10$ *: $0.01 < P \leq 0.05$ ** $P \leq 0.01$

[1]) Fishers Omnibus test; * = $P \leq 0.05$ ** = $P < 0.01$

Soil invertebrates.

Numbers and biomass of soil fauna show a significant positive correlation ($r=0.84$, $P<0.001$ and $r=0.74$, $P<0.001$ for *Lumbricidae* and *Tipulidae* larvae, respectively). Both were involved in the analysis, although only the results for numbers will be presented here. Numbers of *Lumbricidae* decreased with the date of fertilizer supply and increased with the amount of fertilizer supplied. No relationship was found with the date and the amount of slurry supplied. Of the factors affecting the numbers of *Tipulidae* larvae, only the amount of fertilizer supply was of importance, with which it was positively related. Total numbers of soil fauna were negatively related with the date of fertilizer supply and positively so with the amount of fertilizer and slurry supply (Table 5). When ground water tables were included in the analysis in order to determine whether there was also an independent effect of this variable, there appeared to be no significant extra contribution of this variable

(0.05 < P < 0.10). This is due to the fact that ground water tables were highly correlated with the date of fertilizer supply.

TABLE 5. Result of the multiple regression analysis using the number of *Lumbricidae* and *Tipulidae* larvae as the independent variable; peat areas of Ade and Duivenvoorde, 1990.

Factor	Number *Tipulidae* t-value	P[1)]	Number *Lumbricidae* t-value	P[1)]	Total numbers t-value	P[1)]
Date of fertilizer supply	1.30	N.S.	-8.19	*	-6.94	**
Date of slurry supply	0.09	N.S.	0.42	N.S.	0.52	N.S.
Amount of fertilizer supply (kg N/ha)	3.57	**	5.41	*	8.29	**
Amount of slurry supply (kg N/ha)	0.46	N.S.	3.28	*	2.90	**
R-square (adj. for d.f.)	0.43		0.78		0.79	
N (fields)	25		25		25	

[1)] N.S.: not significant, P > 0.10; o: 0.05 < P < 0.10; *: 0.01 < P < 0.05; **: P < 0.01

Relationship between mowing and nesting dates.

The results show that both mowing dates and nesting dates of the Lapwing and the Black-tailed Godwit were correlated and were related to the same grassland management variables. This was not found for the Redshank. As a result, a correlation between mowing dates and first egg dates for the other species may be expected. Median first egg dates and mowing dates per field were indeed significantly positively correlated for the Lapwing in two of three years. Only in 1988 was a significant relation found for the Redshank as well. The correlations for the Black-tailed Godwit were also positive, although not significantly (Table 6).

TABLE 6.Correlations between mowing dates and median first egg dates of the Lawing, the Black-tailed Godwit and the Redshank in fields in the peat areas Ade and Duivenvoorde (1988-1990).

Species	1988		1989		1990		all years	
	r	P	*r*	P	*r*	P	*r*	P
Lapwing	0.49	**	0.50	**	0.14	N.S.	0.51	**
Black-tailed Godwit	0.21	N.S.	0.17	N.S.	0.49	o	0.28	*
Redshank	0.57	*	-0.04	N.S.	no sufficient data	no sufficient data	0.21	N.S.

N.S. = not significant, $P>0.10$
o = $0.05<P<0.10$
* = $P<0.05$
** = $P<0.01$

Effects of mowing dates on nesting success.

It appeared that for the Lapwing, the Black-tailed Godwit and the Redshank respectively, the mowing date in 19% (n=84), 28% (n=81) and 48% (n=29) of the fields was too early to allow hatching of at least the required percentage (87%, 63% and 40%, respectively) of the clutches in those fields (Figure 4).

When determining the nesting success (the percentage of clutches hatched before mowing) using the data of mowing dates and nesting dates for the period of 1984-1990, there appeared to be a positive relationship between nesting success and date of mowing: mowing from the twelfth (17-23 May) to fourteenth week (31 May-6 June) onwards resulted in the highest percentages of nests hatched before mowing for all species. However, the number of nests involved per mowing date differed greatly between the mowing date periods. A better measure for establishing the effect on the nesting success of the total population is to relate mowing dates to the density of successful clutches (cf Buker & Reyrink, 1989). This showed a higher density than the average for the Lapwing in the twelfth (17-23 May) and fifteenth weeks (7-13 June), for the Godwit in the thirteenth (24-30 May), fourteenth (31 May - 6 June) and eighteenth weeks (27 June - 3 July) and for the Redshank in the sixteenth (14-20 June) and eighteenth (27 June - 3 July) weeks (χ^2 test, $P<0.05$; Figure 5).

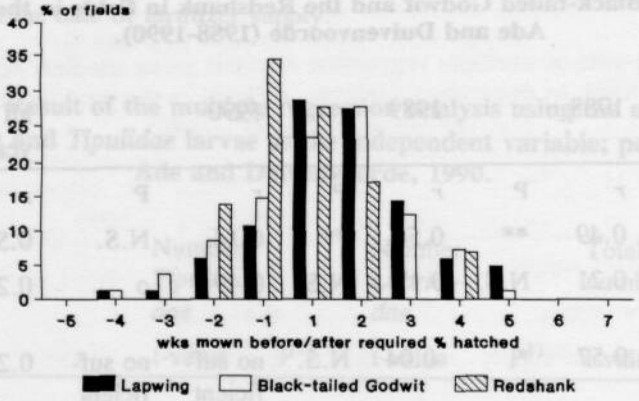


FIG.4. The percentage of fields which were mown a certain number of weeks before (-) or after (+) the date on which at least 87%, 63% or 40% of the clutches of, respectively, Lapwing, Black-tailed Godwit and Redshank in those fields had hatched (1988-1990).

Possible measures for enhancing the nesting success.

To enhance the breeding success of the meadow birds, the usual measure is postponing the mowing date in all fields until one fixed date. On the basis of the data presented here, this would mean a mowing date of around 1 June (Figure 6). In that case, the percentage of fields in which at least the required percentage of the clutches hatched before mowing is 99% for the Lapwing, 98% for the Black-tailed Godwit and 100% for the Redshank. However, for a very large number of the fields, postponing the mowing date until 1 June was unnecessary, as the required percentage of the clutches would already have hatched at a much earlier date. Fine tuning is possible, as nesting dates and mowing dates are correlated with each other. A more flexible measure therefore is to postpone the current mowing date for 1-2 weeks (see Figure 4). In that case, the percentage of fields in which at least the required percentage of the clutches hatched before mowing is 92%-98% for the Lapwing, 87-96% for the Black-tailed Godwit and 87-100% for the Redshank.

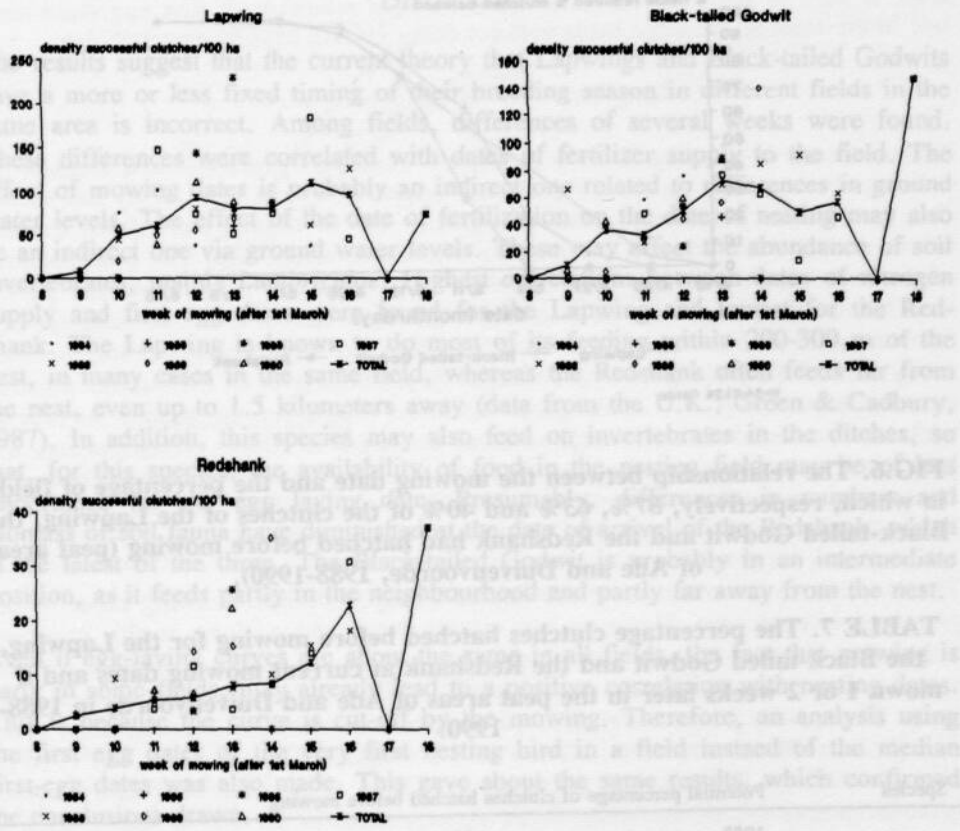


FIG.5. Nest densities of Lapwings, Black-tailed Godwits and Redshanks in relation to mowing dates in the study area 1984-1990.

This would mean that the percentage of clutches hatched before mowing would increase considerably. The greatest increase in clutches hatched before mowing would be for the Redshank and - to a lesser extent - the Black-tailed Godwit (Table 7). In all years, 87% or more of the Lapwing clutches had already hatched before mowing. For the Black-tailed Godwit, 63% would have hatched before mowing in two of the three years, while, for the Redshank, the required percentage of 40% was reached in one of the studied years.

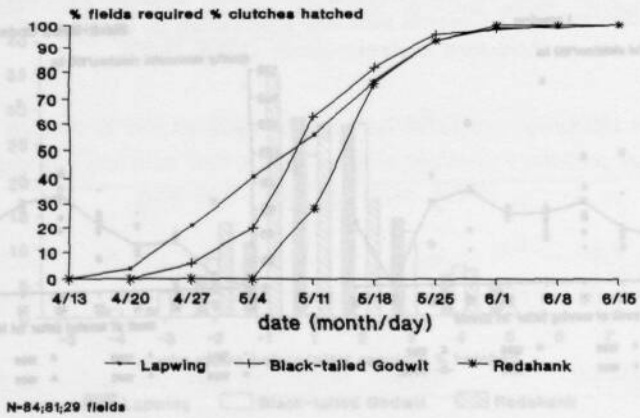


FIG.6. The relationship between the mowing date and the percentage of fields in which, respectively, 87%, 63% and 40% of the clutches of the Lapwing, the Black-tailed Godwit and the Redshank had hatched before mowing (peat areas of Ade and Duivenvoorde, 1988-1990).

TABLE 7. The percentage clutches hatched before mowing for the Lapwing, the Black-tailed Godwit and the Redshank at current mowing dates and if mown 1 or 2 weeks later in the peat areas of Ade and Duivenvoorde in 1988-1990.

Species	Potential percentage of clutches hatched before mowing								
	1988			1989			1990		
	current mowing dates	+ 1 week	+ 2 weeks	current mowing dates	+ 1 week	+ 2 weeks	current mowing dates	+ 1 week	+ 2 weeks
Lapwing	88%	96%	100%	94%	98%	100%	87%	89%	92%
Black-tailed Godwit	80%	90%	98%	75%	90%	99%	66%	83%	94%
Redshank	29%	93%	100%	67%	89%	100%	no sufficient data		

Lapwing N=85;96;38
Black-tailed Godwit N=60;77;35
Redshank N=14;18

DISCUSSION

The results suggest that the current theory that Lapwings and Black-tailed Godwits have a more or less fixed timing of their breeding season in different fields in the same area is incorrect. Among fields, differences of several weeks were found. These differences were correlated with dates of fertilizer supply to the field. The effect of mowing dates is probably an indirect one related to differences in ground water levels. The effect of the date of fertilization on the date of nesting may also be an indirect one via ground water levels. These may affect the abundance of soil invertebrates, mainly *Lumbricidae*. Highest correlations between dates of nitrogen supply and first egg dates were found for the Lapwing and lowest for the Redshank. The Lapwing is known to do most of its feeding within 200-300 m of the nest, in many cases in the same field, whereas the Redshank often feeds far from the nest, even up to 1.5 kilometers away (data from the U.K.; Green & Cadbury, 1987). In addition, this species may also feed on invertebrates in the ditches, so that, for this species, the availability of food in the nesting field may be of less importance for the egg laying date. Presumably, differences in numbers and biomass of soil fauna have diminished at the date of arrival of the Redshank, which is the latest of the three. The Black-tailed Godwit is probably in an intermediate position, as it feeds partly in the neighbourhood and partly far away from the nest.

Even if egg-laying curves are about the same in all fields, the fact that mowing is early in some fields, may already lead to a positive correlation with nesting dates. This is because the curve is cut-off by the mowing. Therefore, an analysis using the first egg dates of the very first nesting bird in a field instaed of the median first-egg dates was also made. This gave about the same results, which confirmed the conclusions drawn.

The results of this study are in contrast with the conclusion of Buker & Reyrink (1989), who found no clear differences in median hatching dates between several areas in Waterland. However, they grouped many fields within a geographical area into one category. Therefore, they studied differences on another scale, which led to a minimum estimate of the differences. In their analysis, they also correlated hatching dates with mowing dates, in which two years were grouped. They showed a positive, although very low correlation for both Lapwings and Black-tailed Godwits, corresponding with the results in this study. For the other species, no significant correlations were found. Their conclusion is that, in general, it is unlikely that birds nest earlier in the early mown fields. A significant difference with the study presented here is that they estimated both first egg dates and mowing dates in periods of five days (pentads), which is less accurate. More important is that they included many fields in which management agreements had been concluded. In these fields, mowing dates were probably determined more by the restrictions in the contract rather than by the characteristics of the field. For this reason, most of the mowing dates in their research were also relatively very

late (June, July) as compared with the mowing dates in the Ade/Duivenvoorde area. It may be that mowing dates are no longer related with first egg dates very late in the season, since the birds will not delay nesting beyond a certain date.

Significance for nature conservation.

Postponement of mowing dates in all fields usually is practised as a measure to enhance the breeding success of grassland breeding waders. This study has shown that in different fields both dates of mowing and of nesting are related to each other, so that there is room for a better adjustment of the two. The postponement of the mowing date for the sake of the meadow birds can be for a shorter period than is usually done in the ESAs and anyway there seems to be no need for one fixed date for all fields combined. However, this may be desirable in order to more easily control the management provisions. A postponement of the current mowing date for a period of 1-2 weeks gives the same results for the nesting success as with one late fixed date (1 June), whereas the negative effects on agriculture, although still present, are reduced. In all years, such a postponement would mean that at least the required percentage of all clutches of all species considered would have hatched before the mowing and so to maintain current population levels.

There seems to be some room for implementing such later mowing dates in the grassland management. However, not on all farms and so long as this concerns only a few fields rich in meadow birds (Bischoff *et al.*, 1987). The costs of later mowing dates are depedent on the area in which the later mowing should take place. The quality of the roughage rapidly decreases when the mowing takes place after 1 June (Korevaar, 1986). Costs of 1-2 weeks delay are about Dfl. 110/ha (source: Vellinga & Corporaal, pers. comm.). Most of the birds nest on a relatively small proportion of the area. In an average farm of 24 ha, of which 75% is mown (thus 18 ha), about 40% (i.e. about 8 ha) could be mown later. This would save about 70% of the population (Figure 7; cf. Beintema, 1983). This means that the total costs for an average farm in the Dutch peat area would be about Dfl. 880.

In the intensively exploited grasslands postponement of mowing dates may be hampered by the tendency to mow all fields within a shorter time period. In the Ade/Duivenvorde area, between 1987 and 1991, the time period between the first and the last mowing date of all mown fields decreased from about 60 days to about 20 days.

In addition, if there are many fields with different mowing dates a control problem arises in the ESAs. It may then be necessary to increase the intensity of checking whether farmers comply with the management provisions. Nevertheless, trying out these measures seems to be worthwile if more farmers will be prepared to take them.

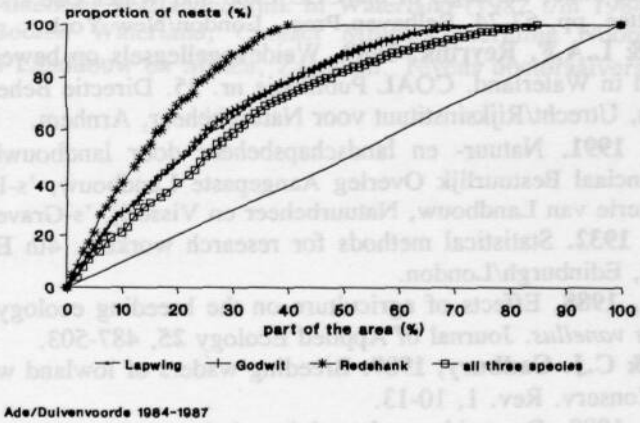


FIG.7.The relationship between the part of the area of meadows (in percentage of the total area) and the maximum proportion of Lapwing, Black-tailed Godwit and Redshank clutches present (in percentage of the total number of all clutches found in meadows).

