Starling Infestations on the Somerset Levels and Their Impact on Dairy Farming

Participatory research into the practical management of starling infestations on the Somerset Levels

Report prepared for DairyCo

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Starling Infestation on the Somerset Levels and their impact on Dairy farming

Murmurations of large flocks of starlings on the Somerset Levels during the winter months provide a magnificent spectacle to the public, despite their numbers declining considerably over the last 5 years. But more than 1 million birds (and up to 9 million in recent years) need a lot of food, much of which is unwittingly provided by the farms in the region.

The starlings preferred food is insects, in particular leather jackets during the autumn and winter months. It is this diet of a grassland pest species which often makes these birds welcome visitors in other parts of Europe. Unfortunately the supply of insects is not enough to sustain the migrant birds that swell the UK population in the winter and alternative feed sources are sought on farms, particularly in prolonged cold spells.

Birds often arrive early in the morning and remain on the farm until dusk before returning to their roosts. Numbers on the farms will vary according to the season and the attractiveness of the farm as a feeding site. The appeal of the farms is dependent on the feeds on offer and control methods in place. The main attracting factor is the grain in maize silage which provides a readily digestible source of energy, but other feeds also can attract the birds.

This study was conducted to determine the cost to dairy farms across the UK infested with starlings and the potential effectiveness of control measures that could be taken to reduce the impact.

The results showed that costs could be as high as £153 per day per 100 cows, although this very much depends on the number of starlings on the farm. This will vary from year to year as well as with the measures taken to prevent access or to scare the birds. The impact on animal health was not investigated but could add considerably to the financial impact of large infestations on farms.

Control measures adopted by farms can work if they are implemented well and persistently maintained from the start of starling activity in the late autumn - do not wait until the problem is out of hand. The ultimate control is removing feeds from the diet that attract the birds, in particular maize silage, although this is not seen as an option by most maize feeders.

Reducing the amount of feed which the birds have access to can reduce the cost. This can be achieved on many farms by feeding twice a day or feeding the TMR after the starlings have left in the afternoon. Removing maize or other ingredients from the TMR during the day is not recommended.

Whilst the financial impact on affected farms is significant, with appropriate controls the worst effects of the problem can be reduced.

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2 INTRODUCTION

Although starling numbers have declined across the UK, high population levels seen by day on many dairy farms (particularly on the Somerset Levels) during the winter months, cause concern as to potential risks to the health of animals and farm staff as well as a significant financial impact on farm economics. The resident UK starling breeding population is in decline, but numbers are augmented in winter by huge flocks migrating from Eastern Europe, the Baltics and Scandinavia seeking refuge and feed before returning to breed.

Flocks of starlings frequent farms to source part, if not all, of their daily feed requirement. Arriving from their night time roosts soon after daybreak, the birds are attracted to exposed maize silage clamps and in particular feed rations (TMR - Total Mixed Ration) fed to cows along feed fences or in troughs. These rations vary in content from farm to farm but have a forage base, i.e. silages (grass, maize and/or whole crop), together with other ingredients to increase the protein and energy value of the ration.

Exposed feeds enable the birds to feed throughout the day and allow them to supplement their diet as they require. A proportion of the bird's diet comes from foraging for insects in the fields surrounding farms but this food source will vary throughout the winter.

Consumption of cattle feed by birds can reduce milk output and increase the cost of winter rations fed to cows. This is due to the selective nature of the starling feeding activity whereby they only eat part of the fed ration, e.g. maize grains. This reduces the total feed value of the ration to the cow. Reduced feed value effectively reduces the potential to produce milk if the loss of energy and protein in the diet is not compensated for through an alternative feed method. This is often not easily achievable with carefully balanced feed rations designed to provide cows with consistently balanced rations throughout the day.

Large quantities of birds generate a high level of faecal contamination into the cow environment, particularly on the exposed feed. This in turn can reduce cow feed intakes, essential for milk production and reproductive performance, and can potentially cause health problems to the cows through ingestion of infectious bacteria.

A range of measures are used on farm which, when implemented correctly, offer varying degrees of starling control. Some of these measures are more successful than others and their appropriateness will vary from farm to farm.

This report presents the findings of a pilot study aimed at measuring the financial impact of starlings on dairy farms in the Somerset levels and evaluating the potential to mitigate the cost through control measures. These measures are aimed at reducing bird numbers on individual farms whilst not significantly affecting the total starling population across the region.

3 OBJECTIVES

The main objectives of the study were as follows:

- Improve the understanding of starling behaviour in the project region through assessment of the following:
    - Factors that encourage starlings
    - Starling daily behaviour patterns on farms
    - The influence of weather on starling behaviour
- Assess and evaluate the effectiveness of measures taken by farms participating in the study to reduce the number of starlings regularly eating cattle feed on the farm. This included:
    - Compare the relative benefits of mitigation strategies
    - Assessment of starling numbers on participating farms and determining a relationship between mitigation strategies and the consequential bird numbers
    - Identify the potential to develop a protocol that reduces starling numbers on an individual farm whilst not significantly affecting the total starling population across the region
- Quantify the potential economic costs of starling infestations on dairy farms on the Somerset Levels. This was assessed for the following criteria:
    - Feed nutritional value decline
    - Feed quantity lost
    - Feed structure change
- Make recommendations for further work

4 STARLING POPULATION OVERVIEW

A detailed desktop study was undertaken to understand more fully the reasons for the regional, national and global population decline, migration patterns and human and cow health issues associated with starlings. The desktop study also provided the background information to this report on starling work already undertaken, with methods of study, starling population and distribution, starling behaviour, feed requirements, land use change and farm systems.

4.1 The European Starling *Sturnus vulgaris*

Global distribution and population trends.

The European Starling is one of the most successful bird species in the world. It is a gregarious bird, particularly evident in the winter when individuals feed and roost in large flocks.

- It is a bird of 21.5 to 22cm in length and between 75 and 90g in weight.
- Plumage is black with green and purple iridescence, especially in summer.
- In winter the body feathers become tipped in white giving a speckled appearance.
- Juveniles are dull brown in summer but moult in the autumn to adult plumage.
- They have a life span of 5-7 years.

The European Starling is indigenous to Europe and Western Asia, established on 5 continents and has been successfully introduced to three (Feare, 1984). On a global scale the starling is undergoing a rapid decline, by nearly 60% between 1980 and 2005 (source: [1]EBCC/RSPB/Birdlife International). The breeding population is thought to be extremely large, in excess of 23 million pairs with a breeding range of >7,000,000 km^2, from 67°N in Norway and 42°N in Spain, even further south in Eastern Europe and the Canary Islands. In the west and south of this range breeding populations are resident but most starlings are migrants, wintering in the west or south of their breeding areas. The preferred breeding habitats are towns and cities, crevices and holes on farmland and woodland.

Range contraction and extinction of some populations have been recorded since 1960 in Finland and further south to Germany, Denmark and Britain, where the pace of decrease is accelerating. The areas of northern Europe where decreases in breeding numbers have been recorded are the sources of birds wintering in Britain. We should therefore expect the numbers of wintering birds to have similarly declined. Assessment of population trends, however, is complicated by a range of factors such as redistribution of birds in response to agricultural change, weather (winter temperatures) and food availability.

4.2 UK distribution and population of starlings

In the UK, although the starling was one of Britain's most common birds it has declined over the last three to four decades and because of this is now classified as Least Concern (LC) on the IUCN Red Data List (IUCN Red List, March 2011).

The British breeding population has been monitored by the British Trust for Ornithology (BTO) since 1962 and although it has declined generally by 68% since recording began, the decline has been greatest in the South West, on farmland and in the last three decades (Table 4.1).

Robinson et al (2006) estimated that the UK total breeding population to be about 9 million birds in the late 1990s. The RSPB (The State of UK Birds, 2011) have estimated the UK breeding population (in 2000) to be 804,000 breeding pairs with a BBS (Breeding Bird Survey) trend between 1995 and 2009 to be down by 45%. Freeman et al (2007), using a method of fitting demographic models directly to avian counts of *Sturnus vulgaris* in Britain for the period 1965-2000, concluded that the national decline is most likely due to changes in survival of juveniles in their first year. British juveniles remain within the country, mostly within a few tens of kilometres of where it breeds.

[1] EBCC – European Bird Census Council

The decline of farmland birds is well documented, with most research concentrated on arable specialists because of the changes and developments to arable practices. Changes in pastoral farming have been just as great, and the use of fertilisers, pesticides and anthelmintics must have an influence on starling breeding success (Robinson et al 2006).

Table 4.1 Population estimates by region and habitat for Starling as measured from BBS, during the period 1994-2000

	Unimproved grass		Improved grass		Arable		Rural human		Suburban		Urban				All habitats	
	A	B	A	B	A	B	A	B	A	B	A	B	Wood	Other	A	B
SW England	2.57	+8.27	0.52	-11.9	0.67	-8.19	1.55	+1.87	2.71	-7.75	1.52	-8.71	0.05	1.05	10.5	-5.51
All Regions	15.8	-6.53	7.64	+3.02	6.21	-0.53	13.9	-1.4	33.4	-1.20	9.82	-0.60	1.53	11.8	100	-0.85

A, percentage of the British starling population supported; B, mean annual percentage change.

Data taken from BTO 2005 Bird Study 52,252-260

Information about the local (Somerset) starling breeding population is documented by Ballance (2006) as "...there are wide variations in breeding abundance: it is commonest in a belt from Burham and Bridgwater south to the Dorset border, including most of the land below the 10m contour. It is very scarce as a breeder in the western uplands, where it is absent from many villages and farms. It nests in various types of building and in old timber (holes in trees). It is commoner in Bridgwater than in Taunton or Wellington. It has declined in the towns to the south, Yeovil and Crewkerne, in conformity with the general picture in England. Pockets of abundance exist in some villages; there were 60 pairs at Combwich in 2003, in the heart of an area of rich grassland feeding and 100 pairs at Ashcott. The 2002-04 survey of the mid-Somerset hills found it breeding in all but 6 tetrads; the highest concentrations were around Stoke St Gregory/ Athelney and from Fivehead to Langport." (These latter areas provide a very good range of feeding and nesting opportunities for starlings).

4.3 Starlings and the Somerset Levels

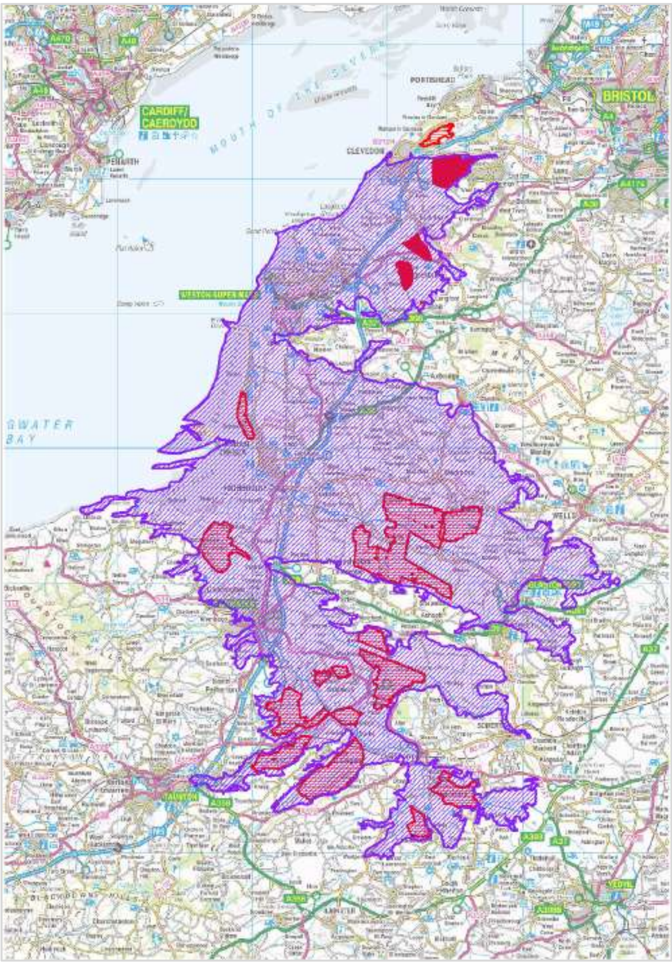


Plate 1

One of the main concentrations of immigrant starlings' winter territories lie within the three wetland Nature Reserves of the Somerset Levels & Moors; Ham Wall (ST460400) managed by RSPB, Westhay Moor (ST455445) owned by Somerset Wildlife Trust and Shapwick Heath (ST430405) by Natural England. The Somerset Levels include the floodplains of the Rivers Axe, Brue, Parrett, Tone and their tributaries and the area is of outstanding importance for the rich patchwork of wet grasslands, reedbeds, mires and fen meadows.

The majority of the area, being only a few meters above sea level, drains via a large network of 8000km of ditches, rhynes and rivers. Parts of the area in the Brue Valley include areas of former raised peatbog, now substantially modified by agricultural intensification and peat extraction.

The area is designated as a Special Protected Area (SPA) under the EU Birds Directive and as a Ramsar site (internationally important wetland designation) supporting a diverse community of terrestrial and aquatic invertebrates, and 17 species registered in the British Red Data Book). There are 34 SSSIs designations, covering over 11,000 ha. These areas are under threat from urban development and predominant reasons for any failures in securing favourable condition of the various features of the Sites are agriculture drainage, fertiliser use, pesticide/herbicide use, inappropriate cutting/mowing, inappropriate ditch management, inappropriate water levels, inappropriate Countryside Stewardship Scheme or Environmentally Sensitive Area (CSS/ESA) prescriptions, overgrazing, peat extraction, public access/disturbance, under-grazing, vehicles, water pollution and agriculture/run-off.

Designations as Sites of Special Scientific Interest (SSSI) or ESA are both intended to contribute to wetland conservation in an important farming area of Somerset, involve restrictions on agricultural practice and therefore affect revenue and capital values (O'Donoghue, 1999). ESA, with low-intensity farming methods have been supported by DEFRA and Europe, but recent changes to Environmental Stewardship Schemes has meant a reduction in payments available to farmers in this area. This will inevitably result in intensification, for farming to be economically viable.

Water levels in the Somerset Levels and Moors are managed by the Somerset Internal Drainage Board using penning structures to minimise the flood potential, improve the conservation value and provide wet fencing for agriculture.

The Somerset Levels & Moors boundary is defined by the 10 metre contour above sea level. Once part of the Severn Estuary, it now includes the largest area of lowland wet grassland and natural floodplain remaining in England. The area surrounding and adjoining the reserves is mostly agricultural with pastoral systems based on permanent grassland. This is the reason why the Levels make suitable winter roosts for thousands of birds during the winter months, including a huge numbers of migrant starlings.

Major land use in the Somerset levels & Moors Natural Area is;

- Livestock farming (dairy, beef & sheep)
- Peat extraction
- Arable farming
- Withy beds & orchards
- Urban development
- Tourism & recreation
- Floodwater storage
- Nature reserves

The Somerset Levels host a popular tourist attraction with daily talks on the Nature Reserves to view the spectacular starling murmurations at dusk before descending into the night roosts. The Somerset Levels and Moors make a perfect winter home for more than one million starlings each year and up to 9 million in some years. Large roosts are found in the Avalon marshes in the Brue Valley. Other roosts sometimes occur in withy beds, woods and town centres. The starlings are here to feed on the cattle-grazed pastures in the flood plain wet grasslands, searching for insect food supplemented by seeds, grain and fruits. Most of the wintering birds arrive by late November and will stay until late February/early March when the return migration begins. In a typical winter the climate brings minor flood events (sometimes more severe) to the moors and the waterlogged fields provide a feeding bonanza for the birds as many seeds and small invertebrates brought to the surface by the flood water, are then readily available as food for starlings (and other wintering bird species, like lapwing).

4.3.1 Starling counts on Somerset Levels 2000-2012

A decline in peak starling counts on the Somerset Levels is evident since 2005 (Figure 4.1).

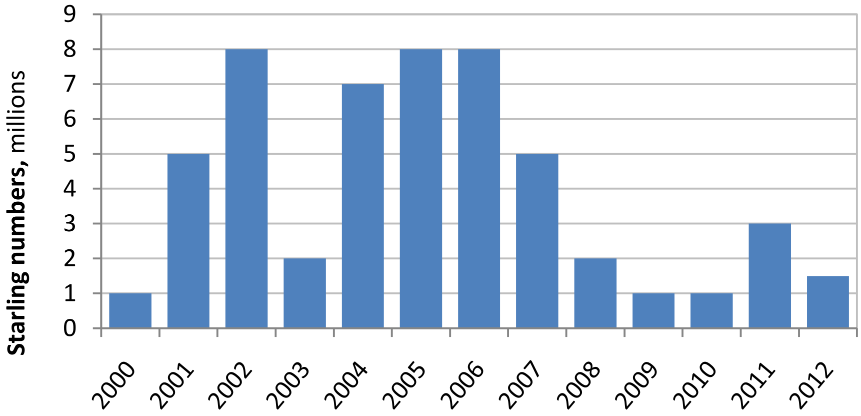


Figure 4.1 Peak Counts on Somerset Levels Jan to March 2000-2012. Note: these are peak counts from Avalon Marshes including Ham Wall, Shapwick Heath, Mere Heath and Greater Westhay. Source: John Leece (BTO) Somerset Ornithological Society 23.02.12

The two consecutive cold winters of 2009/2010 and 2010/2011 across Europe have meant that migrant starling numbers wintering in Britain increased then, but temperatures were also responsible for the decline in breeding success in the following seasons. An increase in numbers of wintering birds in the winter of 2010/2011 also relates to a peak nuisance level of starlings on farms in Somerset.

Unfortunately, BTO could not supply data from the Somerset Levels Atlas 2007-11 for this report.

4.3.2 Dairy herd and maize growing statistics between 1970 and 2010

Over the ten years between 2000 and 2010 the national dairy herd has declined by 26%, although the number of dairy holdings in England, the South West and Somerset has decreased by about 50%.
The number of dairy holdings growing maize in Somerset has declined by 24%, and although there are fewer dairy holdings, the average herd size is up from 127 to 143 (Table 6.11).

Table 4.2 Dairy herds and maize production between 1970 and 2010. Source: DEFRA Survey of Agriculture & Horticulture – June 2000-2010 & DEFRA Farm Surveys.