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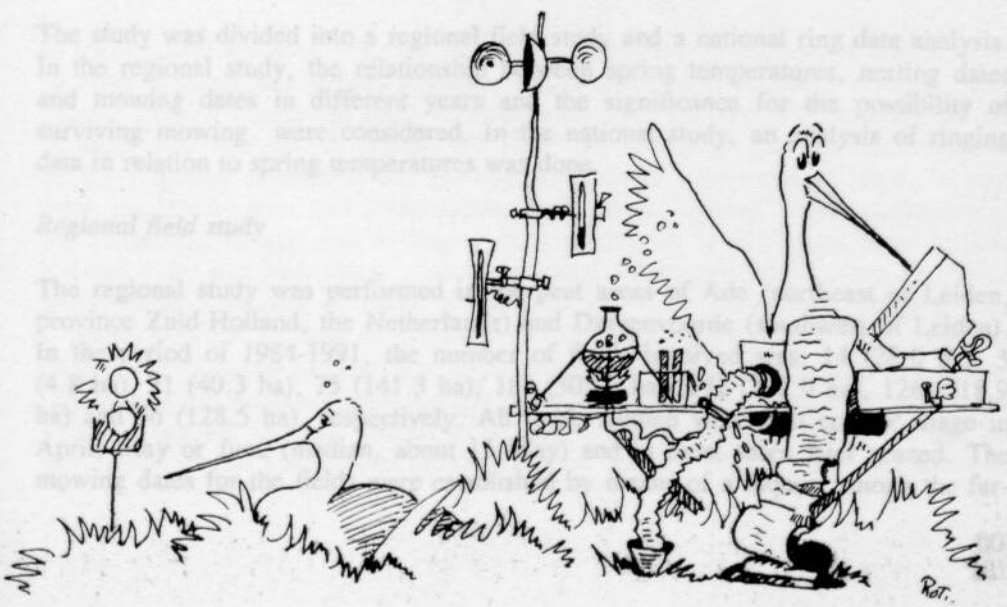
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Chapter 6

The relationship between mowing dates and egg laying dates of meadow birds in intensively exploited grassland areas in the Netherlands: (2) in different years

Maurice Kruk, Barbara van Agt, Robert M.H. Tekke and Marcel A.W. Noordervliet



SUMMARY

(1) The relationship between the timing of mowing and nesting of the Lapwing (*Vanellus vanellus*), the Black-tailed Godwit (*Limosa limosa*) and the Redshank (*Tringa totanus*) in different years in the Netherlands was studied in a regional field study and by means of a national ringing analysis.

(2) Temperature sums were used as a measure for spring temperature, as they are well known among farmers and used for fertilizing. For that reason, they would be a useful measure for prediciting both mowing and nesting dates.

(3) In the regional field study, higher spring temperatures proved to be associated with earlier mowing and earlier breeding of both Black-tailed Godwits and Redshanks; the same relationship was found for all species on a national scale.

(4) Dates of nesting and mowing in different years were positively correlated.

(5) Due to the fact that birds nested earlier in years with early mowing, the negative effect of early mowing on the hatching success was limited. This in contrast with the generally accepted idea of a more or less fixed breeding season.

(6) Without significantly affecting the farming enterprise, the possibility of surviving mowing for Black-tailed Godwit and Redshank may be enhanced up to a level necessary for maintaining the current population levels by postponing the current median mowing dates for 1-2 weeks.



INTRODUCTION

Birds lay earlier in the spring, when it is warm and dry and food is abundant at the time when most of the birds return (O'Connor & Morgan, 1982; Thompson *et al.*, 1986). Spring temperatures may also affect mowing dates. The temperature sum (T-sum), i.e., the sum of the positive average of minimum and maximum air temperatures per 24 hours, starting from the 1st of January, is usually published in farmers' magazines. This parameter indicates the date on which farmers are advised to apply the first nitrogen supplies (between a T-sum of 180° and 280° Centigrade), provided that the bearing capacity of the soil is good enough (Van den Burg *et al.*, 1989). The earlier the fertilization can take place, the earlier the possible date of mowing (Chapter 5). The T-sum may also affect the development of soil fauna and hence nesting dates. As T-sums are well-known among farmers, they might therefore be useful measures for predicting "safe" mowing dates with respect to the meadow birds.

The study presented in this chapter was concentrated on the relationship between mowing and nesting dates in different years and the effect of spring temperatures on the nesting dates and its significance for the possibility of the clutches surviving mowing. In addition, some measures are discussed which may increase the possibility of surviving mowing without too much a burden on the farmers

STUDY DESIGN AND METHODS

Study area, nesting dates and mowing dates.

The study was divided into a regional field study and a national ring data analysis. In the regional study, the relationship between spring temperatures, nesting dates and mowing dates in different years and the significance for the possibility of surviving mowing were considered. In the national study, an analysis of ringing data in relation to spring temperatures was done.

Regional field study

The regional study was performed in the peat areas of Ade (northeast of Leiden, province Zuid-Holland, the Netherlands) and Duivenvoorde (southwest of Leiden). In the period of 1984-1991, the number of fields involved was: 14 (28.0 ha), 3 (4.8 ha), 21 (40.3 ha), 75 (141.3 ha), 188 (305.3 ha), 172 (292.9 ha), 126 (218.9 ha) and 56 (128.5 ha), respectively. All fields studied were first cut for silage in April, May or June (median, about 15 May) and in most cases later grazed. The mowing dates for the fields were established by means of a inquiry among the far-

mers and observations in the field. The fields were selected with the cooperation of the farmers. Fields with a management agreement were excluded. since the grassland management there had already been adapted to the provisions of the management plan, so that as a result a possible relationship between nesting and mowing dates may not exist.

Nest data were collected as described in Chapter 2.

The possibility of the wader species surviving mowing in relation to the mowing in a year may be expressed in two ways. 1). it may be expressed as the percentage of all clutches present during the breeding season hatched before mowing. This method also includes losses due to factors other than mowing, i.e. predation, desertion, etc. In this way, it gives an idea of the nesting success, as all factors afffecting this success are involved. 2). the possibility of surviving mowing may be expressed as the percentage of clutches hatched before mowing of all eventually *successful* clutches. As clutches were marked, farmers could spare them during mowing. Most of these clutches (>70%) would still hatch (Kruk & Noordervliet, 1990). This method gives a better idea of the potential possibilities of surviving mowing, as other factors such as predation, desertion, etc., are excluded. Whether there is an effect of the mowing date on the possibility of surviving mowing was determined by correlating the mowing dates with the number of clutches hatched before mowing.

T-sums were used as estimators of spring temperatures. Data of the nearest weather station (Valkenburg) at about 10 km from the study area were obtained from the National Weather Forecasting Institute KNMI, De Bilt. The date on which a T-sum of 180 or 280 °C was reached (starting from the first of January) was calculated.

National study: analysis of ringing data.

Nesting data were derived from ringing dates of the three meadow-bird species in some important meadow bird areas in the northern, central and southern parts of the Netherlands. The ringing data were obtained from the Dutch Ringing Centre (Vogeltrekstation) and comprised the years 1971-1988. A selection was made of data of chicks of Lapwings, Black-tailed Godwits and Redshanks primarily ringed in grasslands under "normal" agricultural management, i.e., data of a ringer were used if more than 75% of the chicks were ringed in this type of grassland. So, nature reserves, "Environmentally Sensitive Areas", arable land and other habitats such as dunes, moorlands, etc. were excluded in so far as possible. To determine the type of habitat in which the birds were ringed as well as hatching dates, a survey was carried out among 106 ringers (74% response, of which 76% could be used). Hatching dates were calculated from ringing dates corrected for the estimated age at ringing as stated by the ringers. The ringers reported the age at which they had ringed more than 75% of the chicks (with an accuracy of one week). Per

year, at least 50 chicks had to be ringed in order to determine the median hatching date, as only then would the hatching curves show a regular form.

Before the analysis, three soil types were distinguished: clay, sand and peat soils. These types were used because it was expected that they would reflect differences in water levels which result in a diversity in the speed of warming up of the soil (Wesseling, 1987) and related with that the development of soil fauna and other factors such as grassland management. The determination of soil types at the ringing sites was done by means of the soil map of the Netherlands (scale, 1:200,-000). In the analysis, however, it appeared that such a distinction was not necessary, as no differences were found in hatching dates among soil types.

T-sums were used as estimators of spring temperatures. Data were obtained from the National Weather Forecasting Institute KNMI, De Bilt. The Netherlands were divided into five regions based on significant differences between the dates on which T-sums of 180° C were reached at different weather stations (Wilcoxon Signed Ranks Matched Pairs test; Siegel, 1956). The coldest area was in the northeast (Region I), the warmest in the southwest (Region V; Figure 1). Regions were arbitrarily separated by provincial boundaries. Region number II was split into two subregions: Friesland and the remaining area. In Friesland, many eggs of the Lapwing are collected for human consumption until 13 april, which may alter the relationship between hatching dates and T-sums.

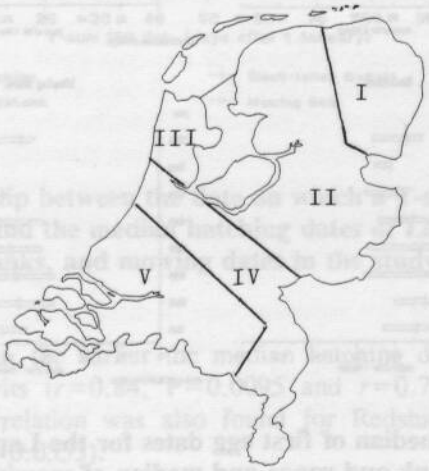


FIG.1. Division of the Netherlands into regions in which a certain T-sum is reached on different dates (Region I is the coldest region, region V the warmest).

Unfortunately, no reliable data on mowing dates on a national scale could be obtained, so that the effect of spring temperatures on mowing dates could not be studied.

RESULTS

Dates of mowing and nesting in different years.

Relationships between the T-sum and median first egg and mowing dates.

There are considerable differences in both median first egg dates and mowing dates in different years (Figure 2). The greatest differences in median first egg dates varied from 11 days (Lapwing) up to 18 days (Black-tailed Godwit). Differences in median mowing dates varied for up to 11 days.

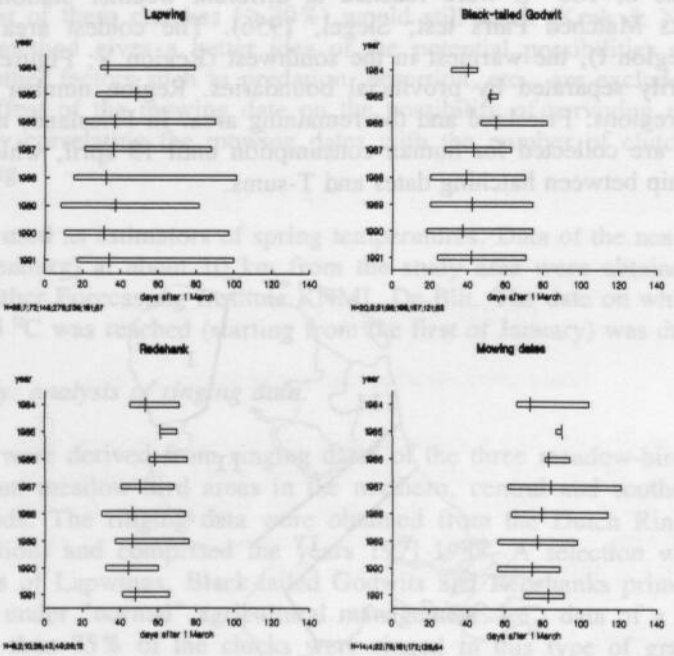


FIG.2.Range and median of first egg dates for the Lapwing, Black-tailed Godwit and Redshank and range and median of mowing dates in the peat areas of Ade and Duivenvoorde in 1984-1991. | = median date.

The warmer the spring, i.e, the earlier date on which the T-sum of 180 °C was reached, the earlier the median hatching date for Black-tailed Godwits and Redshanks (Godwit: r=0.81; P=0.0150; Redshank: r=0.78; P=0.0233). The correlation for Lapwings was also positive, but not significant (r=0.69, P=0.0584; Figure 3). The relationship between the date on which the T-sum of 180 °C was reached and the median hatching dates (in days after 1 January) for Lapwing could be described as: median hatching date = 0.142647*T-sum date + 118.2364, for Black-tailed Godwit as: median hatching date = 0.200978*T-sum date + 120.6591 and for Redshank as median hatching date = 0.182892*T-sum date + 128.8225. The warmer the spring, the earlier the median mowing date in that year (r=0.85; P=0.0074; Figure 4). This relation could be described as: median mowing date = 0.188033*T-sum date + 128.39.

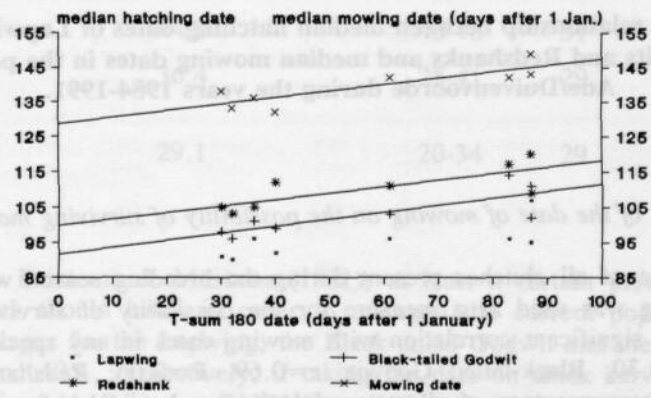


FIG.3.The relationship between the date on which a T-sum of 180 °C is reached in Valkenburg and the median hatching dates of Lapwings, Black-tailed Godwits and Redshanks, and mowing dates in the study area in 1984-1991.

The earlier the mowing, the earlier the median hatching date for both Lapwings and Black-tailed Godwits (r=0.84, P=0.0095 and r=0.75, P=0.0313, respectively). A positive correlation was also found for Redshanks, but this was not significant (r=0.70, P=0.0553).

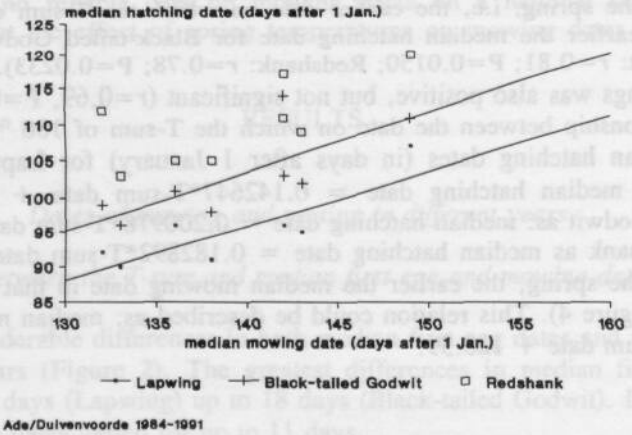


FIG.4. The relationship between median hatching dates of Lapwings, Black-tailed Godwits and Redshanks and median mowing dates in the peat areas of Ade/Duivenvoorde during the years 1984-1991.

Effects of the date of mowing on the possibility of surviving mowing.

The percentage of all clutches present during the breeding season which hatched before mowing was used as a measure for the possibility of surviving mowing. There was no significant correlation with mowing dates in any species (Lapwing: r=0.42, P=0.30; Black-tailed Godwit: r=0.69, P=0.06; Redshank: r=-0.48, P=0.23). If the percentage of all successful clutches hatched before mowing was used as a measure for the possibility of surviving mowing, there also appeared to be no correlation with the mowing date for any species (Lapwing: r=0.18, P=0.66; Black-tailed Godwit: r=0.54, P=0.17 and Redshank: r=-0.540, P=0.21).

In addition, it is possible that mowing dates in different years affect the time period between the median first egg date (or hatching date) and the median mowing date. This time period gives an indication of how much time there is for undisturbedly laying and incubating the eggs and should be at least as long as the theoretical time period required for egg laying and incubating eggs. The time period found between median first egg date and mowing date may differ in all years for all species, although it is less than the variation in mowing dates and egg dates themselves and on the average longer than the required theoretical period (Table 1). For each species, there was no significant positive correlation between the median mowing date

and this time period (Lapwing: $r=0.40$, $P=0.32$; Black-tailed Godwit: $r=0.22$, $P=0.60$; Redshank: $r=0.33$, $P=0.42$).

TABLE 1. Mean time period and range between median first egg dates and median mowing dates, and theoretical time period of egg laying and incubation for the Lapwing, the Black-tailed Godwit and the Redshank in the peat area of Ade/Duivenvoorde in 1984-1991.

species	mean time period between median first egg date and median mowing date (days)	range (1984-1991 in days)	theoretical required time period for egg laying and incubation
Lapwing	44.0	40-48	31
Black-tailed Godwit	36.4	28-41	29
Redshank	29.1	20-34	29

According to Beintema & Müskens (1981), at least a certain percentage of the wader clutches should hatch in order to maintain the current population levels. These percentages for the Lapwing, the Black-tailed Godwit and the Redshank are 87%, 63% and 40%, respectively, if taking the data on chick survival and adult survival as given by Beintema & Müskens (1981), Beintema & Drost (1986) and Beintema (1991). The difference between the median date of mowing in a year and the date on which at least the required percentage of the clutches was hatched showed that the mowing date in 100% of the cases was too early for the Lapwing (all 8 years), in 50% for the Black-tailed Godwit (4 of 8 years) and in 40% for the Redshank (3 of 8 years; Table 2).

In order to increase the breeding success, the mowing date is usually postponed until one fixed date, usually 15 June. In the study area, this in all years would indeed be late enough for the hatching of the required percentage of clutches. Almost the same effect, however, could be reached if current median mowing dates would have been 1-2 weeks later. In that case, for the Black-tailed Godwit and the Redshank, mowing dates would have been too early in none of the years, i.e, less than the required percentage of the clutches would have hatched before the mowing date (bold numbers in Table 2). For the Lapwing, the mowing date would still be too early in two to six of the eight years.

A postponement of mowing dates so mainly has a positive effect on the Redshank and the Black-tailed Godwit (Table 2).

TABLE 2. The percentage of clutches hatched before mowing (in parentheses of all eventually sucessful clutches) of Lapwings, Black-tailed Godwits and Redshanks at current mowing dates and in the case of later mowing 1 or 2 weeks (peat areas of Ade and Duivenvoorde 1984-1991) Bold: the first time that the required percentage or higher is reached.

Required percentages in order to maintain current population levels: Lapwing: 87%; Black-tailed Godwit: 63%; Redshank: 40%.