	1970	1980	1990	1995	2000	2005	2009	2010	trend
National Dairy Herd (head)					1575000			1160000	▼ -26%
England Number of Dairy Holdings				19632	15219	12918	8190	7882	▼
SW Number of Dairy Holdings				7198	5507	4652	3006	2878	▼
Somerset Number of Dairy Holdings				1339	1020	874	572	552	▼
England Number of PP Holdings				114952	119209	126989			▲
SW Number of PP Holdings				30866	32447	34244			▲
Somerset Number of PP Holdings				5032	5299	5714			▲
England PP Area (ha)				2973383	2863552	3142642	3222514	3288366	▲
SW PP Area (ha)				877212	811167	901416	903731	905908	▲
Somerset PP Area (ha)				151758	135666	156855	154259	153593	▼12%
England Number of Maize Holdings				7521	6838	6994			◄
SW Number of Maize Holdings				3672	2996	3026			◄
Somerset Number of Maize Holdings				821	640	640			◄
England Maize Area (ha)	1400	20800	33300	100432	97624	118676	145289	145827	▲50%
SW Maize Area (ha)				49656	42839	52571	63694	62800	▲
Somerset Maize Area (ha)				11178	8993	11125	13701	13144	▲46%
No. of Somerset Maize Growing Dairy Holdings					473	421		359	▼24%
Area of Maize Grown for Dairy herds in Somerset					7540	8117		8652	▲14.7%
Number of Cows in Dairy Herd in Somerset					60136	54878		51380	▼15%
Average herd size in Somerset					127	130		143	▲

This means that the migrant starling populations over the winter have fewer choices of feed sources to access, but they will probably be larger (reflected in the increased area of maize grown in Somerset). The larger the feed source, the larger the flock that can be accommodated on that feed source.
The overall area of maize grown in Somerset has increased by 46%, but over the ten year period, the area of maize grown for dairy has increased from 15.9ha to 24.1 ha per dairy holding. The area of permanent pasture in Somerset has decreased by almost the same amount as the increase in maize area grown for dairy. The changing pattern of agronomy in Somerset could contribute to the reduction in feeding opportunities for starlings and the increase in the likelihood of starlings feeding on farms.

4.4 European Starling – a migrant species

Plate 2. Starling flight lines

As a social and gregarious species, the starling depends on social cues and changing light intensities for the onset of migration flight and return passage for breeding. One way to avoid seasonal (winter) food availability and quality is to migrate; another is to use torpor (temporary hibernation). Starlings can migrate distances of 1,000-1,500 km and long distances in a single day at speeds of 60-80 km/h (Feare 1984) (Plate 2). Starlings can fly up to 50 km to feed and regular flight lines are used between feeding sites and roosts.

In the UK, France and Spain the resident population is augmented in winter by large numbers of migrants from breeding populations in northern and Eastern Europe, and predominantly from around the Baltic Sea area. The extent of migration is dependent on weather. The typical autumn migration of starling populations is for those from northern Europe to head south and west towards UK and northern France, while those from central Europe head south and west towards Spain and North Africa. Our resident starlings are joined in the winter by others from breeding populations elsewhere within Europe. Many of these visiting birds are part of an autumn fly-way that runs east to west across Europe. Birds from the Netherlands are the first visitors to arrive here in the autumn, followed by birds from Germany and southern Scandinavia. The last birds to arrive come from Poland and Russia. Weather conditions each year will influence this general pattern, and so it is possible that in milder winters some of the starlings which normally head towards the UK may stay further east, while in a colder winter birds will be shifted further south and west.

4.5 Starling feeding habits and requirements

Flexible dietary habits, resourceful ability and remarkable adaptability of the species contributes to its success, however it is also these reasons that determine its perception as a pest species. In spells of severe cold weather when natural food supplies are the limiting factor, other passerines suffer their peak annual mortality. Starlings are unusual in that their peak mortality occurs in the breeding season. The study by Taitt (1973) showed that in winter starlings have a higher mean weight which is partly due to lipid deposition, especially when preparing to leave the roost for the return migration.

Starlings are omnivorous passerine birds (perching songbirds) and will eat many types of animal and vegetable matter during the year ranging from insects, invertebrates, grains and seeds as well as fruits and berries. The starling family cannot digest high sucrose fruits because they lack the digestive enzyme sucrase (Brugger et al, 1993).

Densities of soil invertebrates are highest in permanent pasture, grass leys and uncultivated fields, or crops following grass leys and arable fields with grass weed infestation, which encourages flocks to feed in large numbers (Plate3). An increased use of fertilisers, insecticides and anthelmintics are likely to have an impact on the diversity of soil invertebrates.

The beak of the starling is well adapted for "open-bill probing" the soil for terrestrial insects and larvae, and their major and preferred food source are leatherjackets (Tipulidae) and earthworms (Lumbricidae).

Considering the Crane Fly (*Tipula palidosa)* life cycle, availability of 3rd and 4th instar stage leatherjackets (starling predation) is dependent upon suitable weather between September and October. The Crane Fly emerges in August/September, lives for a few days and lays c.400 eggs which hatch at 18 days. Leatherjacket grubs eat grass leaves and roots and are found in this area of soil profile. Between September and October the grubs are vulnerable to drying out and a correlation may exist between late summers with dry conditions and fewer leatherjackets the following year.

In addition to probing for food, starlings will actively pursue insects or hawk for them from a perch (or from the ground). They have also been recorded drinking nectar, feeding on large scraps of food, like chips or bread, and tackling small lizards and frogs. This highlights the resourceful nature of the starling, something which may explain the way in which it has adapted to live alongside Man in some of our more urbanised and rural landscapes.

Diet has a significant effect on the intestinal morphology (Martinez del Rio & Stevens 1989). From late summer or early autumn, the diet starts to change and the amount of plant material that is taken begins to increase within the diet. This seasonal shift is matched by certain morphological adaptations, with the starling's intestine increasing in length. This lengthening of the intestine allows the starling to cope with the increased amount of plant material – as it is more difficult to digest than animal matter.

Plate 3 Bridge Farm starling flock (count 2000) grazing across field for invertebrates on 25/11/11. Starling flocks sweep fields in a continuous rolling motion

4.6 Winter feeding habits

During severe weather, feeding habits change to be almost entirely dependent on Man. When the availability of invertebrates is limited, as occurs during heavy snow or severe frost, starlings increasingly utilize feed put out for cattle on farms. Feed losses on farms can be huge when large flocks are feeding in winter.

Feare & McGinnity (1986) quantified starling daily feed requirement of invertebrates and barley (carbohydrate grain) when foraging on-farm and in-field and they determined that barley or maize grains are an inadequate food for starlings on their own. This was because starlings assimilate them inefficiently and are unable to eat enough to satisfy all of their nutritional requirements. They found that starlings lost weight if less than 60% of their daily intake of dry matter (potentially <45g) consisted of invertebrates despite being able to consume 15g of barley from the cattle feed in 30 minutes of foraging time. In another study (Dunnet, 1956) found that leatherjackets averaged 0.2g each and therefore it was determined that around 175 are needed for a daily intake.

More energy is required for feeding in grassland than on farms and so the possibility exists that the consumption of grain, as a high energy feed, may represent the birds attempt to obtain a proportion of their daily energy requirement rapidly. There also remains the possibility that the grain contains nutrients that are required by starlings but are not found in invertebrates.

In winter, feeding patterns and potential feeding sites are learned by starling groups early in the season (migration period between early November and the end of February or early March) and can show considerable fidelity to a feeding site, returning day after day if a good feeding opportunity is found. This was confirmed by Tinbergen (1980), when looking at starling foraging decisions; hunting trips with high reward lead to follow-up visits in the same area, underlying the significance of location in the exploitation system of the starling.

Summers & Feare (1995) studied starling groups leaving roosts and flying to feed sites at different times. Starlings leave the winter roosts each morning in a series of exoduses so that the process is prolonged, taking up to 50 minutes (also see attached video of radar footage from FERA). Starlings that fed further from the roosts did not leave earlier than the birds that fed nearby and first-year females left later than adult males but did not follow them. After observing departure patterns they concluded that dominant, usually adult birds depart the roost first and attain the best feeding sites. When the subordinate younger birds overfly these sites later they can gauge the potential level of competition and decide whether to stop or fly on.

4.7 Is the European Starling a pest species?

Despite national population decline farmers locally have concerns over an increase in starling infestations targeting their farms over the winter period. Sometimes very large flocks can establish, attracted by easily accessible food fed to livestock. The greater use of maize/wholecrop silage and total mixed ration (TMR) feeding systems over recent years has increased the attractiveness and opportunity for starling flocks to feed throughout the day. However, in some areas of Europe they are used and positively encouraged (by placing nest boxes) in the control of pest invertebrates (mainly Leatherjackets) in crops and grassland.

There are obvious concerns, as potential problems could be feed loss and contamination, cow health risks and fouling accumulation within buildings, which makes for an unpleasant working environment and may compromise hygiene or food quality standards.

4.7.1 Health Risk

Although starlings have been identified as vectors of disease, they are not necessarily contributors to the spread of disease. However, movements between farms and feeding sites pose a potential threat to farm biosecurity. Colles et al (2009) evaluated whether wild starlings acted as a source of human or farm animal infection and concluded that starlings shed a diverse population of Campylobacter genotypes that is largely host-specific. They stated that large flocks potentially produce large-scale faecal contamination: a flock of 15,000 birds can cause more than 10,000 defecations per square metre per night (Odermatt et al., 1998). Starlings have a relatively high carriage rate of Campylobacter (40%), compared with some other wild bird taxa. However, this study provided no evidence to support the contention that wild starlings are a major source of infection of humans or farm animals. Carlson et al (2012) indicated that from studies on US cattle feedlots, European starlings and ambient winter temperatures (10°) are associated with an increased risk of *S. enterica* contamination in cattle feed, although they were most common on the feedlots on the coldest winter days. The results warranted implementing early winter starling control systems to reduce contamination and disease risk.

4.7.2 Legislation

Within the EEC, bird protection legislation falls under the EC Council Birds Directive. Special protection is awarded to many bird species on annexes to the Directive and species determined to be agricultural pests may be listed on a Hunting Annex, where birds may be killed at prescribed times of the year.

In Spain the starling is a species that may be hunted and is subject to a close season. In France the starling is one of 6 species classified as pests and can be shot or trapped. In both France and Spain where crop damage has occurred, roosts have been seasonally sprayed in an effort to control numbers and offer some crop protection (Feare 1992).

The starling was removed as a pest species from the General Licences in England in 2005. All wild birds, nests and eggs in the UK are protected under the Wildlife & Countryside Act 1981, however if a farmer can demonstrate a need, can apply under general licence WML-GL04, through application form A08 at Natural England (NE), to permit deviations from the WCA (1981) to enhance existing scaring methods with lethal shooting with a limit of 50 birds per year.

In countries such as USA and Australia starlings are classified as a pest species and are not afforded any protective legislation. Flocks frequenting farms and businesses are poisoned with avicides to control infestation.

4.7.3 Damage

The starling, as a highly adaptable migratory species, has the capacity to alter its wintering areas and to modify its ranging behaviour within the wintering area. Both of these changes occur in response to changes in food supply. Feare, (1984) identified that starlings causing damage on migration may have bred in countries where the birds cause no damage and are held in esteem on account of their valued role as insect predators. On the grounds of effectiveness, feasibility, cost, humaneness and environmental safety a population limitation strategy is unlikely to be appropriate. A more suitable approach is an ‘immediate crop protection’, whereby crops or feeds suffering losses are protected or defensive measures adopted.

The starling’s adaptability is illustrated by the diversity of climate and agriculture across their wintering roosts in Britain, France & Spain covering twenty-two degrees of latitude. This adaptability enables starlings to exploit a variety of commodities, causing a range of economic loss, but the kind of damage inflicted clearly depends on agricultural activities practiced in the area. Losses and damage to winter cereals have been recorded near roosts. Damage to other crops in Europe such as cherries, olives and vines by juveniles or migrants on passage can be extensive and has been an important driver to change cultivation policy.

Starling damage to livestock feed was documented by Feare (1984) in Britain and Besser et al (1968) in USA. Attempts to assess the extent of these losses have been limited by the lack of a practical assessment technique. Besser et al (1968) first attempted to measure these losses by combining the feed consumption capability of starlings (determined in the laboratory) with extensive field observations of birds at a Colorado feedlot. Seasonal economic significance in Colorado was $84 per 1000 birds in 1967. This is equivalent to approximately $566 at the current time (approx. £360).

Feare & Swannack (1978) estimated the percentage of time that starlings fed at troughs and factored this with feeding rates (items/bird/min). During three consecutive winters 1974-1977, they determined that starlings took between 6.4 and 12.4% of food given to calves. Forbes (1995) reported that starlings consume 50% of their body weight in feed each day. Glahn & Otis (1981), using time-lapse photography to monitor starling use of feed troughs, reported losses of 4.8kg of pelleted feed consumed per 1000 bird minutes. Economic losses will also be dependent on feed prices.

4.7.4 Mitigation against starling infestations

Economic losses due to starling depredations where livestock are fed can be reduced by implementing management practices that limit access to or reduce consumption of grain products by starlings. Management practices were reviewed by Twedt & Glahn (1982) and alternative practices suggested, including physical separation of feed from starlings, use of feed types that reduce the rate of consumption by starlings, and use of feeds that are either unpalatable or not usable by starlings.

However, differences in the ability to carry out control measures and the effectiveness of them arise between farms.

Mitigation is necessary to prevent a starling infestation establishing early in the migration period, as the birds collect at the roosts in November. Many different methods, control measures and equipment exist to help farmers with the problem, with varying level of success.

Bishop et al (2003) reviewed research literature regarding the effectiveness of avian deterrents, other control measures and potential alternatives. Bird scaring devices can be categorised into auditory, visual, chemical, exclusion, habitat modification and lethal control. Although limited information is available regarding effectiveness, conclusions were made. Auditory techniques were thought to be relatively effective but subject to habituation and therefore only of short-term benefit. The use of gas guns in particular, as well as shooting, resulted in complaints of noise nuisance, and therefore some farmers would not be able to use this method if situated in a residential area. The NFU Code of Practice Guidance for bird scarers should be consulted. There was no evidence that ultrasonic systems deter starlings as most species of birds do not hear in the ultrasonic range (>20kHz), and therefore there is no biological basis for their use. Visual techniques vary from extremely effective (human disturbance) to ineffective (scarecrows). Chemical techniques were found to be less effective in the field. Exclusion techniques and habitat modification were found to be extremely effective, and the efficacy depended on the degree of exclusion. A combination of techniques, used in an integrated control strategy, was considered to be more effective than those applied singly.

5 RESEARCH METHODOLOGY

An initial meeting with representatives from Natural England, British Trust for Ornithology and the RSPB, together with potential participating farmers, provided early input into the project. Discussions and input from participants helped to guide the project and ensured that consideration was given to the opinions and requirements of all those concerned about the issues resulting from the starling population during the winter months.

The overall approach to achieving the project objectives involved the selection of 11 dairy farms on the Somerset Levels that were representative of the diverse range of farm systems operating on and around the Levels. These farms were then monitored over the 3 months January, February and March 2012 to provide data to meet the project objectives.

5.1 Final site selection: monitor farms mapped

Using the Kingshay database of local farmers, a brief telephone survey was conducted to establish suitable farms for the project. 85% of these considered that starlings were a problem on their farm. The main criteria for selection were based on the following:

- Location. A range of distances from the main starling roosts at Westhay and Ham Wall were required as well as a consideration for the logistics for conducting the study
- Willingness of farmers to cooperate e.g. be prepared to complete daily observation data
- Starling infestation history. Farms that had a current or previous problem with starlings
- Farm system. A variation in feed systems and farm size was required to provide a representative sample of farms

5.1.1 Participating Farms

The farms selected were all within or near the Somerset Levels area. Altogether 11 farms were recruited to participate in recording data for the project:

- 2 farms were situated near the roosts.
- 2 farms did not feed maize and were not experiencing a starling problem. These were included to determine any changes in infestation level resulting from changes to the feed ration during the project period.
- A cluster of 5 farms, around Bridge Farm were recruited to see if there was a shared problem with farms in close proximity and on these farms we would record more detailed observations and assess food loss, in weight and nutritional value.
- One farm was recruited in the east of the region, off the Levels but still experiencing a starling problem.
- One farm was selected for its westerly location relative to the night time roosts.

The location of the participating farms can be seen on Plate 4 and in Table 5.1.

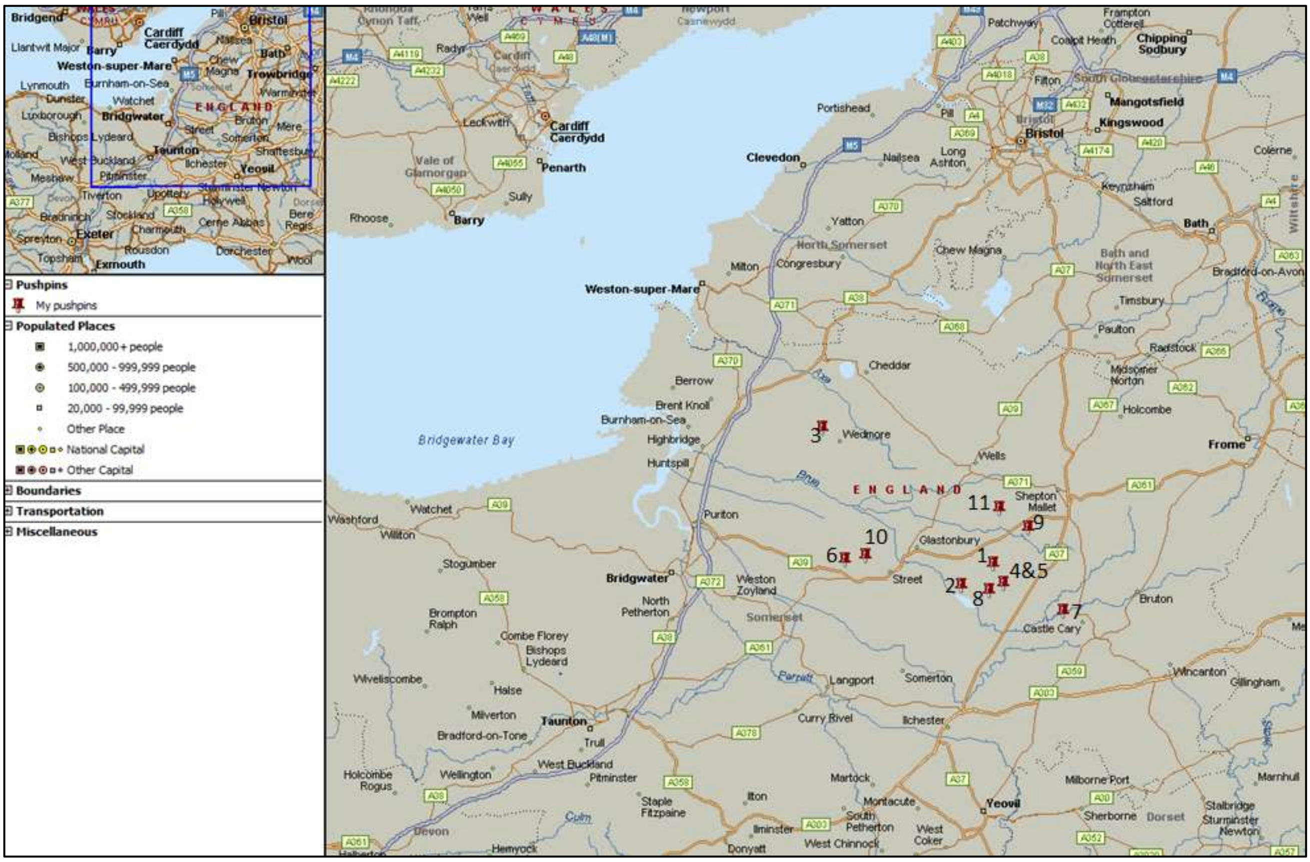


Plate 4 Map of location of participating farms. Starling Project 2012

Table 5.1 Location of Participating Farms. Starling Project 2012

	Area	Postcode	Distance from roost (miles)	Herd Size	Yield (litres per cow)
Farm 1	West Bradley	BA6	6.5	175	8,380
Farm 2	Baltonsborough	BA6	5.6	580	9,186
Farm 3	Wedmore	BS28	5.9	200	11,000
Farm 4	Lottisham	BA6	6.9	150	9,268
Farm 5	Lottisham	BA6	6.9	180	9,890
Farm 6	Walton	BA16	2.0	240	8,000
Farm 7	Castle Cary	BA7	12	300	10,500
Farm 8	Baltonsborough	BA6	7.3	350	9,200
Farm 9	Pilton	BA4	9.4	500	10,270
Farm 10	Ashcott	TA7	1.6	190	7,500
Farm 11	North Wootton	BA4	6.8	250	8,278

5.2 Assessments made & data collected

5.2.1 On-farm assessments

Assessments were made to determine:

- Farm systems
- Feeding strategy
- Farm layout
- Proximity of neighbouring dairy farms, trees, wires and orchards for bird perching and feed hawking (all of which contribute to farm attractiveness to starlings).