Species	Lapwing			Black-tailed Godwit			Redshank		
Year	current mowing dates	+ 1 week	+ 2 weeks	current mowing dates	+ 1 week	+ 2 weeks	current mowing dates	+ 1 week	+ 2 weeks
1984	62% (75%)	68% (82%)	74% (**89%**)	55% (60%)	**86%** (**95%**)	100% (100%)	25% (25%)	**50%** (**50%**)	75% (75%)
1985	57% (67%)	71% (83%)	71% (83%)	**100%** (**100%**)	100% (100%)	100% (100%)	0% (0%)	**100%** (**100%**)	100% (100%)
1986	79% (**90%**)	81% (93%)	**95%** (94%)	39% (48%)	**64%** (**74%**)	72% (90%)	23% (30%)	**54%** (**70%**)	77% (100%)
1987	78% (**87%**)	85% (94%)	85% (94%)	**80%** (**89%**)	89% (90%)	90% (100%)	**40%** (**48%**)	73% (88%)	80% (96%)
1988	60% (81%)	65% (**92%**)	69% (98%)	**69%** (**87%**)	77% (96%)	80% (99%)	**40%** (**65%**)	58% (94%)	62% (100%)
1989	51% (76%)	57% (85%)	59% (**87%**)	45% (**63%**)	60% (84%)	**71%** (100%)	**48%** (**56%**)	78% (91%)	86% (100%)
1990	53% (62%)	55% (64%)	56% (65%)	57% (**74%**)	**67%** (86%)	74% (96%)	**48%** (**54%**)	70% (74%)	89% (100%)
1991	72% (74%)	81% (84%)	**88%** (**90%**)	**80%** (**85%**)	82% (88%)	93% (100%)	**64%** (**64%**)	82% (82%)	100% (100%)
all years	64% (77%)	70% (85%)	75% (**88%**)	**66%** (**76%**)	78% (89%)	85% (98%)	36% (**43%**)	**71%** (81%)	84% (96%)

Relations between median hatching dates and T-sums on a national scale.

The analysis was carried out by the use of national ringing data and was therefore not based on nest discoveries. As such, it is different from that of the regional study mentioned above. Great differences in median hatching dates in different years were also found here (in the order of 1-3 weeks).

When studying the relationship between the median hatching dates per region and the T-sums starting the first of January, no significant correlations at all were found. T-sums of 180 or 280 °C starting from the first of March, the time when most species have returned to the breeding area, however, showed positive correlations in many cases. Other T-sums starting from the first of March were also tried in order to determine which T-sum would give the highest correlations with median hatching dates. For the T-sum in each region, the temperatures of the weather station situated in the region, which gave the highest correlations, is presented here. For all species in most regions (and soil types), there is a significant positive correlation between hatching dates and T-sums starting from the first of March (Figure 5-8): the colder it was, the later the nests hatched. In one region (Region number IV), however, no correlations were found for any of the species concerned. For the different species, the T-sums with which highest correlations were found were different.

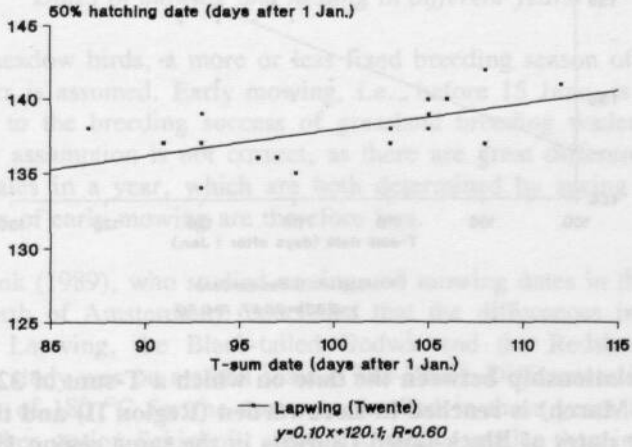


FIG.5.The relationship between the date on which a T-sum of 210 °C (starting from 1st March) is reached in Twente (Region II) and the median hatching dates of Lapwings in the same region 1971-1988.

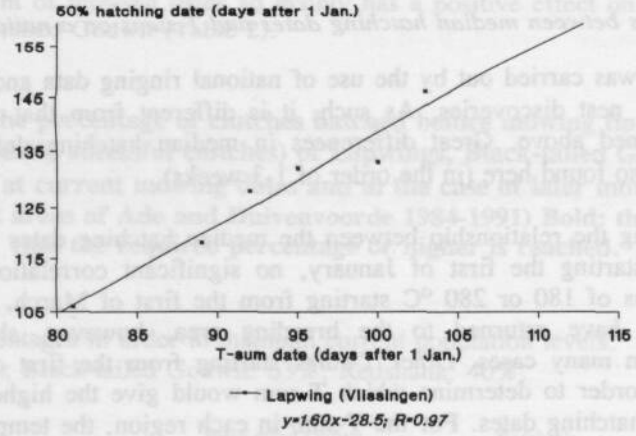


FIG.6.The relationship between the date on which a T-sum of 180 °C (starting from 1st March) is reached in Vlissingen (Region V) and the median hatching dates of Lapwings in the same region 1971-1988.

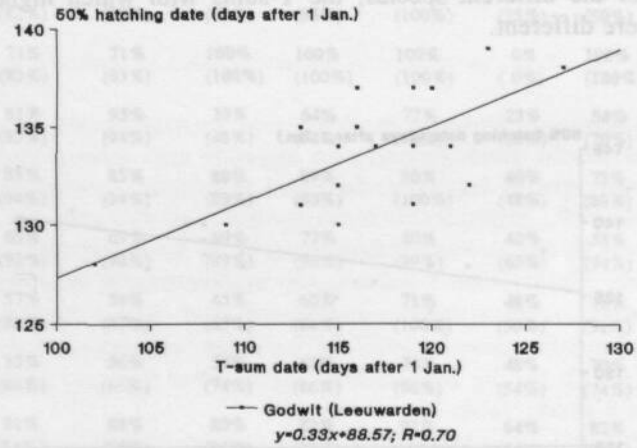


FIG.7.The relationship between the date on which a T-sum of 320 °C (starting from 1st March) is reached in Leeuwarden (Region II) and the median hatching dates of Black-tailed Godwits in the same region 1971-1988.

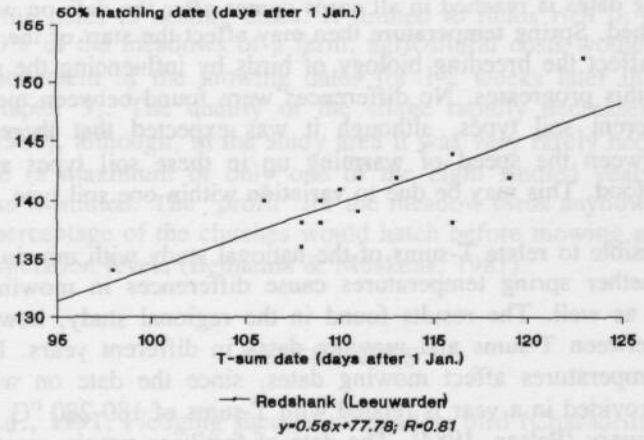


FIG.8.The relationship between the date on which a T-sum of 280 °C (starting from 1st March) is reached in Leeuwarden (Region II) and the median hatching dates of Redshank in the same region 1971-1988.

DISCUSSION

Dates of mowing and nesting in different years.

In studies of meadow birds, a more or less fixed breeding season of the grassland breeding waders is assumed. Early mowing, i.e., before 15 June, is considered to be detrimental to the breeding success of grassland breeding waders. This study shows that this assumption is not correct, as there are great differences in nesting and mowing dates in a year, which are both determined by spring temperatures. Negative effects of early mowing are therefore less.

Buker & Reyrink (1989), who studied nesting and mowing dates in the peat area of Waterland (North of Amsterdam), concluded that the differences in the breeding season of the Lapwing, the Black-tailed Godwit and the Redshank are small. However, their study was on a small scale (1982-1984). Differences in the dates on which a T-sum of 180 °C for the area was reached in these years (range, 1 - 25 February; weather station Schiphol), were also much smaller than in the period of 1971-1988 (range, 26 January - 1 April). As a result, differences in the timing of the breeding season in 1982-1984 were less pronounced.

In warm spring weather, nesting and mowing take place early. The date on which a certain T-sum is reached in some regions may be later than the median first egg date with which it was correlated. This means that temperatures also affect the

dates of the first egg dates after the median first egg date. The date on which 90% of the first egg dates is reached in all cases comes after the date on which a certain T-sum is reached. Spring temperature then may affect the start of the nesting cycle, but can also affect the breeding biology of birds by influencing the rate at which, once started, this progresses. No differences were found between median hatching dates on different soil types, although it was expected that there would be a difference between the speed of warming up in these soil types and hence the abundance of food. This may be due to variation within one soil type.

It was not possible to relate T-sums of the national study with mowing dates; so, it is unclear whether spring temperatures cause differences in mowing dates on a national scale as well. The results found in the regional study, however, show a relationship between T-sums and mowing dates in different years. It is plausible that spring temperatures affect mowing dates, since the date on which nitrogen supplies are provided in a year is related with T-sums of 180-280 °C, starting from the first of January (Pelser, 1984). The date of fertilizer supply greatly affects the date of mowing (Chapter 5). In addition, a correlation was found between nesting dates of Lapwings and Black-tailed Godwits with mowing dates, suggesting a common factor, i.e., spring temperatures, which results in synchronization.

Significance for nature conservation.

If one wants a "fine tuning" of the grassland management for the sake of grassland breeding birds on a national scale, more knowledge is necessary to accurately predict the timing of nesting of the birds and mowing dates. In that way, a "safe" mowing date could be predicted. This study has shown that, on a regional scale, the dates of mowing and nesting in a year are correlated with each other and both are affected by spring temperatures. It is therefore possible to forecast the peak of hatching, in particular those of the Black-tailed Godwit and the Redshank, which are the most vulnerable species where mowing activities are concerned. For the Lapwing, the earliest breeding species, early mowing is of less importance. This species is capable of providing many replacement clutches, which may frequently be found in the short vegetation *after* the mowing or in pastures. These replacement clutches reduce the percentage of nests hatched before mowing. So, the effect of early mowing on this species is less than would be expected on the basis of the number of clutches hatched before mowing. Another reason why the effect of early mowing on the Lapwing seems to be less is that the data on adult survival (Beintema & Müskens, 1981) are not very reliable. It was assumed that this was 0.68 for both first year and older adults. Beintema & Müskens used the same data for the Black-tailed Godwit, which later appeared to be too low estimations (Beintema & Drost, 1986). If adult Lapwing survival indeed is also higher, the required recruitment and thus the required percentage of clutches hatched before mowing will also be (much) lower.

The peak of mowing can be calculated as well. This makes possible a better adjustment of mowing dates to nesting dates. If limited to fields rich in meadow birds, e.g., about 40% of the meadows of a farm, agricultural costs would be about Dfl. 880 for postponement of the mowing dates for 1-2 weeks later than the current dates (see Chapter 5). The quality of the silage rapidly decreases after 1 June (Koorevaar, 1986), although, in the study area it was very rarely necessary to mow after this date (a maximum of only one of the eight studied years), so that the agriculutal loss is limited. The "profit" for the meadow birds anyhow would be that the required percentage of the clutches would hatch before mowing and so maintain the current population levels (Beintema & Müskens, 1981).

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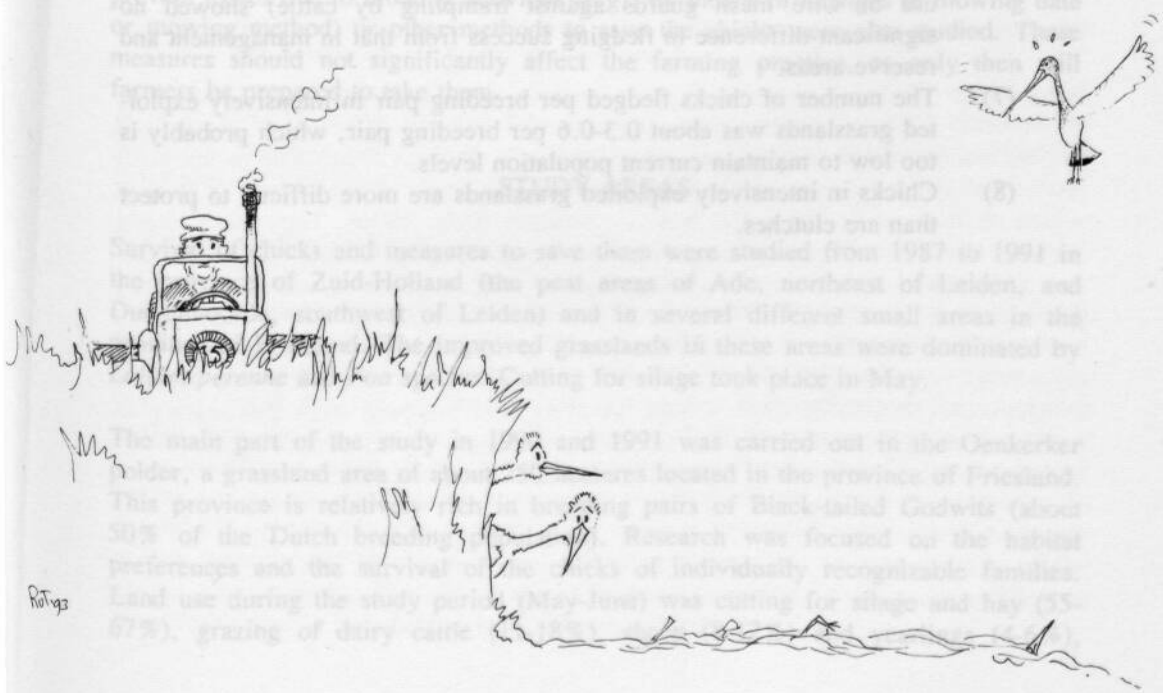
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Chapter 7

Survival of black-tailed godwit chicks (*Limosa limosa* L.) in relation to mowing activities in intensively exploited grassland areas in the Netherlands

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SUMMARY

(1) A study was carried out in order to determine the possible effects of mowing on survival of Black-tailed Godwit (*Limosa limosa* L.) chicks in intensively exploited grasslands as well as a possible measure to reduce mowing victims.

(2) Godwit chicks start to roam about fields within a few days after hatching. Families with chicks had a preference for more herb-rich meadows or pastures with either a short or tall vegetation; preferences changed during the season. Herb-rich field fields probably provide more food for chicks.

(3) The number of chicks present during mowing could be significantly reduced by putting sticks with plastic bags tied to the top in the fields one day before mowing.

(4) Losses of chicks as a result of mowing activities were limited to 5-20% of the total number of chicks hatched. Total mortality was 77-87% of all chicks hatched. Just hatched chicks had the greatest risk of dying as a result of mowing (38-95% killed), while most of the older chicks were capable of escaping from the mowing machine (5-45% killed).

(5) Most losses of chicks must have been due to factors other than mowing, such as predation, weather conditions and food availability.

(6) Areas with nest protection activities (marking nests with sticks and the use of wire mesh guards against trampling by cattle) showed no significant difference in fledging success from that in management and reserve areas.

(7) The number of chicks fledged per breeding pair in intensively exploited grasslands was about 0.3-0.6 per breeding pair, which probably is too low to maintain current population levels.

(8) Chicks in intensively exploited grasslands are more difficult to protect than are clutches.

INTRODUCTION

The Dutch grasslands are of great international importance for the world population of Black-tailed Godwits (*Limosa limosa* L., Charadriiformes). The area represents the breeding habitat for about 65-90% of the total Western and Middle European breeding populations (Piersma, 1986; Rooth, 1989). Most of them breed in the intensively exploited grasslands.

Relatively few studies have been focused on the effects of farming activities on the survival of chicks. The reason is that these kinds of studies are very time-consuming. The rare studies on this subject give little information. Chicks of the Black-tailed Godwit have a preference for "tall" grass (Buker & Groen, 1989a; 1989b; Fabritius, 1975; Mulder, 1972), so that significant losses of chicks may be expected due to mowing. Indeed, such large losses are frequently reported (Rebergen, 1987). In 1988, press reports appeared concerning "disasters" for this species as a result of early mowing activities. In addition, the studies concern atypical conditions in management areas and reserves where cutting dates are relatively late in the breeding season (Buker & Groen, 1989a; 1989b; Buker & Winkelman, 1987).

Therefore, it is necessary to collect data on the survival and habitat use of Black-tailed Godwit chicks in intensively exploited grasslands. The effect of measures to prevent losses due to mowing activities (e.g., by means of changes in mowing date or mowing method) or other methods to save the chicks were also studied. These measures should not significantly affect the farming practice, as only then will farmers be prepared to take them.

STUDY AREAS

Survival of chicks and measures to save them were studied from 1987 to 1991 in the province of Zuid-Holland (the peat areas of Ade, northeast of Leiden, and Duivenvoorde, southwest of Leiden) and in several different small areas in the province of Friesland. The improved grasslands in these areas were dominated by *Lolium perenne* and *Poa* species. Cutting for silage took place in May.

The main part of the study in 1990 and 1991 was carried out in the Oenkerker polder, a grassland area of about 250 hectares located in the province of Friesland. This province is relatively rich in breeding pairs of Black-tailed Godwits (about 50% of the Dutch breeding population). Research was focused on the habitat preferences and the survival of the chicks of individually recognizable families. Land use during the study period (May-June) was cutting for silage and hay (55-67%), grazing of dairy cattle (11-18%), sheep (8-12%) and yearlings (4-6%),

arable (maize; 2-3%), zero-grazing (0-5%) and grazing by horses (1-3%) and beef cattle (1%). A part of the grassland was reseeded (1991: 2%).

Dates of mowing and grazing and numbers of livestock were recorded. A nature reserve in the area (4%) was included in the study in 1991. The management of this reserve is aimed at increasing the breeding success of the nesting birds by means of late cutting dates and low cattle densities.

METHODS

Hatching success.