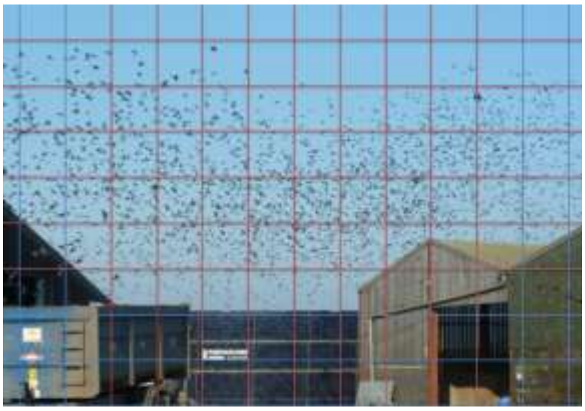


Plate 5. Gridded photograph for bird number assessment (count 5120)

5.2.2 Participating farms recording

Milk production, bird infestation score (am, noon and pm) and weather conditions were recorded daily.

Bird infestation scores were recorded on a 0-5 scoring system (5 being a very high level of bird numbers and 0 no starlings present). These scores were recorded by the participating farms and were intended to represent relative starling numbers on a daily basis on a specific farm. Although the score is subjective the experience of the participating farmers in assessing relative numbers was quite obvious. Training was provided to farmers to ensure that scoring was being undertaken on the same basis across all farms.

5.2.3 Bird number assessments

Bird number assessments and level of infestations on-farm were made by using vantage point surveys after initial counting of flocks from gridded photography (see Plate 5). At least 2 surveys were conducted on all farms during the study period and a further 2 surveys were made on the four main survey farms. Additional surveys were conducted on the 4 main farms to monitor variation in comparison with farmer scores (5.2.2.). This was undertaken by one member of the research team who was trained by BTO to undertake this kind of work.

5.2.4 Starling control (mitigation)

Mitigation methods were assessed for how well they were implemented together with their effectiveness in reducing birds and a mitigation score was assigned to each farm. The overall effectiveness of mitigation on an individual farm was based on bird number assessments made by one trained bird assessor visiting all farms on a number of different occasions. Mitigation assessments were made at the original farm assessment and at the same time as all other surveys i.e. at least twice and on all farms.

5.2.5 Feed loss assessments and economic impacts

Feed loss assessments were made on 3 of the farms by evaluating loss of quality and volume from fed TMR and also evaluating feed quality loss from maize clamps where starlings had free access.

Feed trough feed quality and volume loss: Cow access to a 4m section of feed trough was prevented during the period 7am to 5pm and sampling was undertaken when the feed was dispensed (am) and before starlings were on the farm and again after starlings had left at the end of daylight hours (pm). The exposed ration was turned regularly to simulate cow disturbance of the ration. Measurements taken am and pm included:

- Total weight of TMR (restricted access area only)
- Sieving of TMR using Penn State Forage Particle Separator sieves (Department of Dairy and Animal Science, Pennsylvania State University) to assess ration structure change.
- Sampling for laboratory analysis of feed nutritional value

The data collected was subjected to a statistical ANOVA at the P = 95% level. From this the economic impact was calculated.

Maize clamp feed quality loss: Analysis of samples from the maize clamp 10cm behind the clamp face were collected and compared to samples taken from loose maize at the base of the clamp that had been pulled out of the clamp and foraged by starlings.

6 RESULTS

It is assumed that starling numbers will increase on an individual farm in line with the available quantity of desirable feed if no mitigation methods are in place. Bird numbers will also be influenced by seasonal weather patterns and the overall starling population in the region.

6.1 Study conditions

The study was completed in an unusually mild winter, with few prolonged periods of frost or snow cover. This resulted in less pressure on the migrant flocks of starlings to feed on farms during the study period compared with the previous year. Some levels of bird infestation on farms were significant, but also some farms reported much less of a problem during the period of this study compared with previous years, despite having made no changes to starling mitigation or farm feeding systems.

Weather and temperature differences between years were notably different with average temperature being higher compared to the two previous winters (Table 6.1).

Table 6.1 Average rainfall and temperature.
Source: Met office - Yeovilton

Winter - October to March	Average period rainfall	Average minimum temp	Average maximum temp
	mm	°C	°C
2009/11	66	2.5	9.7
2010/11	49	1.9	9.7
2011/12	46	4.4	12.2

The level of starling infestation on-farm over the 2011/2012 winter has been considered to be lower than the previous year. The 2010/2011 winter level of starling infestation was reported to be the worst experienced in the UK for several years resulting from extreme temperatures across Eastern Europe and the Baltics causing a higher starling population migrating to roosts in Somerset. The continuous periods of cold weather in the UK during the 2010/2011 winter encouraged on-farm feeding as the essential invertebrate content of their diet was unavailable in the fields either through exhaustion of supply or frozen ground and snow cover.

The roost population in 2011/2012 declined by 50% on the previous year probably due to an unsuccessful breeding season in 2011, a low percentage of juvenile survival from the previous breeding season and a larger than normal proportion of adults remaining in Central & Southern Europe because of the mild winter weather at the time of migration.

UK winter temperatures in 2011/2012 have been unusually mild, and starlings have been able to graze for invertebrates almost every day. As previously discussed, starlings need at least 60% of their winter diet to consist of invertebrates in order to maintain body weight and to reach suitable body condition for successful breeding.

The starlings departed from the UK for nesting sites this year earlier than normal, probably due to target body condition being reached, above average temperatures, or simply the optimum photoperiod had been reached. High survival rates and good food supplies during the 2011/2012 winter should lead to a good breeding season in 2012. If temperatures remain mild for the rest of the year a high survival rate of juveniles could be expected. Successful breeding and high juvenile survival rates could result in an increase in the migrating population coming to the Somerset roosts in the winter of 2013.

Minimum and maximum temperatures were recorded daily at Bridge Farm (Kingshay offices) during December, January, February and March. The following observations were made:

- No consecutive daily maximums below zero °C were recorded.
- Two periods of night (minimum) temperatures below zero °C were recorded, 2 days (16th and 17th January) and 14 consecutive days 31st January to 13th February.
- The 2 day period had minimum temperatures of -1.6 and -1.2^{o}C. Daytime temperatures averaged 7^{o}C. Grazing by starlings in fields for invertebrates was observed as normal.

- During the second period of frosty weather minimum temperatures ranged from -0.6 to -4.7ºC whilst day temperatures ranged between 1.8 and 7.1ºC. Field grazing was also observed during this period, although some participating farms observed an increase in bird numbers on farms.

6.2 Farm starling number scoring

Participating farms scored bird numbers daily. These scores were relative to starling activity on the farm on previous days and were also based on experience of numbers in previous years. This proved to be a pragmatic and satisfactory approach to recording individual farm data.

Comparing farms using this data was possible due to the experience of starling infestations over a number of years by those individuals recording data. Effective comparisons were able to be made between farms and, although not statistically robust, enabled a cost effective method of compiling data on starling activity. Scores for the study period are presented in Table 6.2.

Table 6.2 Participating farmers data on bird numbers.
Score 0-5 (where 0=no birds, 5=heavy infestation)

Farm	January	February	March	3 month Average
1	1.6	2.4	1.8	2.0
2	3.9	5.0	1.7	4.7
3	0.4	0.4	–	0.4
4	1.6	2.0	0.8	1.8
5	1.8	2.3	1.0	2.1
6	4.7	3.3	0.7	4.0
7	1.4	2.0	0.3	1.7
8	3.4	3.8	3.1	3.6
9	0	0	0	0
10	0	1	0	<1
11	0	1	0	<1

A graph of all farms daily starling number scores recorded throughout January to March 2012 can be found in Appendices 11.1.4.

Average score across all farms am, noon and pm:

- Average January = 2.4
- Average February = 2.7
- Average March = 1.4
- 3 month average = 2.2
- Range during any time of day:
    - max = 5.0
    - min = 0.0

Feedback from the participating farmers indicated:

- These figures were considerably lower than they would have been in previous years.
- General agreement that February had been the worst month for starlings on farms.
- Differences between farms as indicated by the scores were consistent with their reasoning and understanding of the starling activities during the study period.

6.2.1 Behaviour Patterns

From data collected and observations made the general perception was that flocks of starlings arrived on farms soon after first light (approximately 7.30-8.30 am). Using farm buildings or surrounding trees for perching the flocks either grazed in the surrounding fields or fed on the cattle feeds throughout the day.

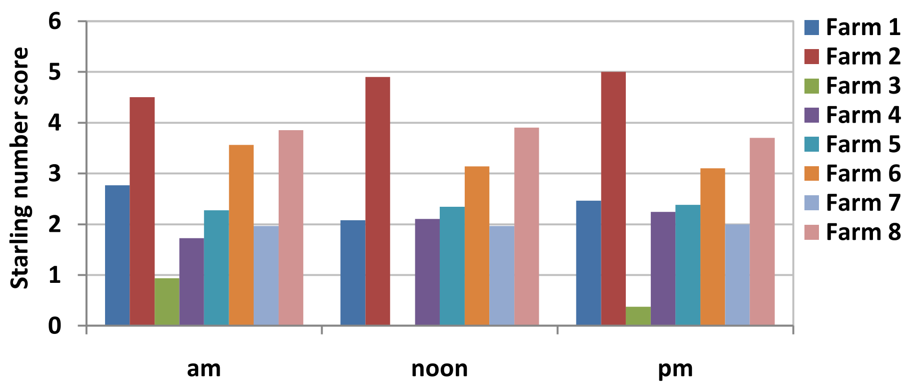
The assumption is that the same birds remained on or around the farm throughout the day. This may not be the case and there is no evidence to support this assumption, nevertheless the effect on the farm would still be the same.

No data was collected, or appears to be available from BTO, RSPB or NE regarding whether the same birds returned to the same farm on consecutive days (see note on further work, Recommendations Section 8).

Daily starling activity on the farm varied between farms. No fixed patterns were determined although some observations were made (Figure 6.1):

- If starlings were present at all they were consistently on or around the farm throughout the day.
- There was a tendency for lower bird numbers during the middle of the day on a number of the farms, although this was not always consistent.
- Only one farm recorded consistently no birds during part of the day and that was at the noon recording.

Figure 6.1 Starling numbers at 3 daily measurement times during February 2012



6.2.2 Temperature and Starling Numbers

Starling number scores were matched to daily maximum temperature and 24hr minimum temperature (Figures 6.2 and 6.3).

Interpretation of these results is as follows:

- No correlation between temperature and starling numbers was determined either for maximum daily temperature or minimum 24hr temperature.
- Only limited cold periods occurred during the study period (see Section 6.1) and occasional days of cold weather did not appear to affect the daily pattern of starling numbers on farms.
- Participating farms considered that starling numbers normally increased with colder temperatures. This is a logical conclusion based on anecdotal evidence from previous winters. Prolonged cold weather would reduce the natural feed supply in the surrounding fields.

Figure 6.2 Bird scores versus daily maximum temperature. All participating farms. Starling study 2012

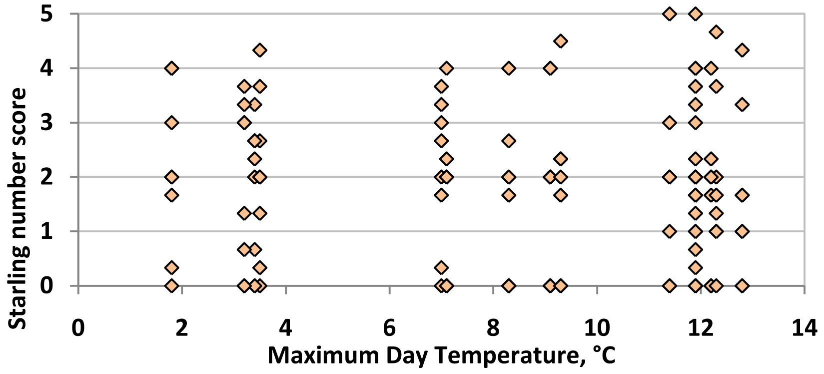
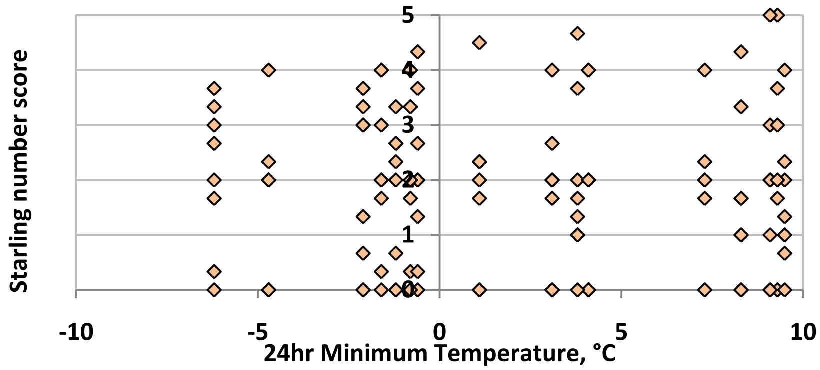


Figure 6.3 Bird scores versus 24hr minimum temperature. All participating farms. Starling study 2012



6.2.3 **Summary of starling number scoring**

Monitoring bird number fluctuations using farmer recording proved a cost effective method of collecting data for the study. Participating farmers all had considerable previous experience of starling infestations on their farms and this, combined with the scoring method, enabled them to make justifiable day to day comparisons.

The scores indicated that starling numbers were lower than in previous years. This concurs with data recorded by BTO with regard to numbers at the roosts on the levels.

February records showed the highest numbers on farms but no correlation was found between daily temperature fluctuations.

Starling numbers on the farms remained relatively consistent during the day although it is not known whether the same birds remained on the farm all day or repeatedly returned to the same farm.

The starling scores have been used, in part, to assess the success of the mitigation methods used to deter starlings on the participating farms. This is discussed later in this report.

6.3 Starling Number Assessments

Vantage Point surveys were carried out on the 4 main farms by counting bird numbers on gridded photography, as well as observations on several farm visits. Experience gained from visual observations made for more accurate assessments on the other 6 farms which were observed on a number of occasions and correlated with score assessments recorded by the farmers (Figure 6.4).

Table 6.3 Starling number estimates from vantage point surveys

Starling Assessment Surveys – bird numbers

	Survey Type	Av	min	max
Farm 1	Vantage Point	2100	50	4680
Farm 2	Vantage Point	20000	3300	50000
Farm 3	Estimate	200		
Farm 4	Vantage Point	8700	2900	19000
Farm 5	Vantage Point	9100	3100	20000
Farm 6	Estimate	15000		
Farm 7	Estimate	2000		
Farm 8	Estimate	8000		
Farm 9	No significant bird numbers observed			
Farm 10	No significant bird numbers observed			
Farm 11	No significant bird numbers observed			

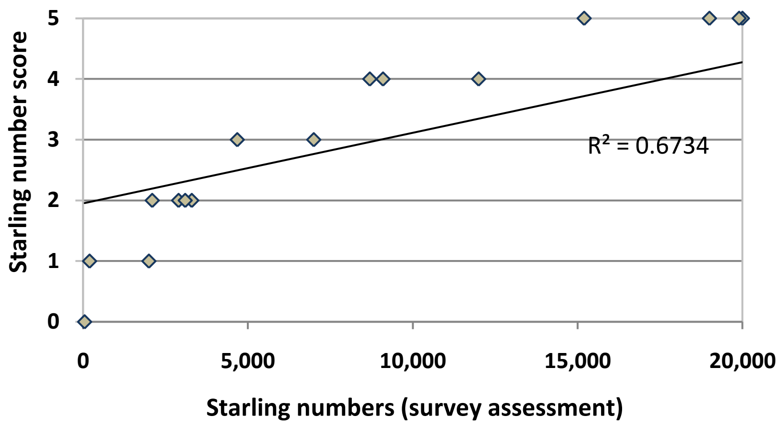


Figure 6.4 Correlation between starling numbers from survey assessment versus farm starling number scores

6.4 Farm systems of participating farms

The participatory farms ranged in milking cow herd size from 150 to 580. The total amount of exposed feed available to starlings on a daily basis is a reflection of herd size. Ingredients within the TMR rations fed will potentially affect the level of attractiveness to starlings. Table 6.4 shows the participating farms feeding systems in relation to bird numbers.

Table 6.4 Participating farms feeding systems and bird numbers

Farm feeding			Troughs		Concentrate use			Feeds													
Farm	Quantity of TMR fed (t/day)	Feeding frequency per day	In buildings	Outside	In parlour	Out of parlour feeders	In TMR	Grass silage	Maize silage	Alkalage	Soya	Rapemeal	Wheat (rolled/crimped)	Blend	Trafford Gold	Caustic Wheat	Linseed	Mycosorb	*Average bird score	**Average assessed birds numbers
1	7.1	2	✓	✓	✓	-	✓	✓	✓	-	-	-	-	✓					2.0	2,102
2	26.9	1	✓	✓	✓	-	✓	✓	✓	-	✓	✓	-	-	-	✓	-	-	4.7	20,000
3	9.0	2	✓	-	✓	-	✓	✓	✓	-	-	-	-	✓	-	-	-	-	0.4	-
4	10.5	1	✓	✓	✓	-	✓	✓	✓	-	-	-	✓	✓	-	-	-	-	1.8	8,700
5	12.6	1	✓	✓	✓	-	✓	✓	✓	-	-	-	✓	✓	-	-	-	-	2.1	9,100
6	12.8	2	✓	✓	✓	-	✓	✓	✓	-	-	-	✓	✓	-	-	✓	-	4.0	-
7	9.4	1	✓	✓	✓	✓	✓	✓	✓	-	-	-	✓	✓	-	-	✓	-	1.7	-
8	14.4	1	✓	✓	-	-	✓	✓	✓	✓	-	-	✓	✓	-	-	-	✓	3.6	-
9	25.7	1	✓	✓	✓	-	✓	✓	✓	-	-	-	-	✓	-	✓	-	-	0	-
10	9.7	2	✓	✓	✓	-	✓	✓	-	-	-	-	-	✓	-	-	-	-	0	-
11	13.0	–	✓	✓	-	-	✓	✓	-	-	✓	✓	-	✓	✓	✓	-	-	0	-

*See Section 6.2

** See Section 6.3

Farms in the study had many similarities but specific on-farm circumstances affected starling numbers:

- Two herds were over 500 cows (Farms 2 & 9). These herds therefore had a large feed source, both in storage and tonnage dispensed daily of over 25 tonnes of TMR ration. However, Farm 2 had the highest starling score and Farm 9 had one of the lowest indicating that feed source size is only part of the criteria dictating starling numbers.
- Only one farm (Farm 3) had no outside troughs, with all milking cows fed inside their cubicle housing. The buildings were effectively netted, preventing starling access to this feed resulting in a very low starling number score.
- Five farms fed twice a day, and five farms fed once a day. The farms feeding once a day, usually early in the morning, exposed the whole ration to starlings for the whole day with the greater potential of feed loss and contamination. Those feeding twice a day halved the exposure and potential loss and contamination. No relationship between feeding frequency and bird numbers was determined.
- Out of parlour concentrate feeders have been reported as being attractive to starlings. Only one farm in the study had these feeders but did not experience a starling problem with them this year, contrary to previous years. This was reflected in the farm's starling numbers.