In all fields to be mown (1990: 60; 1991: 57 fields), each nest was marked with a short garden cane at 3-4 m from the actual nest site. In the grazed fields (1990: 26; 1991: 29 fields), except in the reserve area, wire mesh guards were used to prevent trampling by cattle (Hendriksma, 1964). Nests were checked at 1-5 day intervals. Most of them were visited on the expected day of hatching, using the degree of flotation of the eggs as an estimator of the incubation period (Van Paassen *et al.*, 1984). Chicks were ringed at the nest site just after hatching. When the nest was found to be empty on the expected day of hatching, the presence of egg shell fragments was taken as evidence of successful hatching.

Chick survival and habitat use.

Marking breeding adults.

Black-tailed Godwit chicks and their parents usually remain close together. Movements could be traced by locating marked parents. Survival of chicks and habitat use of individual families with chicks were checked. Incubating parent birds were cage-trapped on the nest during about the last week of incubation, a time at which chances of deserting the nest are smallest (Bub, 1976). They were ringed with an aluminum "Arnhem" ring from the Dutch Ringing Centre (Vogeltrekstation) and marked with a temporary leg flag, as well as coloured with a temporary plumage dye (according to Wader Study Group, undated). In 1990, thirty-seven and in 1991, forty-five Black-tailed Godwits were marked in this way. Twenty-eight nests of forty-eight (58.3%) hatched successfully in 1990; thirty-five nests of seventy-two (48.6%) in 1991. Losses of nests after trapping were due mainly to predation or agricultural activities (including grazing); a maximum of four (1990) and two (1991) clutches were deserted as a result of the trapping.

Fledging success, chick mortality and productivity.

Chick survival was checked by daily counts of broods, made from a vehicle or a portable blind, between the middle of May and the middle of July. The chicks of about 50% of the observations of marked birds could not be seen due to the tall vegetation and hence the exact number of chicks present could not be determined. When the parents' behaviour indicated the presence of at least one young, a minimum (one) and a maximum estimation (the highest possible number based on previous observations) of the number of young present was made (Buker & Winkelman, 1987).

Brood habitat use.

After hatching, chicks frequently move from the nest site to other fields. Notes were made on the type of field in which they were present. This comprised the agricultural use (pasture, i.e., grazed in the first cut or meadow, i.e., mown in the first cut) as well as the vegetation height (in cm) and vegetation type. Two classes were distinguished: (a) low vegetation ($\leq$21 cm); and (b) tall vegetation ($>$21 cm), i.e., ready to be mown. The vegetation height of a field was determined by weekly measurements at five random places. Vegetation types were determined in June. Two vegetation types were distinguished: (a) the Poö-lolietum type with grass species covering more than 75% (very intensively used, relatively species-poor fields, on which *Lolium perenne*, *Poa annua* and *Poa trivialis* are the most abundant species); and (b) a "rest-type" (all other types of fields, usually more herb-rich and dominated by *Rumex* species and *Bromus hordeaceus*).

A large number of the families was observed daily. Since the daily observations were not mutually independent, a Bonferroni test was used (Hochberg, 1988) to determine the distribution of broods over the grass types.

Surviving mowing activities.

Surviving mowing was determined by means of observations in a total of 72 fields from a blind or a vehicle (in some cases, by riding with the farmer on the tractor). One to four stationary observers were situated at the field edges so that they together could oversee all the ditches. These are frequently used by chicks to escape from the mowing machine. The number of chicks present and the number of those killed as a result of the mowing activities were estimated. In the Oenkerker polder study area,observations were made in all the fields which were mown. In the Ade/Duivenvoorde area and the study areas in Friesland outside the Oenkerker polder, parents and chicks were not individually marked, so that the age of the chicks was unknown. The age of chicks in those cases (48 fields) was described as the relative size in comparison with the parent birds.

Fledging success.

To estimate the daily survival until fledging and the number of young fledged, some assumptions had to be made, as not in all cases could the exact number of young be assessed (Buker & Winkelman, 1987; Table 1).

TABLE 1.Assumptions made for calculating the number of young fledged per breeding pair (based on Buker & Winkelman, 1987).

(1) Black-tailed Godwit fledging period is 25-32 days after hatching (Glutz *et al.*, 1977).
(2) Chicks were considered to have *probably* fledged when the behaviour of parents indicated the presence of young at 16-25 days after hatching.
(3) Chicks were considered to have *certainly* fledged when the behaviour of parents indicated the presence of young >25 days after hatching of the clutch.
(4) The fate of the chicks was considered as *unknown* if observations were made only in the period <16 days after hatching.
(5) The maximum number of young fledged is the number of observed chicks >25 days.
(6) Pairs with 1-2 and 1-3 chicks "probably" or "certainly" fledged are placed under the category "probably or certainly 1 young fledged";
(7) Pairs with 1-4 and 2-3 chicks "probably" or "certainly" are placed under the category "probably or certainly 2 young fledged".
(8) When a marked adult was observed in a group < 26 days after hatching of the young, the pair was considered to have not one young fledged, whereas after 26-30 days, it was considered to have *probably* fledged young.

Effects of sticks with flags.

In 26 fields (size on the average, 1.5-2 ha) in the Ade/Duivenvoorde area, a study was conducted in an attempt to determine the effect of sticks with flags on the presence of families with broods in fields ready to be mown. In 13 fields, three to five garden sticks of three metre length were placed at about 80 centimeters into the ground. A plastic bag was connected at the top. The canes were put down in a "zig-zag" pattern. The distance between the canes was about 20-40 m, depending on the field size. The number of families with chicks present was counted in these experimental fields. The sticks were then left for about 48 hours in the fields, during which no visits were made. After this, the number of families present was again determined. In four fields, the sticks remained 96 hours in the fields, after which the number of families present was once more determined.

In addition, 13 control fields without sticks were visited at the same dates as the experimental fields. The control fields were visited to study the possible movements of the broods due to the influence of the investigator(s).

The sticks might have had a negative effect on continued incubating of clutches. Therefore, the fates of the clutches present in the two types of fields were established. These fates could be successful, preyed upon, deserted or still incubated.

RESULTS

The presence of broods in fields.

Length of stay of broods in fields.

For eleven (1990) and eighteen (1991) families, it could be determined how many days they remained in the nesting field. Families which were disturbed by mowing activities were not included. The families stayed on the average 4.3 days (range, 1-24 days), or 6.5 days (range, 1-27 days), respectively, in the field in which the chicks were hatched. Within a week, 79% of the families had left the nesting field.

Habitat use.

The distribution of Black-tailed Godwit broods was significantly different from a random distrubution (Bonfferoni-test; Hochberg, 1988). Densities of families from 14 to 24 May (to 1 June in 1991) were highest in meadows of the rest-type with short vegetation. In the period from 25 May to 11 June, densities were the highest in meadows of the rest-type with tall vegetation. These fields were mown later than those of the Poö-Lolietum type, so that they still had tall vegetation at this period of the season. In the period from 12 to 23 June, when the meadows of the rest-type were also mown, densities were highest in pastures of the rest-type with either a short or tall vegetation (Figures 1 and 2).

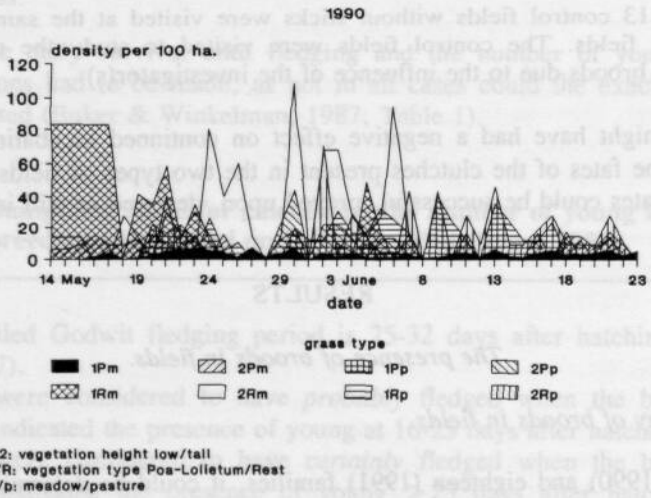


FIG.1. Daily brood densities per grass type in the Oenkerker polder study area in 1990

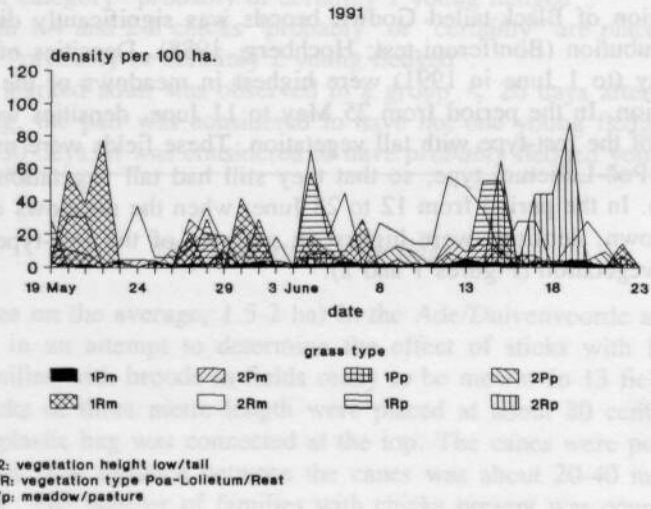


FIG.2. Daily brood densities per grass type in the Oenkerker polder study area in 1991

Chick mortality.

The mortality pattern for chicks of marked parent birds showed that most deaths occurred during the first 7-14 days after hatching. Posthatching mortality in 1991 did not differ much from that 1990 (Figure 3). The minimum survival curve is described by assuming all chicks with unknown fate as dead. The maximum survival included chicks of which the fate was unknown as being still alive. Total mortality was 32-96% (1990) and 50-95% (1991) of the total number of chicks hatched, or 77-87% when using the criteria of Table 1. Daily survival thus was between 0.9043 and 0.9880.

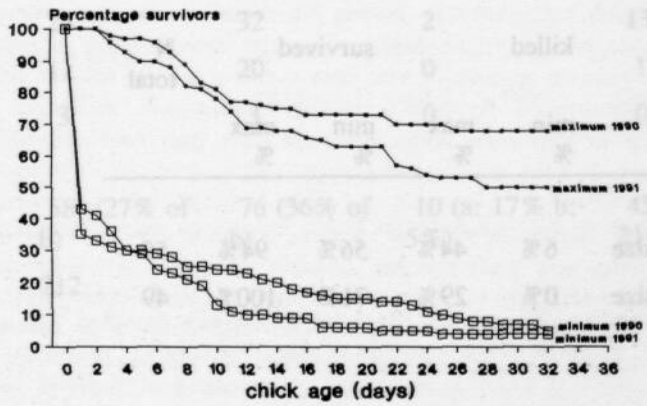


FIG.3. Chick survival curves in the Oenkerker polder study area in 1990 and 1991. Initial sample sizes are n=94 (1990), 118 (1991).

Chick mortality in relation to mowing activities.

The studies in Ade/Duivenvoorde of 1987-1989 and in several locations in Friesland in 1989 showed that a large fraction of Black-tailed Godwit broods was present during mowing activities. In two-thirds (65%) of the 48 fields where observations were made during mowing activities, one or more families were observed. Because the exact age of these young chicks was unknown, a distinction was made between chicks smaller or larger than half of the adult size, which indicates chicks of about two weeks of age.

The total number of chicks killed due to the mowing was estimated at 3-36%. Minimum survival was determined by assuming that chicks saved by the farmer (by

catching them) would otherwise have been killed, while maximum survival was determined by considering chicks saved by the farmer as also having survived without this interference. The survival chances of chicks smaller than half of the adult size seemed to be smaller than those of this size or larger (6-44% killed versus 0-29% killed), but this difference was not significant (Table 2; χ^2 test, $P > 0.05$).

TABLE 2.*Minimum and maximum survival of Black-tailed Godwit chicks during mowing activities with respect to their age (expressed as relative size compared with adults) on 48 fields in Ade and Duivenvoorde 1987-1989 and several areas in the province of Friesland in 1989.*

age class	killed		survived		N total
	min %	max %	min %	max %	
< ½ adult size	6%	44%	56%	94%	50
≥ ½ adult size	0%	29%	71%	100%	49
total	3%	36%	63%	97%	99

Of chicks of which the age was known, 17-59% of the young present during mowing were killed. This equals 5-21% of all chicks hatched, or 7-27% of the total juvenile mortality. Chicks which were preyed upon during mowing activities were included as being indirect mowing victims. Predators take advantage of the fact that the chicks lose their cover if the fields are mown. Chicks present during mowing were up to sixteen days of age. Just hatched chicks (age 0 days) had a significantly higher mortality (38-95%) during mowing than did older (age 1 day and older) chicks (mortality, 5-45%; χ^2-test, $P < 0.05$; Table 3).

TABLE 3.Age-distribution of Black-tailed Godwit chicks present during mowing in the Oenkerker polder study area (1990 & 1991) and the (possible) number of chicks killed due to mowing; chicks preyed upon during mowing were included as being mowing victims ("-" = no observations).

Age (days)	Present during mowing		killed	
	min	max	min	max
0	21	21	8	20
1- 7	23	32	2	13
8-14	11	20	0	12
>14	3	3	0	0
total[a]	58 (27% of b)	76 (36% of b)	10 (a: 17% b: 5%)	45 (a: 59% b: 21%)
total hatched[b]	212			

Productivity.

Productivity in the two study years did not vary much. When taking into account the assumptions mentioned earlier and assuming that the distribution of fledged young/died young is the same within the group of unknown fate (Buker & Winkelman, 1987), the number of fledglings per breeding pair was 0.35-0.58 in 1990 and 0.33-0.61 for the pairs nesting outside the bird sanctuary and 0.70 for the pairs nesting inside the sanctuary in 1991. Differences between years and areas were not significant. The greater part of the losses took place in the chick stage (Table 4).

TABLE 4.Number of eggs, hatchlings and fledglings per breeding pair of marked Black-tailed Godwit pairs in the Oenkerker study area in 1990 and 1991.

site	year	Mean number of eggs per pair	hatchlings per pair	fledglings per pair	Number of pairs
outside the reserve	1990	4.00	2.49	0.35-0.58	37
outside the reserve	1991	3.92	2.75	0.33-0.61	36
inside the reserve	1991	3.80	2.80	0.70	10

Effects of placing sticks in fields to frighten away families.

In fields with sticks, 70% of the Black-tailed Godwit families had left the field (n=23), in control fields, 15% (n=20; χ^2-test, $P<0.005$). When the sticks were left for another 48 hours (1991, 4 fields), the number of families present in the experimental fields was reduced even more, whereas it was almost constant in the control fields. The difference, however, was not significant (Fisher's exact probability test, $P>0.05$).

Concerning clutches present in experimental and control fields: in the exerimental fields after 48 hours, only one of the total of 13 clutches of all five species present was deserted, probably due to the presence of the sticks with flags; in the control fields, none of the 15 clutches was lost during this period (Fisher's exact probability test, $P>0.05$).

DISCUSSION

Fledging success.

In the intensively exploited grasslands in which nest protection took place, the number of young fledged per breeding pair was about 0.3-0.6 (which is about 12-25% fledging success of hatched chicks). This was 0.7 chicks in a reserve area.

Fledging success may even be overestimated for two reasons. Firstly, only birds trapped on the nest were involved in the study, i.e., birds of which at least two-thirds of the incubation time had elapsed. Most of the clutches, however, are lost early in the breeding season (Beintema & Müskens, 1987), so that the trapped birds had already survived the most "difficult" period. On the other hand, lost clutches early in the season are followed by replacement clutches, whereas, later in the season (after the middle of May), this occurs less frequently or even not at all (Van Balen, 1959; Buker & Winkelman, 1987). However, exceptions are possible. Black-tailed Godwits even may start breeding again after loss of chicks (Kruk *et al.*, 1991). As most of the birds were trapped later in the season, there is probably no bias concerning greater survival chances. Secondly, in 1990 thirteen and in 1991 nineteen clutches were saved during mowing activities after they were marked. If the nests had not been marked, the breeding pair presumably would have failed to raise any chicks, although it cannot be precluded that replacement clutches still would have succeeded. The actual number of young produced per pair in intensively exploited grasslands without any form of nest protection, however, will be smaller. At worst, this would be 0.13-0.27 in 1990 and 0.12-0.24 in 1991. These figures are calculated by assuming that every nest found can be attributed to one breeding pair and that breeding pairs of which clutches hatched on or after the date of mowing would be unsuccessful breeding pairs. On the other hand, the number of young fledged per breeding pair may be underestimated. Firstly, some nests were probably deserted due to the research activities. These pairs might otherwise have produced one or more fledged young. Secondly, breeding pairs of which clutches were lost may have produced a replacement clutch outside the study area and have raised chicks. These effects might partly compensate for the lower fledging sucess as calculated above. The estimations based on the assumptions as presented in Table 1 therefore are probably the best possible.

A remarkable result is that the number of young fledged per breeding pair in the reserve area was not significantly different from that in the intensively exploited part of the area. Predation of clutches in the reserve area was higher than in the intensively exploited part, leading to a smaller number of chicks hatched. Some of the chicks, which were hatched in the reserve area left this area and roamed in fields of the intensively exploited part. Buker & Winkelman (1987), who carried out their study under optimal conditions in the Schaalsmeerpolder reserve and management area, reported 0.39-0.65 young fledged per breeding pair in 1984

(n=63) and 0.81-1.18 in 1985 (n=82). Their results of 1984 are also of the same order as the figures for the intensively exploited part of the area in this study. The number of hatchlings in the study of Buker & Winkelman was larger (namely, 3.26 in 1984 and 3.29 in 1985), also suggesting a very poor chick survival in 1984. Those found in this study are in accord with their data. They attribute the low number in 1984 to poor weather conditions (heavy rainfall). The results of 1985 conceivably are extremely high. In the years 1986-1988, there was an increasing predation of clutches, leading to a hatching sucess of even less than 40%, so that the number of fledged young per pair must have been much smaller (Groen & Buker, 1991). A similar study of Fabritius (1975) in the same area in the beginning of the seventies, however, showed much larger numbers of fledged young. Data of Shoppenhorst (1991) of an intensively exploited grassland area (area of Blockland; 130 ha) near Bremen (Germany) show a fledging success of 0.34-0.37 per breeding pair. In the reserve areas near Bremen he found a fledging sucess of 0.47 (in the area of Niedervieland; 497 ha) and 0.98-1.04 respectively (area of Hollerland, 265 ha). Other studies in the intensively exploited part of the Bremen area mentioned in Shoppenhorst (1991) show a fledging sucess in intensively exploited areas varying between 0.17 and 0.53 (average: 0.41), in te reserve areas elsewhere in Germany between 0.3 and 2.0 (average: 1.01). All data in the intensively exploited areas are more or less in accord with those found in our study, whereas those found in the reserve areas are somewhat higher. However, as the methods used in the studies of Shoppenhorst are different from ours, it is unclear to what extent the data are comparable.