Feeding maize:

- Feeds used varied between farms although all farms used grass silage and all but two of the farms fed maize silage. Maize silage is seen as the main attracting factor to farms. Farms not feeding maize (Farm 10 & 11) had a low incidence of starlings on the studied farms although low bird numbers were not exclusively associated with the 'no maize' farms.
- The two farms not feeding maize in their ration fed a grass silage base with blends. They both had no starling infestation recorded on farm (apart from opportunistic visits when flying to and from the roosts) until they introduced maize during the latter part of the starling season:
    - Farm 10 introduced maize silage in February, due to insufficient stocks of grass silage stocks. This resulted in increased levels of starlings although limited data was collected to quantify this.
    - Farm 11 introduced crimped maize in February in order to increase energy in the ration. This increased starling numbers considerably until the crimped maize was removed from the diet. Again, limited data was collected to quantify this. This farm had abandoned the use of maize this winter because of major starling problems in previous years.

Other feeds have been associated with starling feeding choice.

- Only one farm (Farm 8) fed alkalage which is urea-treated wholecrop (thought to be attractive to starlings)
- Three farms (Farm 2, 9 & 11) fed caustic wheat (which is thought not to be attractive to starlings).

6.4.1 Summary of farm systems and implications for starling numbers:

The relationship between feed type and starling numbers is inconclusive although maize is clearly a major factor in the attraction of starlings. Not feeding maize is likely to have a dramatic effect on starling numbers on a farm although other mitigating protocols can also have a big impact on starling numbers. This study did not evaluate starling feed choice for the separate ingredients of the TMR feed.

Proximity of neighbouring farms, building design, level of mitigation, proximity of orchards or trees suitable for perching could affect how 'attractive' farms are to starlings but the data set was not large enough to determine any differences.

No other clear relationships were determined between farm infrastructure and the starling numbers observed on farms.

6.5 Effectiveness of mitigation or control strategies

A number of methods for starling control are used on farms throughout the region with varying degrees of effectiveness. Table 6.5 describes the methods found during the study either on participating farms during the study period or used historically. The potential advantages and disadvantages described in the table are derived from observations during the study together with discussion with the farmers.

Table 6.5 Starling mitigation methods

Starling prevention methods	Potential effectiveness	Potential advantages	Potential disadvantages
Cover maize silage face: with a sheet or net	High	Effective if implemented conscientiously	Only protects a small proportion of the exposed feed
Net buildings	High	Effective if implemented conscientiously. Must be <28mm	Not all farm situations and buildings can be netted
Feed ingredients in the cow diet i.e. removing maize	High	High potential but more work needs to be done to ascertain which feeds other than no maize are not attractive to starlings	Change of farm policy on feeding and crop rotation
Dogs	High	Dogs chasing feeding birds can be very effective	Training requirement and time consuming
Human activity	High	Continuous human activity, making noise and gesticulating has been shown to be very effective	Difficult to find appropriate person
Shooting (licensed allowance)[1]	High	Short lived deterrent	Limited potential due to the licence being for 50 birds per year
Feed additives	Medium	Potential solution if the right product can be developed	Current products expensive and reportedly have little effect. Further product development and independent assessment required
Birds of prey	Medium	Skilled use of an experienced bird will act as a good deterrent	Requires good training and conscientious handler
Change time of feeding	Medium	Feeding late afternoon reduces feed exposure to starlings by up to 16 hours	Change of farm routines. Would have to consider if cow performance would be affected
Scarecrows	Medium	Moving inflatable scarecrows regularly appears to be a reasonable deterrent	Practicalities of positioning and response dependent on habituation
Scaring devices			
Bird mimicry audio Banger strips Gas pop guns	Low	Initially work but need to be very regularly changed and moved to maintain any level of mitigation	Birds soon get used to consistent audio sounds and then they provide little benefit
Fishing line stretched across main flight areas	Low	Can disrupt bird flight and therefore act as a deterrent	Determined birds in high levels of infestation unlikely to be deterred
Decoy birds	Low		Very limited benefit
Hanging up dead birds	Low	Short lived deterrent	Very limited benefit

All participating farms had more than one control method in place in an attempt to reduce starling activity on the farm. These methods were assessed for their effectiveness and given a score 1-5 (1 = used but generally ineffective & 5 = very effective, blank = mitigation not undertaken during study period) by the Kingshay assessor. Table 6.6 presents the results of this work.

[1] If farmers can demonstrate that there is a current starling problem on farm an application can be made for a licence to shoot birds, to enhance current scaring methods. WML A08 application form can be downloaded from the Natural England website at: www.naturalengland.org.uk/ourwork/regulation/wildlife/licences/applicationforms.aspx from the website www.naturalengland.org.uk , by emailing wildlife@naturalengland.org.uk or telephoning the Bristol office on 0845 601 4523.

Table 6.6 Mitigation scores and average starling number scores

Relative effectiveness of on farm starling mitigation

	Cover silage face with sheet	Cover silage face with net	Net buildings	Auditory scaring devices	Birds of prey	Shooting to scare	Disturbance/ Farm activity	Scaring devices/ Hanging dead birds	Using staff to frighten	No maize fed	*Mitigation Score	**Average starling number score	Jan Average starling number score	Feb Average starling number score	Mar Average starling number score
Farm 1	2						3		1		6	2.0	1.6	2.4	1.8
Farm 2				1	2	1			1		5	4.7	3.9	5.5	1.7
Farm 3	3		3	1		3		1	2		13	0.4	0.4	0.4	–
Farm 4				2		2			2		6	1.8	1.6	2.0	0.8
Farm 5			2	2		2			2		8	2.1	1.8	2.3	1.0
Farm 6		1	1	1	1			1	1		6	4.0	4.7	3.3	0.7
Farm 7				1		1	4				6	1.7	1.4	2.0	0.3
Farm 8	1			1		1		2	1		6	3.6	3.4	3.8	3.1
Farm 9		2		2		3	3		3		13	0	–	–	–
Farm 10				1		2			2	5	10	1	–	–	–
Farm 11						2		1	2	5	10	0	–	–	–

*Scores 1-5 (1= used & 5 = very effectively used, blank = mitigation not undertaken during study period)

Assessment was made following a number of visits to the participating farms and using the following criteria:

- Implementation of the mitigation method compared with other participating farms e.g. how complete was the netting of buildings.
- How conscientious was the farm in maintaining the mitigation throughout the study e.g. was the mitigation carried out on all visits to the farm.
- A greater score was given to scaring devices for those farms using more than one method or deploying the same method in multiple locations.
- Starling activity (Kingshay assessor).
- Not feeding maize silage scored highly based on an assumption that it is one of the main attracting factors for starlings. This was backed up by observations during the study.

A positive correlation for the mitigation score against the average starling score over the study period was determined (Figure 6.5).

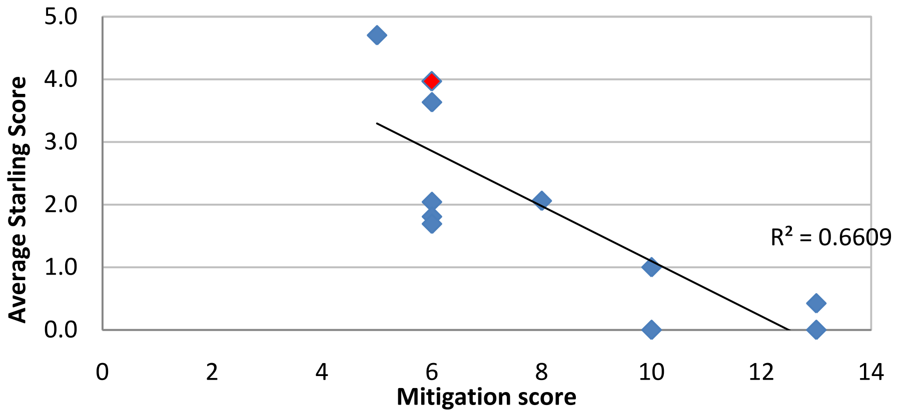


Figure 6.5 Mitigation score and the resultant average starling score. Starling project 2012

More or better implemented mitigation resulted in reduced bird numbers. These results indicate that reducing starling numbers on individual farms is potentially possible, although different winter conditions may give different results.

Starling number differences between farms were related to mitigation but also conditions prevailing on the farm.