According to Beintema & Müskens (1981), at least 1.43 young per breeding pair should fledge if the current population levels are to be maintained. The numbers found in the intensively exploited grasslands of the Oenkerker polder study area, those inside the reserve area, those found in the Schaalsmeerpolder reserve area by Buker & Winkelman (1987) and in most of the studie mentioned in Shoppenhorst (1991), are all smaller. However, as Buker & Winkelman (1987) state, the survival of adults probably is higher than estimated by Beintema & Müskens (1981) and must be of the order as given by Beintema & Drost (1986). Buker & Winkelman base their assumption on the observations in their study area. The necessary recruitment may therefore be much lower, about 0.54-0.95 young per breeding pair, depending on the assumptions made about mortality in the first two years after fledging. A productivity of 0.45 fledged young per breeding pair (the average of the reported 0.3-0.6) would mean that yearly survival of adults should be 0.89. According to Beintema & Drost, the actual figure is 0.88 and survival of fledged young in the first year should be 0.75 (according to Beintema & Drost, the actual figure is 0.4).

Factors affecting chick survival.

The lack of significant differences in chick survival between the intensively exploited grasslands and reserve areas sugests a limited effect of mowing on the mortality of the chicks. Indeed, mortality of chicks as a result of mowing was relatively low. This limited efect is also clear when comparing survival of chicks which were threatened by mowing with those which were not. Fledging success of the former was 15-31%; whereas, for the latter, this was 14-18%. These differences for both the minimum and maximum estimates were not significant (χ^2 test, $P>0.05$). This small effect of mowing can be explained as follows.

Firstly, during the mowing, only a small fraction of the total number of birds hatched is present (27-36%). Van Paassen (1981) found even a lower percentage of about 10%. Nevertheless, it is clear that, when the farmer starts mowing, most of the families wander away in time. Most of them remained for only a short period (usually less than one week) in the field where the chicks were hatched and travelled great distances through different fields (see also Buker & Groen, 1989; Buker & Winkelman, 1987). There may be several reasons for these shifts in the location of families. There may be a lack of shelter in fields due to differences in the rate of growth of the vegetation and the grassland operations. In contrast to other studies, we found that families with broods do not always reach highest densities on the fields with tall grass. More important seems to be the availability of food for young chicks (i.e., insects on leaves), as the families prefer to remain in the herb-rich fields, even when vegetation is short. Food supply for young chicks is less in the most intensively exploited fields (dominated by grasses) than in the more herb-rich ones (Beintema *et al.*, 1991).

Secondly, mortality of chicks due to mowing may be limited, since the losses of chicks during mowing are greatest for just hatched chicks. According to Buker & Groen (1989a), who studied survival of Black-tailed Godwit chicks in a management and reserve area, chicks older than 12 days are more likely to survive the mowing. However, they provided no data on observations in the age-group of 3-11 days. In their study, the total number of chicks killed due the mowing was estimated at about 9% (n=68) of the chicks present. This is a smaller number than found in the intensively exploited grasslands; 89% of the mowing victims in their study were just-hatched chicks. The results of the study in the Oenkerker polder area are in accord with this figure.

Losses of chicks due to mowing in the study presented in this Chapter were estimated at a maximum of more than half of all chicks present, or about one-fifth of the total number of chicks hatched. According to Van Paassen (1981), 30% of the chicks present during mowing, or 3% of all chicks hatched is killed during mowing activities. The minimum estimation of 5% in this study agrees with this. Observations of Vloedgraven *et al.* (1986) show losses of Black-tailed Godwit

chicks present during mowing of 0-21% (n=33). In all cases, the data suggest that losses due to mowing are not dramatic. However, although losses in each plot actually being mown are small, chicks may repeatedly move to new plots which are just ready to be mown due to their preference for tall grass. In 1990 and 1991, however, this was found for only two families, which were observed to be present during mowing in two or even three different fields. The other families were not or only once threatened by mowing. It cannot be excluded, however, that families which had moved outside the study area were also threatened by mowing two or more times. The effect of mowing as a mortality factor in intensively exploited fields nevertheless seems to be less than usually assumed. This is also suggested by Beintema (1991): Black-tailed Godwit chick survival, as estimated from ringing data was not particularly poor as compared with other wader species which have a lower risk of being threatened by mowing activities. Therefore, the greatest proportion of the chicks must die as a result of other factors such as predation, weather conditions or starvation. Beintema (1991) shows that weather conditions (i.e., a wet or a dry spring) have a positive or negative effect on the survival of the chicks. According to Beintema, this is an indirect effect through food availability. In dry years, the older chicks have more problems in reaching the soil fauna, which go deeper into the soil. During the study years, precipitation in May was very light. This will have negatively affected chick survival. It is possible that, in other years, chick survival was much higher and may have compensated (partly) for the poor survival in other years. The data on chick survival reported by Buker & Winkelman (1987) in 1985 and those of Fabritius (1975) suggest that such "highly productive" years may indeed occur. It remains unclear, however, whether such years are also represented in the intensively exploited areas. Therefore, a long-term study would be necessary. The studies of Shoppenhorst (1991) show that within three years there already may be large differences in fledging success between years.

Significance for nature conservation.

The fledging success of Black-tailed Godwit chicks in intensively exploited fields was found to be low and presumably too low to maintain the current population level. However, this survival (at least in some years) may be poor also in reserve areas. This percentage of young fledged (12-25%) is much lower than the 60% estimated by Fabritius (cited in Beintema & Müskens, 1981). Beintema & Drost (1986), however, estimated it at 22% on the basis of ringing data. The maximum estimate of this study agrees with this. Another estimate of Beintema (1991) is about 50%. Black-tailed Godwit adult survival should therefore be higher than 0.68 as estimated from ringing data by Cavé (cited in Beintema & Müskens, 1981) in order to produce enough offspring so that population levels would not decline. As stated above, the survival of adults may indeed be much higher, namely about 0.87-0.89 (Beintema & Drost, 1986; Buker & Winkelman, 1987), which would be high enough to maintain current population levels.

If factors other than agriculture are of great importance for survival, as this study suggests, the losses due to mowing, albeit relatively small, may nevertheless be of significant importance. They may result in the recruitment coming (just) below the "required recruitment" (Beintema & Müskens, 1981).

Possibilities in intensive agriculture for enhancing the fledging success, however, are low. Clutches are more easily protected than chicks. Three measures can be taken to increase the survival of chicks without significantly affecting the farming enterprise. 1). saving chicks during mowing activities; 2). reducing the mortality of chicks due to mowing by chasing them away by putting sticks with plastic bags tied to the top on fields to be mown; or 3). mowing from the centre to the edges of a field (Van Paassen, 1985; Verstrael, 1987). In the intensively exploited grasslands hardly any other measures are possible. More important, therefore, may be to concentrate in the first place on the reduction of losses of clutches, so that larger numbers of chicks may hatch.

Despite this poor chick survival, the most recent figures on Godwit population in the period of 1984-1990 levels suggest an increase (Verstrael *et al.*, 1990). Therefore, there are no indications at all, as yet, for a decline in population sizes due to too low productivity.

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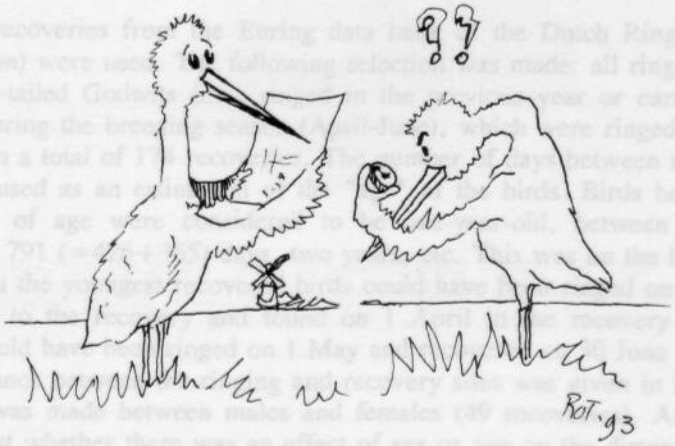
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Appendix to Chapter 7

Natal philiopatry in the Black-tailed Godwit (*Limosa limosa* L.)



INTRODUCTION

Several wader bird species show nest-site fidelity (e.g., Gratto *et al.*, 1985; Soikelli, 1970; Thompson & Hale, 1989). About 80-90% of breeding Black-tailed Godwits (*Limosa limosa* L.) return to the environment of the nest site in the previous year. Most of these birds make a new nest within 100m of their old nest site (Buker & Winkelman, 1987 and Groen, 1992 mention 73%; Jona, 1979, mentions 75% within 150m). Such behaviour might lead to physiological and ethological adaptation to local circumstances.

There is less information on the nest-site choice of meadow bird chicks. If chicks show breeding-site fidelity to their parent's breeding sites, local recruitment might be extremely important for maintaining local population densities and, moreover, might lead to site-dependent natural selection. Many studies on Charadriiform birds show natal philiopatry (i.e., the return of birds to the area of their birth), which in some cases is sex-biassed (Gratto *et al.*, 1985; Redmond & Jenni, 1982; Skeel, 1983; Soikelli, 1970; Thompson & Hale, 1989).

Results of Groen (1992, also mentioned in Bruggink, 1992) indicate such behaviour for Black-tailed Godwit as well. The number of observations in this study, however, is very low (16). In this paper I wil analyse ring recoveries of Black-tailed Godwits to test the hypothesis that chicks return to their parent's breeding grounds.

The ecological and evolutionary consequences of natal philiopatry would lead to local catastrophies of bird populations when local conditions change suddenly and therefore provide arguments for a constant management of breeding sites.

METHODS

Data of ring recoveries from the Euring data bank of the Dutch Ringing Centre (Vogeltreksation) were used. The following selection was made: all ring recoveries of adult Black-tailed Godwits (i.e., ringed in the previous year or earlier) in the Netherlands during the breeding season (April-June), which were ringed as chicks. This resulted in a total of 174 recoveries. The number of days between ringing and recovery was used as an estimation of the "age" of the birds. Birds between 259 and 426 days of age were considered to be one-year-old, between 624 (i.e., 259+365) and 791 (=426+365) days, two years, etc. This was on the basis of the assumption that the youngest recovered birds could have been ringed on 15 July of the year prior to the recovery and found on 1 April in the recovery year. The oldest birds could have been ringed on 1 May and recovered on 30 June of the next year. The distance between the ringing and recovery sites was given in kilometers. A distinction was made between males and females (49 recoveries). An ANOVA was used to test whether there was an effect of sex or age on the distance between the recovery and the ringing sites.

The direction of the recovery (in degrees from ringing site to recovery site) was subdivided into five classes: 1). no direction (i.e. the ringing site is the recovery site); 2). north (between 315 and 45 degrees); 3). east (between 46 and 135 degrees); 4). south (between 136 and 225 degrees); and 5). west (between 226 and 315 degrees).

RESULTS

The "age" of recovered adult birds varied between one and 26 years. The median was four years (Figure 1). This means that Black-tailed Godwits may return to the breeding ground in their second (calender) year.

Sixty-six percent of all recoveries was within 5 kilometers of the ringing site, 77% within 10 km and 90% within 23 km; the median distance was 4 kilometers, the average was 9.3 km (Figure 2).

In the ANOVA, no effect of sex or "age" on the distance between ringing site and recovery site could be demonstrated ($P=0.19$ for sex and $P=0.98$ for "age"; $N=49$).

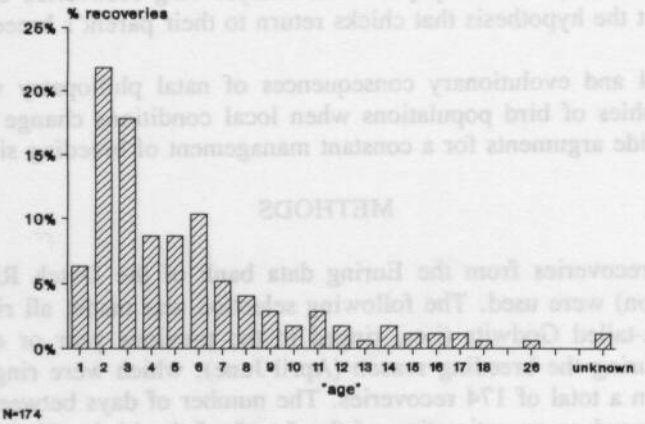


FIG.1. "Age" (in years) distribution of adult Black-tailed Godwits in the breeding season (April-June), ringed as chicks, at the recovery site.

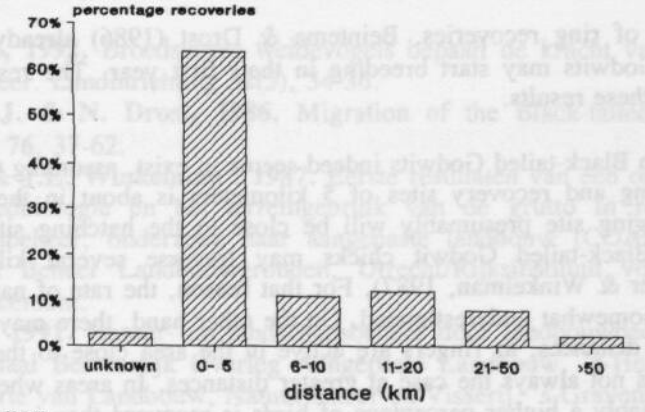


FIG.2. Distance between ringing site and recovery site of adult Black-tailed Godwit during the breeding season (April-June) ringed as chicks.

The direction of the recovery showed a significant effect for northern and eastern directions (61% when "no direction" is excluded) as opposed to southern and western (χ^2 test, $P<0.01$; Figure 3).

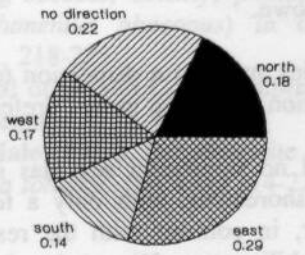


FIG.3. The direction of the recovery (from ringing site to recovery site) of adult Black-tailed Godwit in the breeding season (April-June), ringed as chicks.

DISCUSSION

On the basis of ring recoveries, Beintema & Drost (1986) already showed that Black-tailed Godwits may start breeding in their first year. The results presented here confirm these results.

Phiyliopatry in Black-tailed Godwits indeed seems to exist, assuming that a distance between ringing and recovery sites of 5 kilometers is about in the same polder area. The ringing site presumably will be close to the hatching site, albeit it is known that Black-tailed Godwit chicks may traverse several kilometers until fledging (Buker & Winkelman, 1987). For that reason, the rate of natal philiopatry may even be somewhat underestimated. On the other hand, there may be some bias towards short distances, as ringers are active in the area close to the ringing site, whereas that is not always the case at greater distances. In areas where ringers are active, presumably a higher percentage of birds is recoverd than in areas in which no ringers are active. It may be that the distribution of suitable breeding sites largely determines the chances of returning to the breeding site. However, suitable breeding sites occur in most of the grasslands and are not limited to only a few good areas.

The hatching-site fidelity of chicks is lower than the nesting-site fidelity of the adult breeding birds. Of the adult birds, about 75% returned to within 100 m of the breeding site (Buker & Winkelman, 1987), whereas only 23% of the chicks was recovered within less than one kilometer from the ringing site.

The recovery during the nesting season will almost certainly imply that the bird was nesting. For 37 recoveries (22%) this was indeed reported, whereas, for the other recoveries, it was unknown.

The direction of the recoveries suggests a dispersion towards northern and eastern directions. Why such a direction should be more "preferred", however, is unclear.

Black-tailed Godwits showed no significant sex bias in natal philiopatry. This is common among Scolopacid shorebirds, with only a few exceptions (Redmond & Jenni, 1982). It is, however, in contrast with the results of Groen (1992), who found male biassed natal philiopatry. His study, however, concerns only 16 observations.

The results demonstrate the great vulnerability of local populations of birds and show that enhancing breeding success may be of great importance for local population levels.

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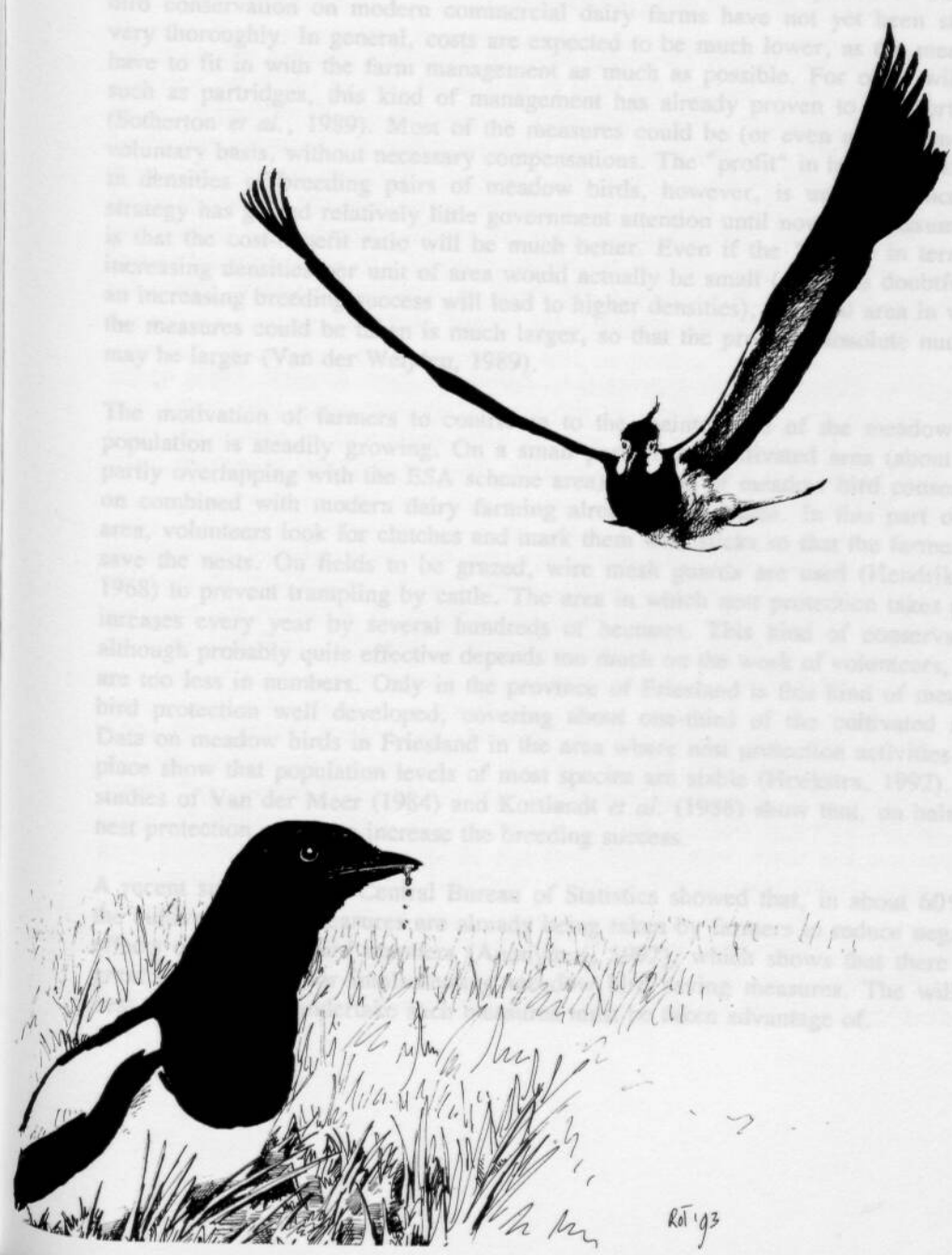
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Chapter 8

Prospects for meadow bird conservation in the Netherlands





In this chapter I will discuss the possibilities and limitations of a strategy of interweaving the interests of meadow bird conservation and commercial (dairy) farming based on the results of the sudies of this thesis and seen in the light of future developments. I will end this chapter with some recommendations for instruments for meadow bird conservation.

In the Netherlands and other European countries, the costs and profits of meadow bird conservation on modern commercial dairy farms have not yet been studied very thoroughly. In general, costs are expected to be much lower, as the measures have to fit in with the farm management as much as possible. For other wildlife, such as partridges, this kind of management has already proven to be worthwile (Sotherton *et al.*, 1989). Most of the measures could be (or even are) taken on a voluntary basis, without necessary compensations. The "profit" in terms of increase in densities of breeding pairs of meadow birds, however, is unclear, since this strategy has gained relatively little government attention until now. The assumption is that the cost-benefit ratio will be much better. Even if the "profit" in terms of increasing densities per unit of area would actually be small (which is doubtful, as an increasing breeding success will lead to higher densities), the total area in which the measures could be taken is much larger, so that the profit in absolute numbers may be larger (Van der Weijden, 1989).

The motivation of farmers to contribute to the maintenance of the meadow bird population is steadily growing. On a small part of the cultivated area (about 5%, partly overlapping with the ESA scheme area), a form of meadow bird conservation combined with modern dairy farming already takes place. In this part of the area, volunteers look for clutches and mark them with sticks so that the farmer can save the nests. On fields to be grazed, wire mesh guards are used (Hendriksma, 1968) to prevent trampling by cattle. The area in which nest protection takes place inreases every year by several hundreds of hectares. This kind of conservation, although probably quite effective depends too much on the work of volunteers, who are too less in numbers. Only in the province of Friesland is this kind of meadow bird protection well developed, covering about one-third of the cultivated area. Data on meadow birds in Friesland in the area where nest protection activities take place show that population levels of most species are stable (Hoekstra, 1992). The studies of Van der Meer (1984) and Kortlandt *et al.* (1986) show that, on balance, nest protection measures increase the breeding success.

A recent survey by the Central Bureau of Statistics showed that, in about 60% of the cultivated area, measures are already being taken by farmers to reduce negative effects on meadow bird numbers (Anonymus, 1992), which shows that there is a great preparedness for implementing meadow bird saving measures. The willingness of farmers to undertake such measures must be taken advantage of.

More recently, a study on a demonstration farm in the western peat area of the possibilities of meadow bird protection combined with commercial farming has been started (Remmelink *et al.*, 1992). The results will be tested in practice. The consequences for the farmer will also be studied. The area in which commercial farming is combined with meadow bird conservation might therefore increase in the near future.

The results of the studies reported in this thesis have made plausible that "fine tuning" of grassland operations in intensively exploited grasslands is possible and may be valuable for meadow bird conservation.

It appeared that *rolling and harrowing* have no disastrous negative effect on the nesting success. This is beacuse the scale as well as the date on which the activities are carried out normally ensure that only a relatively small proportion of all clutches of the early breeding birds in the breeding season is confronted with these activities. High water tables increased the extent of rolling and resulted in a later date for rolling. Therefore, the need for measures to save clutches in these types of fields is much greater, although these fields are usually exploited less intensively. Relatively simple measures such as not rolling strips of 2 m width along grips and ditches and rolling one week earlier will result in significantly smaller losses for the Lapwing due to the rolling; however, the "profit" is small.

The negative effects of *early mowing* (i.e., before 15 June; Reyrink, 1988) on the nesting success of meadow birds in the present situation were also lower than expected. Now that factors affecting mowing dates and timing of nesting are more clear, it is possible to predict "safe" mowing dates on the basis of ground water levels and spring temperature.

The survival chances of chicks were also less negatively affected by mowing activities than expected (Buker & Groen, 1989). As the greater part of mortality must be due to factors other than mowing (see chapter 7), however, the possibilities for enhancing the fledging success by farmers in intensively exploited areas are small or even not existent.

These results mean that species such as Lapwing, Black-tailed Godwit, and - to a lesser extent - Redshank may benefit from the strategy which attempts to integrate farming and wildlife interests. The more critical meadow bird species such as the Ruff and the Common Snipe at present require specific conditions which presumably interfere too much with current methods of commercial dairy farming. For these species nature reserves will be more valuable in maintaining the populations.

The strategy of "integration" of farming and nature conservation interests on a farm level therefore allows perspective for the Dutch meadow bird community, but implies some limitations as well. Thus, at present, it seems that there is no single

adequate strategy for meadow bird conservation on its own. Both strategies should therefore be combined in order to maintain the Dutch meadow bird populations at fairly high levels.

Due to new developments, it is also necessary to continually seek for new possibilities for meadow bird conservation. Despite developments in dairy farming which have negatively affected breeding success, most of the Dutch meadow bird populations are still breeding in the intensively agriculturally exploited grasslands. Therefore, developments affecting dairy farming in the Netherlands will always affect the possibilities for meadow bird conservation within both strategies. Meadow bird conservation on commercial dairy farms may be of importance due to the following reasons.

Firstly, there is a biological reason. The population on the intensively exploited grasslands at least for a part will be adapted to rapid changing conditions affecting the breeding success. This becomes more clear when taking into account the studies which show the earlier breeding of birds during this century and the breeding of Black-tailed Godwit and Redshank on arable land (see the Introduction for more details). Such, on an evolutionary scale, "rapid" adaptations are also known from other bird species, such as herons and gulls (SOVON, 1987). The integration of agriculture and meadow bird conservation has the advantage that a more broad "spectre" of environmental conditions will be present (to which populations will partly adapt), than in designated reserve areas only. This resulting in a greater genetic diversity, which may be favourable for maintaining populations.

Secondly, there are social reasons for maintainting meadow bird populations outside reserve areas. Nature conservation and development in suburbs, industry areas etc. may have high conservation value. It also may be important that nature management will stay a part of the farmers' business. For a long period, farmers have been considered as being dumb "financial profit maximalisators", which has appeared to be a wrong assumption (Van der Ploeg & Roep, 1990). Now we have seen that such an appoach has a "boomerang effect" on the environment (pollution and loss of conservation value). Therefore, nowadays the emphasis is laid on a more "sustainable farming system" (see below: National developments in dairy farming).

Thirdly, it would be a great loss for our direct environment if we had to travel large distances for seeing a few meadow birds. The recreational value of meadow birds still is of large importance (cf Van Zomeren, 1993).

Fourthly, if we want to maintain current population levels, the conservation of meadow bird populations outside reserves even is inevitable. Because of the huge amounts of money necessary for reserves and management areas, the development in these kind of areas is slow. Furthermore, the rate at which these areas are

established depends on agricultural developments as well. For example: many farmers at the moment do not have any need for buying roughage from the reserve areas. Therefore, the costs of reserve areas have become much higher. As a result, budgets for nature conservation come under pressure. In times of economical recession with many budget cuts this inevitably will lead to less purchase of the reserves and even to changes in the management which are less favourbale for the meadow bird population (e.g. nature development schemes, see below).

New developments may hamper or favour meadow bird conservation on the intensively exploited grassland area. These will discussed below.

New chances and threats to the Dutch meadow-bird population.

The following developments which may be relevant to the meadow bird populations can be discerned (cf Terwan, 1992):

1). international developments in dairy farming policy (i.e., the Common Agricultural Policy of the EC and GATT);
2). national developments in agricultural policy;
3). developments in environmental policy;
4). developments in nature policy;
5). developments in the policy for the rural areas;
6). social developments.

International developments in dairy farming.

Developments in dairy farming are of great importance to the Dutch meadow bird populations. Dairy farming has rapidly changed since 1950 and is still changing, mainly as a result of EC policy. Since the Community has taken over the most important aspects of the agriculture and food policies, the Common Agricultural Policy is now the major factor influencing farmers' production and decisions. In addition, EC policy on environmental issues is also affecting Dutch agriculture. The policy aimed at the reduction of leaching of nitrogen, e.g., has great significance for dairy farming in the Netherlands and subsequently for the meadow birds (see Chapter 3). The EC policy (MacSharry plans) for the near future, which has also been part of the GATT agreement, is (Commission of the European Communities, 1991):

The maintenance of the milk quota system for dairy farming. National quotas will be reduced by 5% (at the farm level with an average of 4%). Countries are allowed to exempt small farmers (producing less than 200 tonnes of milk) and to redistribute 1% in less favoured areas. During 10 years, compensation will be given (50 ECU per tonne milk). Furthermore, dairy product prices will be lowered

by 10%. For extensive farms (less than two cows per ha), a yearly compensation of 75 ECU per animal (only for the first 40 cows) will be supplied.

The limit on the milk quota may lead to lower demands for land and thus result in lower land prices. Because the growth of the milk production is limited, the only possible means of increasing income is by lowering costs for the concentrates and other costs per cow. Therefore, the use of fertilizer and concentrates will be less, resulting in a higher demand for land. A higher demand for land, however, will increase the land prices. On balance, there will be no great changes in the area of land in agricultural use. Therefore more extensive land use (i.e., lower milk production and lower fertilizer supplies per ha) would be possible. This, in principle, increases the possibilities for meadow bird-friendly grassland management. On the other hand, it also means that roughage becomes more important and therefore grass is cut as early as possible, as the young grass has a high protein content (which is important for a high milk production) and can be digested more easily. Other grazing systems such as strip grazing and zero grazing for that reason may also become more common. This "pressure" on a shift towards very early cutting dates and intensive grazing may have detrimental effects on the breeding success of the meadow birds (Musters *et al.*, 1986). As very young grass will lead to higher nitrogen losses, the shift towards very early cutting dates (i.e., at the end of April or the first week of May) has presumably now been halted (Terwan, 1992).

The GATT eventualy may lead to a milk production against world market prices. This will cause the enlargement of farms as well as an intensifaction of the land use, which will be disadvantegeous to the meadow bird population. Some technical developments which then will be stimulated already are being introduced: the milk robot and heavier machinery. It may be expected that in case of its application, the milk robot will lead to a shift from grazing towards zero grazing and probably from grass to other fodders (i.e., maize). Both will be of negative value for the meadow bird populations. For the moment, however, it is not to be expected that the milk robot will be applied on a large scale.

The development and use of heavier machinery, in particular mowing machines enable the farmers to mow larger areas within a shorter time period. Such a development will be disadvantegeous for the survival of both clutches and chicks of meadow birds.

National developments in dairy farming.

The Dutch national Government strives for a "sustainable agriculture". The policy consists mainly of its own interpretations of the EC policy. The most important are:

1). The milk quota system. Since 1989, transfer of the milk quota has been possible. Therefore, a concentration of milk production on farms with a large quota and a favourable ratio between costs and benefits may be expected. This will be unfavourable for the meadow birds in these areas. Extensification of other areas, on the other hand, may be favourable, but over-extensifaction would be a threat, as it would lead to neglect of fields or even areas as a whole.

The milk quota system has caused an increase in the average milk production per dairy cow. Since the introduction of milk quotas in 1984, the numbers of livestock have decreased and milk supplies per dairy cow have significantly increased. The higher milk production has led to lower cattle densities, which may be favourable to the meadow birds (more possibilities for changes in grassland use). A part of the grassland area, however, is being increasingly used for sheep grazing. This will reduce the positive effects.

2). Land development. The conservation of wildlife will increasingly become a part of land development programmes. Drainage in the peat areas will now be subsidized only up to 60 cm below the field surface. This may lead to better chances for meadow bird life.

Environmental policy.

The most important environmental policy affecting meadow bird life is the legislation on manure application. A ban on spreading manure in the winter and the obligation to work the manure into the soil in the spring cause more nests to be destroyed (for more details, see chapter 3). For continued successful meadow bird management, it will be necessary to actively promote and develop methods of spreading manure very early in the spring so that the nests are preserved. The development of other techniques which require a low bearing capacity of the soil, however, proceeds very slowly and is not far enough yet to be a promising alternative. Nevertheless, the new legislation will be applied to the peat areas in 1994.

In general, the manure policy will lead to an increasing demand for land in order to reduce loss of minerals, costs for fodder and costs for levies (on overproduction of manure and possibly on fertilizer). Environmental measures will also induce dairy farmers to grow other crops such as maize and beets at the cost of the grassland area. This will lead to a decrease in the suitable breeding area for some species such as Black-tailed Godwits and Redshanks. The Lapwing and the Oystercatcher, however, may benefit from this development, because they also breed on arable land in high densities.

Nature policy.

A major development in nature policy in the Netherlands is the idea of "nature development". In this vision, large areas are sought where human activity is only aimed at the creation of conditions corresponding with actual or potential "natural processes" already present or "potentially present". The condition of nature during the last interglacial period is used as a reference point (RMNO, 1988). This vision is directly connected with the role of man in nature conservation. For the lowland peat areas, this means the development of large marshy areas, i.e., the inundation of entire peat polder areas.

Apart from the direct loss of meadow bird breeding areas, the withdrawal of large areas from agricultural production has consequences for the remaining agricultural area. The dairy farmers will namely produce the national quota in the remaining area. Thus, on balance, there will be more environmental pressure on the remaining agricultural area. As a result, the chances of meadow bird conservation in the remaining area will become smaller. Therefore, it should be realized that, if current population levels of meadow birds are to be maintained, care should be taken in developing these plans. The development of such large marshy areas may both directly and indirectly be at the cost of the conservation of the meadow birds.

On the other hand, the national nature policy also includes the increase in the area of ESAs. As stated earlier, the effects of this policy on population levels of meadow birds are not quite clear.

Policy for the rural areas.

Many of the rural areas, in particular in the western part of the Netherlands, are rapidly disappearing as a result of urbanization. About 40% of the non-agricultural claims on the land is meant for roads and town planning. Furthermore, there are claims for nature development plans (see above) and recreation. Loss of agricultural land for other purposes in most cases, if not all, means a loss, direct and indirect (by disturbance) of suitable breeding areas for the meadow birds. According to estimations of the Dutch Agricultural Economical Institute, about 60,000 ha of more than 2,000,000 ha cultivated area will be available for non-agricultural purposes in the year 2000. For the grassland area, a decrease of about 2.1% (i.e., about 27,500 ha) of the present area (1,312,600 ha) is to be expected (Terwan, 1992).

Social developments.

The most important social development is that there is an increasing interest of the general public in nature conservation and environmental issues. Increasingly, farmers are also beginning to see the importance and need for nature conservation.

On the other hand, the environmental regulations lead to increasing resistance of the farmers to governmental measures. The environmental laws themselves demand much attention and investments of the farmers. As more and more rules come into force, farmers may become demotivated. As a result, the nature conservation aspects may attract less attention.

Meadow bird conservation in the future.

As described above, there are many developments which may affect the meadow bird populations in the near future, in both positive and negative ways. The new threats to the meadow bird populations in the Netherlands may partly reduce or completely abolish the positive effects of the current and future efforts. It is clear that the meadow birds may well adapt to changing conditions such as earlier mowing and habitat changes (for more details, see the Introduction). The adaptations may therefore mitigate the expected negative effects. The adaptations themselves, as well as adaptations to new conditions will, however, be limited in number and possibilities and in no case could be an excuse for not taking any measures at all. The changing conditions, however, could be a challenge for nature conservationists to find new ways of meadow bird conservation and for an increasing application of already existing valuable measures.

There seems to be considerable scope for implementation of meadow bird conservation on intensive dairy farms, although the introduction of the measures is (partially) hampered by several developments, such as nature development programmes and EC agricultural and environmental policy. These developments are seen by most of the Dutch farmers as a threat. They make them wary of taking action aimed at wildlife conservation in fear of being confronted with severe restrictions on their farm management (Schönwetter, 1992). In addition, the high financial input for nature reserves and management areas means that there is severe competition for financial means between this and other kinds of meadow bird conservation. If a good balance is not found between conservation in ESAs and in the "normal" agricultural areas (which requires further study), this could mean that, within several years, the meadow bird populations on convential commercial dairy farms would be severely reduced. Only small populations would remain on a small, fragmented and limited part of the dairy farms, i.e., those situated in the ESAs. Therefore, efforts to save meadow bird populations should be as effective as possible and not be mainly limited to ESAs.

The main instruments for meadow bird conservation could be developed by creating new opportunities for conservation by the farmers themselves rather than imposing limitations by means of stricter regulations than are in force at present. This means that forms of land use could be strived after which prevent a "rolling off" of intensive agriculture on the environment, or even, a agriculture which serves the environment and other aims. Farmers themeselves nowadays feel the

need for such a kind of agriculture, as does society. Therefore, the following instruments may be valuable:

1). An increase in studies and experiments on wildlife conservation on modern dairy farms. Research into more promising opportunities on the farm to lend nature a helping hand will have to be carried out more frequently. Furthermore, it is desirable that the various forms of agricultural nature management be thoroughly studied in order to determine their cost effectiveness. In principle, policy makers should be interested in such studies, as they will give a firmer basis to the discussion now being carried out in the nature conservation movement as to which strategy should best be chosen. The need for such studies, which from the beginning try to integrate several aims, may seem obvious. However, the most common policy is one of "repairing arisen new problems retrospectively". This can be illustrated by the policy concerning the new manure legislation (see chapter 4 of this thesis).

2). An increase in wildlife conservation advice. There is a increasing demand from farmers for information on wildlife conservation. In the Netherlands, the Centre for Agriculture and Environment (CLM), distributes leaflets on meadow bird conservation (Van Paassen, 1985) and courses on meadow bird management are given. This kind of advice, unfortunately, not in all cases has a good follow-up. There are some good examples of continuous cooperation between farmers and nature conservationists (e.g., in the peat area of Waterland, north of Amsterdam and in the province of Friesland). Farmers, however, in most cases need intensive assistance and "on site" advice instead of general information and a regular feedback in order to make the conservation efforts more effective. Therefore, a group of conservation advisers, comparable to the Farming and Wildlife Advisory Group in Great Britain (Kruk, 1991), is to be recommended. In the province of Zuid-Holland, a so called "meadow bird coordinator" was appointed for two years (Provincie Zuid-Holland, 1992). He may be very useful in giving advice on meadow bird conservation on modern commercial dairy farms and is also capable of training volunteers (both in practice and in courses) who may assist farmers in protecting clutches. Such a coordinator is present in the provinces of Noord-Holland and Overijssel as well.

Besides the advices, also in the agricultural colleges more attention could be paid to integrating wildlife conservation and farm management. Only recently, such courses in some colleges have been started (Koomen, 1991).

3). An increase in relatively cheap means for meadow bird conservation. These measures range from informal unpaid to formal paid positions. Financial stimuli may in some cases be necessary. They should include not just the usual compensation for restrictions in management agreements, but also investment subsidies and rewards when positive effects on nature have been realized. The most recent and

promising example of the latter is a system of paying for conservation results as an additional provision of the Dutch ESA scheme. The general idea is to pay farmers for the actual results they achieve without prescribing any measures. Such a system would more appeal to some of the farmers than the existing ESA scheme, as, at present, there is a fixed level of compensation for farmers who comply with the restrictions, but there is no incentive for doing conservation well or better. It could appeal to the farmer as an entrepeneur if he was paid for results (Van Paassen, 1991; Van Strien *et al.*, 1988). This suggestion has received support from both some of the farmers' and nature conservation organizations (Kruk & Ter Keurs, 1989). It is principally a more cost effective system: only wildlife which is actually present is being paid for. The financial reward itself will probably be much smaller than in the present ESA scheme. The idea of "Nature production" is now being tested experimentally (Twisk *et al.*, 1992).

4). A reform of the EC agricultural policy. EC measures could create more space for wildlife conservation in the rural areas. As a matter of fact, this requires reform of the EC Common Agricultural Policy. A first proposal for such a reform has been offered by Woods *et al.* (1988). The main core of reforming the EC policy should be a decrease in subsidies on agricultural products and an increase in subsidies on activities which actually enhance nature and landscape values. A first small step in that direction has now been made. EC Policy usually includes extensive legislation. It should, however, be realized that the willigness of farmers to accept such new legislation is limited. Therefore, new legislation should be an outermost means.

The means mentioned above (additional to the Dutch ESA scheme) might be capable of conserving a unique and characteristic part of the Dutch avifauna.

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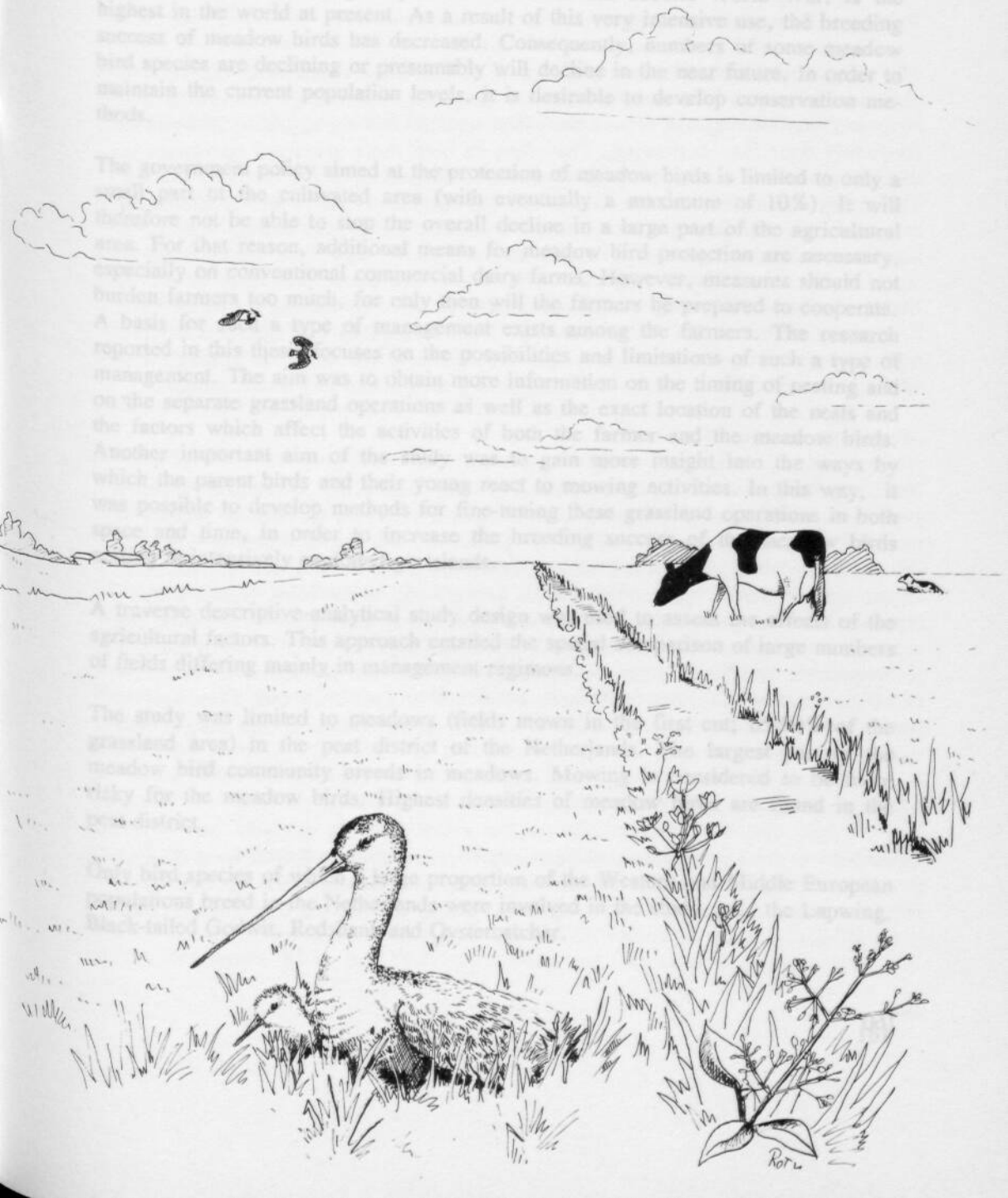
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Chapter summary



Meadow birds are ground nesting birds breeding in grasslands in the Netherlands. They are the "product" of cattle husbandry in the Netherlands since the Middle Ages. The Dutch meadow bird populations are of international importance, as a large proportion of the total number of Northwestern and Middle European breeding pairs is breeding in the Netherlands. Most of them breed in the intensively exploited grasslands. The level of intensification of dairy farming in the Netherlands, which has greatly increased since the Second World War, is the highest in the world at present. As a result of this very intensive use, the breeding success of meadow birds has decreased. Consequently, numbers of some meadow bird species are declining or presumably will decline in the near future. In order to maintain the current population levels, it is desirable to develop conservation methods.

The government policy aimed at the protection of meadow birds is limited to only a small part of the cultivated area (with eventually a maximum of 10%). It will therefore not be able to stop the overall decline in a large part of the agricultural area. For that reason, additional means for meadow bird protection are necessary, especially on conventional commercial dairy farms. However, measures should not burden farmers too much, for only then will the farmers be prepared to cooperate. A basis for such a type of management exists among the farmers. The research reported in this thesis focuses on the possibilities and limitations of such a type of management. The aim was to obtain more information on the timing of nesting and on the separate grassland operations as well as the exact location of the nests and the factors which affect the activities of both the farmer and the meadow birds. Another important aim of the study was to gain more insight into the ways by which the parent birds and their young react to mowing activities. In this way, it was possible to develop methods for fine-tuning these grassland operations in both space and time, in order to increase the breeding success of the meadow birds nesting in intensively exploited grasslands.

A traverse descriptive-analytical study design was used to assess the effects of the agricultural factors. This approach entailed the spatial comparison of large numbers of fields differing mainly in management regimens.

The study was limited to meadows (fields mown in the first cut; 65-90% of the grassland area) in the peat district of the Netherlands. The largest part of the meadow bird community breeds in meadows. Mowing is considered to be more risky for the meadow birds. Highest densities of meadow birds are found in the peat district.

Only bird species of which a large proportion of the Western and Middle European populations breed in the Netherlands were involved in the study, i.e., the Lapwing, Black-tailed Godwit, Redshank and Oystercatcher.

Data on grassland exploitation were obtained from the farmers and from personal field observations. Nests were sought during the breeding season and individually marked. The fate of each nest was recorded. In addition, observations were made on chicks present during mowing activities.

Data on survival and habitat use of chicks were obtained by observations of individually marked parent birds trapped on the nest as well as ringed chicks.

Rolling and harrowing. (Chapter 3)

The extent and dates of rolling and harrowing will largely determine the survival chances of meadow bird clutches early in the spring. Knowledge concerning this, however, was lacking and it was therefore studied. Rolling appeared to be more frequently done than harrowing. The effect of both these grassland operations on clutches present is disastrous. Rolling was more important to the breeding success. The wetter a field, the later the date of rolling. High water tables also increased the extent of rolling activities. Heavy rainfall in March led to later rolling. Rolling in most years affected the nesting success of the Lapwing only. Nest losses could be significantly reduced by rolling one week earlier than usual; preferably before 21 March if possible. Lapwing clutches could also be saved by leaving a strip of about 2 m along furrow drains and ditches free from rolling, as this species showed a high preference to nest in these strips. To eliminate the need for rolling, it is advised to deny cattle access to the fields during the autumn and winter months.

Manuring. (Chapter 4)

New regulations introduced for spreading slurry in order to reduce nitrogen emissions, will presumably have a severe negative effect on the nesting success of most of the meadow bird species. In particular, the early breeding Lapwing (*Vannellus vanellus*) and Black-tailed Godwit (*Limosa limosa*) are at risk. Soil fauna, notably leather jackets (*Tipulidae* larvae) and earthworms (*Lumbricidae*), represent a major part of the diet of these birds, particularly early in the breeding season when clutches have to be formed. No single negative effect at all of the new techniques on soil fauna could be demonstrated. For the protection of the early breeding meadow birds, new machinery which can be used even with a low bearing capacity of the soil must be developed, so that slurry can be spread before their nesting season.

Mowing. (Chapters 5 and 6)

In contrast to former studies, considerable differences and variations were demonstrated in both nesting dates and mowing dates in different fields as well as in different years. The factors affecting both timing in mowing and nesting were

studied in order to make possible predictions for "safe" mowing dates for meadow birds, i.e. facilitating a sufficient breeding success.

Differences in both mowing dates and nesting dates in different fields were positively correlated with dates of fertilizing. The effect of timing is presumably caused by differences in water tables: higher tables resulting in later dates of fertilizing and lower biomass of soil fauna. As a result of this, for both Lapwings and Black-tailed Godwits, synchronization between nesting dates and mowing dates reduces the negative effects on the nesting sucess in early mown fields. Postponing mowing dates in early mown fields in order to increase the breeding success of these species may therefore be limited to a period of 1-2 weeks after the current mowing dates. The costs to the farmers in that case would be about Dfl. 110,-/ha.

Differences in both mowing dates and nesting dates between years were correlated with spring temperatures. As a result, there are no systematic differences in nesting success in different years. Early mowing in some years therefore does not necessarily mean a severe decline in the nesting success. The degree of this nesting success, however, may be too low to maintain current population levels. Here also, postponing the mowing dates for a period of 1-2 weeks would be sufficient for increasing the nesting success to such a level that it would lead to the maintainance of the current population levels.

Effects of mowing on survival of chicks. (Chapter 7)

Knowledge of fates of chicks in intensively exploited grasslands was almost completely lacking. In this type of grassland, Black-tailed Godwit chicks in particular may be vulnerable to mowing activities, as broods of this species are usually found in the taller grass. The mortality of chicks due to mowing activities, however, was limited to a small percentage of the total number of chicks born. Only very young, just hatched chicks ran a risk of dying as a result of the mowing. Older chicks in most cases were capable of escaping or wandering away before the mowing started. The number of chicks present during mowing can be reduced even more by placing sticks with plastic bags tied to the top in the fields ready to be mown. In intensively exploited grasslands, the number of fledged young per breeding pair did not significantly differ from that in management and reserve areas. This number, however, was probably too low to maintain the population at the same level. Other factors affecting chick survival such as weather conditions, predation and food supply are presumably of greater importance to chick survival. Nevertheless, although mowing losses are actually small, these may still be of considerable importance. Protection of chicks, however, is much more difficult than the protection of clutches.

On the basis of ringing data, a great breeding site fidelity of Black-tailed Godwit chicks was shown. More than 60% of the birds was recovered within a range of 5

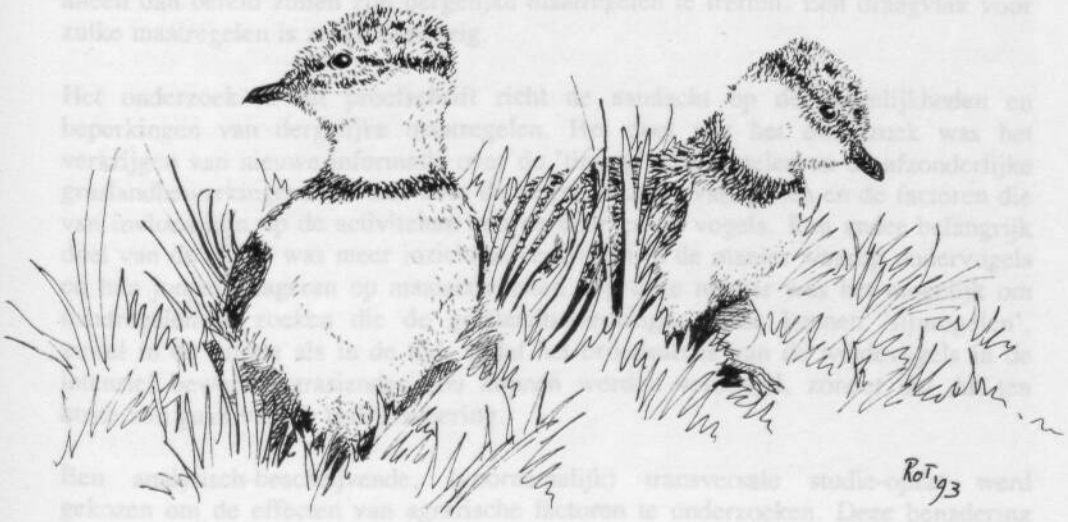
km from the site where they were ringed as chicks. This means that increasing the breeding success may increase the number of the local population of breeding pairs. As a matter of fact, it implies also a great vulnerability of local populations for extinction.

Prospects for meadow-bird conservation. (Chapter 8)

There is no single strategy which may be effective for meadow bird conservation in the Netherlands. Both nature reserves and management areas as well as implementation of measures for meadow-bird conservation on conventional commercial dairy farms are necesarry. The latter, however, has received too little attention up to now. New threats to the meadow bird population, such as the new manure legislation and EC policy may reduce the positive effects of the current efforts for meadow bird conservation. They represent a new challenge for conservationists. Some recommendations for maintaining the current population levels are given.

Samenvatting

Weidevogelbescherming op moderne commerciële melkveehouderijbedrijven in het veenweidegebied van Nederland: mogelijkheden en beperkingen



Weidevogels zijn een groep van vogels, voornamelijk steltlopers, zoals Kievit, Grutto en Tureluur, die voor hun voortplanting afhankelijk zijn van graslanden. De weidevogels zijn het 'produkt' van de Nederlandse rundveehouderij sinds de Middeleeuwen. Zij vormen in Nederland een zeer belangrijke natuurwaarde, die van internationaal belang is, gezien het grote aandeel van de Nederlandse populatie op die van Midden- en West-Europa. Het grootste deel van de weidevogelpopulatie broedt in de agrarisch gebruikte gebieden. De melkveehouderij is sinds de Tweede Wereldoorlog zeer sterk in intensiteit toegenomen en is nu waarschijnlijk de meest intensieve ter wereld. Dit laatste wordt over het algemeen beschouwd als de meest belangrijke factor die een achteruitgang van de weidevogelstand heeft veroorzaakt. In het bijzonder wordt het broedsucces, dat wil zeggen het aantal jongen dat door een broedpaar in een jaar wordt grootgebracht, te laag geacht als gevolg van diverse graslandbewerkingen zoals weiden en maaien. Deze bewerkingen vinden tegenwoordig veel eerder in het seizoen plaats en volgen elkaar ook sneller op, zodat de periode tussen de bewerkingen te kort wordt om de eieren uit te broeden en/of de jongen vliegvlug te laten worden. Om de huidige populatieniveaus te behouden, moeten dan ook beschermingsmaatregelen worden ontwikkeld.

De rijksoverheid heeft ter bescherming van de weidevogelpopulatie in 1975 de Relatienota uitgebracht, waarin een beleid van reservaatvorming en het sluiten van beheercontracten is geregeld. Dit beleid heeft echter slechts betrekking op een marginaal deel van de oppervlakte cultuurgrond, nl. uiteindelijk maximaal 10%. Dat zal zeker niet voldoende zijn om de populatie op het huidge niveau te behouden. Daarom moet ook buiten deze Relatienotagebieden worden gezocht naar weidevogelbeschermende maatregelen. Dit soort van bescherming zal echter boeren niet te veel mogen belasten (in de zin van kosten en/of moeite), omdat boeren alleen dan bereid zullen zijn dergelijke maatregelen te treffen. Een draagvlak voor zulke maatregelen is zeker aanwezig.

Het onderzoek in dit proefschrift richt de aandacht op de mogelijkheden en beperkingen van dergelijke maatregelen. Het doel van het onderzoek was het verkrijgen van nieuwe informatie over de 'timing' van nestelen en de afzonderlijke graslandbewerkingen, alsmede over de exacte lokaties van nesten en de factoren die van invloed zijn op de activiteiten van de boer en de vogels. Een ander belangrijk doel van de studie was meer inzicht te verkrijgen in de manier waarop oudervogels en hun jongen reageren op maaiactiviteiten. Op deze manier was het mogelijk om maatregelen te zoeken die de graslandbewerkingen meer kunnen 'fijnregelen', zowel in de ruimte als in de tijd, zodat het broedsucces van de weidevogels in de intensief bewerkte graslanden zou kunnen worden verhoogd, zonder dat dat ten koste zou gaan van de bedrijfsvoering.

Een analytisch-beschrijvende, (voornamelijk) transversale studie-opzet werd gekozen om de effecten van agrarische factoren te onderzoeken. Deze benadering

hield in dat er een ruimtelijke vergelijking werd gemaakt van grote aantallen percelen, die voornamelijk verschilden in beheer.

De studie was voor het grootste deel beperkt tot maailand (land dat in de eerste snede wordt gemaaid) in het veenweidegebied. Maailand betreft ongeveer 65-90% van de graslandoppervlakte. In dit deel zijn de weidevogeldichtheden het hoogst. Maaien wordt ook meer risicovol voor weidevogels geacht.

Alleen soorten waarvan een groot deel of de West- en Middeneuropese populatie in Nederland broedt werden in het onderzoek betrokken. Het betrof hierbij de soorten Kievit, Grutto, Tureluur en Scholekster.

Gegevens over het graslandgebruik werden verkregen van de boeren en door middel van eigen veldwaarnemingen. Op de percelen werden de nesten gedurende het broedseizoen opgezocht en gemarkeerd met bamboestokjes. Van ieder nest werd het lot (uitgekomen, verlaten, en dergelijke) genoteerd. Bovendien werden observaties gedaan aan kuikens tijdens het maaien. Gegevens over de overleving en habitatgebruik van kuikens werden verkregen door oudervogels, die werden gevangen op het nest, te merken, alsmede door het ringen van de kuikens op de nestplaats.

De belangrijkste resultaten van de studie zijn, in de volgorde van de graslandbewerkingen:

Rollen en slepen (hoofdstuk 3).

De omvang en datum van rol- en sleepactiviteiten zal de overlevingskansen van legsels grotendeels bepalen. Kennis omtrent deze factoren ontbrak en werd daarom onderzocht. Rollen wordt vaker uitgevoerd dan slepen. Aangezien het effect van beide graslandbewerkingen op aanwezige legsels hetzelfde is, is rollen daarom veel belangrijker voor het broedsucces. Hoe natter een perceel (hogere grondwaterstand), hoe later de roldatum. Hoge grondwaterstanden zorgen er ook voor dat op een grotere schaal wordt gerold. Daarnaast zorgt een grotere hoeveelheid neerslag in maart voor een latere roldatum, wat bevestigt dat met name de natte percelen gevoelig zijn. Rollen bleek in de meeste onderzoekjaren alleen van belang voor het nestsucces van de Kievit. De nestverliezen zouden substantieel worden verkleind als er één week eerder werd gerold dan nu het geval was, bij voorkeur voor 21 maart. Nesten kunnen eveneens worden gespaard door een strook van ongeveer 2 meter breedte langs slootkanten en greppels te ontzien. Kieviten blijken een hoge voorkeur te vertonen om in deze strook te nestelen. Om de noodzaak tot rollen te voorkomen zou vertrapping van de zode door vee in het najaar en winter zoveel mogelijk moeten worden uitgesloten.

Mesten (hoofdstuk 4).

Nieuwe technieken die worden geïntroduceerd om drijfmest te verspreiden, zoals zodebemesting en mestinjectie, met het doel ammoniak-emissies te verkleinen, zullen waarschijnlijk een sterk negatief effect hebben op het nestsucces van de meeste weidevogels. Dat geldt in het bijzonder voor de Kievit en Grutto. De bodemfauna, te weten regenwormen en emelten, vormen het belangrijkste stapelvoedsel van de weidevogels. In het bijzonder is dat het geval vroeg in het seizoen als de legsels moeten worden aangemaakt. Van de nieuwe mesttechnieken kon evenwel geen schadelijk effect op de bodemfauna worden aangetoond. Machines die kunnen worden ingezet bij een weinig draagkrachtige grond zouden (verder) moeten worden ontwikkeld, zodat de mest kan worden uitgereden voor het broedseizoen.

Maaien (hoofdstukken 5 en 6).

In tegenstelling tot voorgaande studies werd een aanzienlijke variatie in zowel eilegdata als maaidata op verschillende percelen alsmede in verschillende jaren aangetoond. De factoren die zowel de "timing" van het maaien als van het nestelen bepalen werden bestudeerd met het doel een voorspelling mogelijk te maken van "veilige" maaidata voor de weidevogels.

Verschillen in maaidata en eilegdata op verschillende percelen waren beide positief gecorreleerd met de datum van kunstmest uitrijden. Het effect van deze variabelen wordt waarschijnlijk veroorzaakt door verschillen in grondwaterstanden, die zorgt voor een latere datum van uitrijden van kunstmest en een lagere biomassa aan bodemfauna. Voor Kievit en Grutto veroorzaakt dit mogelijk een synchronisatie tussen eileg- en maaidata, zodat de negatieve effecten of vroege maaidata op het nestsucces wordt gereduceerd. Een uitstel van de maaidata om het nestsucces te vergroten kan daarom minder groot zijn dan meestal wordt gehanteerd (nl. tot 15 Juni), en zou beperkt kunnen blijven tot 1-2 weken later maaien dan de huidige datum van maaien. De kosten hiervan voor de boer zijn ca. fl. 110,- per hectare. Omdat een groot deel van de weidevogels nestelt op een beperkte oppervlakte land, zouden de kosten dus beperkt kunnen blijven.

Verschillen in maaidata en eilegdata in verschillende jaren waren beide gecorreleerd met voorjaarstemperaturen. Als gevolg daarvan zijn er in verschillende jaren geen systematische verschillen in nestsucces. Vroeg maaien in sommige jaren is daarom niet automatisch schadelijk(er) voor het broedsucces. Ook hier zou een uitstel van 1-2 weken van de huidige maaidata waarschijnlijk voldoende zijn om een voldoende hoog broedsucces te behalen om de huidige populatieniveaus te handhaven.

Effecten van maaien op de overleving van Grutto-kuikens (hoofdstuk 7).

In intensief gebruikt grasland wordt met name de Grutto zeer gevoelig geacht voor maai-activiteiten, omdat kuikens van deze soort een voorkeur voor langer gras vertonen. Kennis omtrent de overlevingskansen van kuikens in intensief gebruikt grasland was echter vrijwel afwezig. De mortaliteit veroorzaakt door maaiactiviteiten is echter maar enkele procenten van het aantal geboren kuikens. Alleen zeer jonge, net uit het ei gekropen kuikens hebben een groot risico te worden gedood door de maaimachine, terwijl oudere kuikens in de meeste gevallen in staat zijn te ontsnappen of al wegtrekken voor het maaien eigenlijk is begonnen. Het aantal kuikens dat tijdens het maaien aanwezig is kan evenwel nog verder worden gereduceerd door stokken met plastic zakken in het te maaien perceel te plaatsen. Het aantal vliegvlug geworden jongen per broedpaar verschilde niet significant tussen intensief gebruikte graslanden en reservaat- en beheergebied. Het was waarschijnlijk wel te laag om de populatie in stand te houden. Andere factoren die de overleving van de kuikens bepalen, zoals het weer, predatie en voedsel, zijn van groter belang voor de overleving dan maaien. Niettemin kunnen de geringe verliezen die aan het maaien te wijten zijn van belang zijn. Dit omdat de geringe verliezen de totale reproduktie net onder het vereiste niveau kunnen brengen dat nodig is om de populatie in stand te houden. De bescherming van kuikens in intensief gebruikt grasland is echter veel moeilijker dan die van de nesten.

Op basis van ringgegevens kon een grote trouw van kuikens aan de plaats waar zij werden geringd (dat wil zeggen ongeveer de plaats waar zij werden geboren) worden aangetoond. Meer dan 60% van de (volwassen) vogels die werden teruggemeld in de broedtijd werd binnen een straal van 5 kilometer van de plek gevonden waar zij als kuiken waren geringd. Dat betekent dat een verhoging van het broedsucces ten goede zal komen aan de lokale populatie, aangezien er slechts geringe emigratie naar andere gebieden is. Overigens betekent dit ook dat de kans op lokaal uitsterven aanwezig kan zijn.

Toekomstverwachtingen voor weidevogelbescherming (hoofdstuk 8)

Er is niet een enkele natuurbeschermingsstrategie waarmee de Nederlandse weidevogelpopulatie veilig kan worden gesteld. Zowel Relatienotagebieden als de invoering van weidevogelbeschermende maatregelen op "gewone", moderne melkveehouderijbedrijven zijn noodzakelijk. Dat laatste heeft tot nu toe echter veel te weinig aandacht gekregen, terwijl de studie in dit proefschrift (en veel andere studies) aantoont dat er wel degelijk mogelijkheden voor het behoud van weidevogels op intensief gebruikt agrarisch land aanwezig zijn. Nieuwe kansen en bedreigingen voor de weidevogelpopulatie staan echter al weer op stapel, zoals de nieuwe mestregelgeving en het EG-landbouwbeleid. De bedreigingen kunnen de huidige inspanningen ten aanzien van de weidevogelbescherming weer voor een groot deel teniet doen. Zij vormen echter ook een nieuwe uitdaging voor natuurbeschermers

om te zoeken naar nieuwe wegen van weidevogelbescherming of een vergrote inzet van de bestaande middelen. Enkele aanbevelingen voor het behoud van de Nederlandse weidevogelpopulatie worden dan ook gegeven.

Nawoord

"Zoals alle andere kunsten, is de wetenschap van ontleding en gevolgtrekking er een die alleen kan worden geleerd door een geduldige studie, doch het leven is niet lang genoeg om enige sterfelijke ziel toe te staan om er de hoogst mogelijke graad van perfectie in te verkrijgen" (Sherlock Homes, The Sign of Four).

Veel mensen hebben op de een of andere wijze bijgedragen aan de totstandkoming van het proefschrift.

Dr. Albert J. Beintema (Instituut voor Bos en Natuuronderzoek te Arnhem) leverde als referent waardevol commentaar op de concept-hoofdstukken.

Dr. Arco J. Van Strien (Centraal Bureau voor de Statistiek) leverde zeer vele nuttige suggesties ter verbetering van het onderzoek en de teksten. Zijn ervaringen als ex-promovendus bleken eveneens van groot belang.

Ik ben Erik R. Gertenaar zeer erkentelijk voor zijn bijzondere organisatietalent en hulp bij al het veldwerk.

Marcel A.W. Noordervliet leverde een belangrijke bijdrage bij het analysewerk.

Ook veel studenten leverden een bijdrage aan het veldwerk en het verzamelen en verwerken van gegevens. Het zijn: Christa P. Groshart, Carola Alsemgeest-Van den Broek, Tanja Kassenaar, Annet S. ten Cate, Joslyn C.E.W. Hooijmeijer, Martien Kooyman, Barbara van Agt, Robert M.H. Tekke, Karin A. Hoffman, Margot A. Heineman, Jeroen H.W. Hendriks, Marian A. Joven van Sluys, Frode Numan en Wout J. van der Slikke.

Verder hielpen tijdens het veldwerk Bram ter Keurs, Leon S. Bouman en Johan Kieft.

Ik ben Peter A. van der Ploeg erkentelijk voor zijn levering van enorme aantallen gegevens over nesten en maaidata.

Gerard de Hoog en Cor Noorman voorzagen mij van enkele gegevens over nesten in verband met rolwerkzaamheden.

Jan Faber van de Vogelwacht Trywâlden hielp bij het vinden van een geschikte plaats voor het Grutto-onderzoek. Bouke Faber, Japie Seinstra, A. Osinga, Keimpe de Vries en Tom de Vries assisteerden bij het nesten zoeken. J. Wobma, G.B. Kamstra, Jan Faber, P. de Vries, J. en L. Waldus, U. Jellema, S. van der Hem, Klaas Nauta en A. Folkerts maakten observaties over kuikenmortaliteit tijden het maaien in diverse Friese wachtgebieden. Jan Hoekstra van de Bond van Friese Vogelbeschermings Wachten zorgde voor de coördinatie van dit alles.

Sjaak en Pip van Schie (Warmond), Piet van der Geest (Warmond) Ab van der Geest (Warmond), Ab van der Meer (Oud-Ade), Jan Wesselingh (Rijpwetering), Piet van der Plas (Sassenheim), Theo van der Plas (Sassenheim), M.L. Ruiten (De Kaag), de gebroeders P. & J. Zonneveld (Voorschoten), Piet Th. Zonneveld (Voorschoten), Piet E. van Vliet (Voorschoten) en H.G.M. Hooymans (Voorscho-

ten) stonden toe dat er naar nesten werd gezocht op hun land en leverden gegevens over hun bedrijfsvoering. Ik ben hen daarvoor zeer erkentelijk. In de Bovenkerker polder stonden de veehouders Cor Koster, Barend Koster en Cees Lambalk toe dat wij vele zoden uitstaken op zoek naar wormen en emelten. In de Oenkerker polder werd zeer bereidwillig meegewerkt door de boeren Ype de Vries, Eeltsje Faber, J. Sikma, S. Sipma, A. Lijzenga, J. Rijpma en B. Wentink.

De directeur van de Praktijkschool voor het Veehouderij en het Weidebedrijf te Oenkerk, de heer A. Osinga, ben ik erkentelijk voor de accommodatie en de mogelijkheden tot onderzoek in het land van de Praktijkschool. Ook het personeel van het logeergebouw van de school ben ik erkentelijk voor hun uitstekende verzorging van de "Skriesologen".

Sjoerd Braaksma van het Staatsbosbeheer in Leeuwarden gaf een vergunning tot het verrichten van onderzoek in het reservaat "de Puollen" in de Oenkerker polder.

Rinse D. Wassenaar van het Vogeltrekstation gaf hulp bij het verstrekken van de benodigde ringvergunningen en ringgegevens.

Michiel M. Dorenbosch (Ministerie van VROM) gaf waardevolle tips en suggesties die uiteindelijk hebben geleid tot hoofdstuk 4.

Ich bin Herr Arno Shoppenhorst Dipl.-Geogr./Landschaftsökologe erkenntlich für die Literatur über Wiesenvogel in Deutschland.

I am indebted to Dr. A.C. Ford for critically reading the manuscript and correcting the English.

Robert Tekke maakte de mooie tekeningen en de cartoons in dit proefschrift.

Tenslotte ben ik Saskia bijzonder erkentelijk voor haar morele en alle overige steun.

CURRICULUM VITAE

Maurice Kruk werd op 27 augustus 1963 in Rijsoord (gemeente Ridderkerk) geboren. Hij deed in 1981 eindexamen VWO-ongedeeld aan de Scholengemeenmschap Gemini te Ridderkerk. In dat jaar begon hij met zijn studie Biologie in Leiden. In 1984 deed hij het candidaatsexamen B1 (algemene Biologie). Het doctoraalpakket bestond uit het hoofdvak Milieubiologie en de bijvakken Milieukunde en Biologie & Samenleving. Het doctoraalexamen werd behaald in maart 1987. Van 1987-1991 werkte hij onder leiding van drs. W.J. ter Keurs aan dit proefschrift. Vanaf 1992 is hij aangesteld als projectmedewerker bij de sectie Milieubiologie van de Rijksuniversiteit Leiden en verricht daar onderzoek naar de relaties tussen landbouw en natuur.