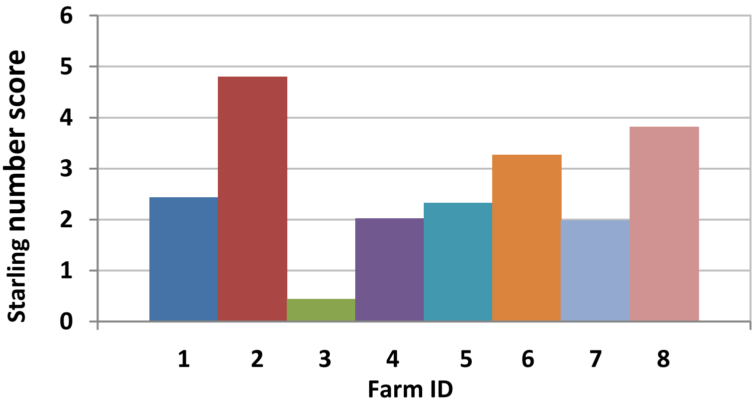


Figure 6.6 Starling number averages by participating farm for February 2012

Starling number differences in February 2012 (Figure 6.6) can be reasoned as follows:

- **Farm 1** - Low mitigation score but a high level of disturbance from building works involving human activity and limiting trough use
- **Farm 2** – Large feed source and relatively low mitigation score
- **Farm 3** – High mitigation score resulting from early season and persistent mitigation
- **Farms 4 & 5** – Average mitigation scores
- **Farm 6** – Farm located near the night time roost combined with inconsistent and ineffective mitigation
- **Farm 7** – Low mitigation score but a high level of human activity through the study period due to farm building development
- **Farm 8** – Low mitigation and mainly outside feed troughs
- **Farms 9, 10 and 11** – no starlings due to highly effective mitigation

6.5.1 The cost of starling control

The cost of implementing control measures will vary according to the farm layout and size. The table in Appendices 11.1.5 provides a summary of costs of available equipment (Wildlife Management, SASA. January 2012) and other cost information provided by the farms in the study.

6.5.2 Summary of mitigation strategies

A wide range of mitigating strategies was observed on the participating farms. Assessing these for their effectiveness in reducing starling numbers indicated that reducing numbers of starlings is potentially possible through the selection of the right strategy combined with the right level of determination to implement the control method. Implementation and conscientiousness was determined to be most important from the onset of the migration period.

Not all strategies are appropriate for all farms and although changes in feed management i.e. not feeding maize, has a dramatic effect on starling numbers this might not be an economic strategy for many producers. Feeding alternative energy sources to compensate for the loss of maize from the ration needs further research as alternative feeds may also be attractive to starlings.

Assessments of the effectiveness of used mitigation methods were entirely consistent with the findings of Bishop et al (2003), as discussed in Section 4.7.4.

6.6 Feed loss from starlings

The quantity and cost of feed consumed by starlings on farms was evaluated on 3 of the participating farms. These pilot trials were conducted to test the protocol for feed loss/cost evaluation and to provide an indication of the potential effect on the economics of starling infested dairy farms from the feed consumed by visiting birds. The work was not intended as a full evaluation of the economic effects of bird infestations which would need to include other issues, in particular:

- Cattle health problems associated with faecal contamination of feedstuffs and the housed environment
- Milk loss through reduced feed intakes resulting from reduced palatability of feed caused by starling interference and faecal contamination
- Inappropriate feed management as a tool to reduce contamination i.e. changing feed times or diet balance resulting in poorer overall rationing
- Other health problems associated with incorrect feeding i.e. cow fertility
- Contaminated work environment for staff

Feed loss was calculated for the daylight hours when birds were on the farm. This was, in general, between 7 am and 5 pm. Access to feed by cows would normally be constantly 24 hours a day.

Starling access to the full 24 hour feed resulting from once a day feeding in the morning potentially represents a greater cost and risk of contamination compared with feeding twice a day or feeding once a day but in the late afternoon once the starlings have left the farm.

Starling flocks were not consistently on farms during the study period and this enabled a range of data to be collected assessing the effects of feed loss under different levels of bird infestation.

6.6.1 Feed loss from maize silage clamps

Assessing changes in feed value of maize silage before and after starling feeding indicated a significant loss of energy (Table 6.7).

Table 6.7 Change in feed value for clamped silage, before and after starling feeding

	ME MJ/kg DM	Starch %	NDF %	Oil %	Bypass starch %	Dry Matter %	Crude Protein %
Clamp mean no starling feeding	11.27	35.57	36.93	2.77	12.7	31.07	8.87
Clamp mean after starling feeding	11.03	31.47	39.73	2.27	8.1	29.73	8.87
Change	0.23	4.10	-2.80	0.50	4.6	1.33	0.00
Significance p	**0.01**	**0.00**	0.10	**0.00**	**0.02**	0.48	1.00
LSD 95%	0.14	1.22	3.62	0.09	3.64	4.53	0.16

*Figures in bold = statistically significant P = < 0.05

The results showed a significant decline in starch %, bypass starch % and Oil % all of which would indicate the removal of maize grain from the silage. From these results it can be concluded that starlings seek out the maize grains in the silage, which have starch content in excess of 70%, which results in a significant loss in the energy content of the feed.

6.6.2 Quantity of feed lost

Feed weight loss measurements, after accounting for changes in dry matter, ranged from 1% to 12%. These figures are relevant to the area of feed trough tested on-farm and will not necessarily be consistent across all exposed feed. Dry matter increased after feed-out by an average of 1%.

Feed loss was a direct reflection of bird activity on the farm on the day of testing. The high level of feed loss was associated with the largest flocks recorded during the study i.e. in excess of 20,000 birds (Section 6.4) whilst the lowest levels occurred when very few starlings were present on the farm.

The average cost of the loss in the quantity of feed equates to £0.22 /cow/day and ranged from £0.04 to £0.37/cow/day. This figure is based on a compensatory feed value for the TMR of £184/tonne DM.

6.6.3 Change in feed structure

The TMR feed was sieved before and after starling feeding to determine any changes in the structure of the ration. The ration structure changed significantly to have a greater percentage above 1.3 cm and a decline in the percentage of the ration between 0.5 and 1.3 cm (Table 6.8).

The decline in particles between 0.5 and 1.3 cm could include the removal of maize grains although this test method provides no evidence as to the nature of the ingredients lost from starling feeding.

Table 6.8 Percentage of TMR ration by particle size after sieving AM and PM

Sieve size (cm)	1.9	0.8	0.2	<0.2
Minimum Circular Particle size (cm)	1.3	0.5	0.1	<0.1
Structure AM	41.6	31.6	21.8	4.9
Structure PM	44.4	28.4	21.7	5.2
Change	2.8	-3.3	-0.2	0.3
Significance p	**0.01**	**0.01**	0.85	0.19
LSD 95%	2.02	2.39	1.79	0.44

*Figures in bold = statistically significant P = < 0.05

6.6.4 Feed value loss from TMR feed

TMR feed value assessment indicated a significant decline in ME and starch % and an increase in NDF when comparing TMR feeds fed-out in the morning compared with the feed at the end of the day after exposure to starling feeding (Table 6.9).

Table 6.9 Change in feed value of TMR feed, before and after starling feeding

	n	ME MJ/kg DM	Starch %	NDF %	Sugar %	Oil %	Dry Matter %	Crude Protein %
TMR mean AM	10	11.73	20.4	37.5	3.1	5.0	38.3	17.3
CV		0.02	0.04	0.09	0.49	0.13	0.15	0.03
TMR mean PM	10	11.05	14.5	42.7	3.0	5.3	38.4	16.6
CV		0.03	0.25	0.06	0.51	0.09	0.10	0.04
Change		0.7	5.9	-5.2	0.1	-0.3	-0.1	0.7
Significance p		**0.04**	**0.04**	**0.02**	0.7	0.61	0.95	0.2
LSD 95%		0.65	5.72	3.79	0.66	1.72	4.58	1.46

*Figures in bold = statistically significant P = < 0.05

These results are in line with the feed structure changes measured and the changes in feed value on the maize silage clamps and indicate significant losses in the feed value of TMR rations when starlings are present. The loss in quality and volume of the TMR approximately equated to an average of £0.28/cow/day and ranged from £0.05 to £0.46/cow/day, based on a dry matter intake of 20kg.

However, this may not reflect the cost to the farm as compensatory feeding may not be an option. Changing the TMR balance to reflect a daily change in bird numbers is not a practical solution and feeding extra concentrate feed is not always an option. The calculation of the cost of starling feeding based on the loss in milk production is presented in the next section.

6.6.5 Calculation of the cost of feed loss

The cost of feed loss to dairy farms resulting from a loss in milk production and a loss in feed volume is shown in Table 6.10.

The cost of lost quality is calculated as a loss in milk from the decline in the quality of the ration. The loss in feed volume is calculated from the measured ration weight reduction. The figures are presented as average, minimum and maximum based on the data collected during the study.

These figures give a guide to the potential cost resulting from starlings that are eating exposed TMR feed. They do not take account of other cost implications listed in Section 6.6.

Table 6.10 The cost of starling eating a cattle TMR for 100 cows at different levels of infestation

Starling Feed Loss Cost Calculation

Example assumptions:	
Number of milking cows being fed TMR	100
DMI (Assumed intake of TMR) - kg DM / day / cow	20
Days affected by starlings during winter	90
Feed loss cost £ / tonne DM (Kingshay Relative Value)	184
% of cows rations affected	100
Milk price - p per litre	28

	Average	**Minimum**	**Maximum**
Lost milk output due to loss of feed quality			
Loss of ME (per kg DM)	0.7	0.3	1.1
Potential lost milk - litres per cow from TMR	2.64	1.13	4.15
Loss of milk - £/cow/day	0.74	0.32	1.16
Cost per day – milk loss	£73.96	£31.70	£116.23
Cost per winter – milk loss	£6,657	£2,853	£10,460
Volume of feed loss			
Feed weight loss %	6	1	10
Feed loss kg DM/cow/day	1.2	0.2	2
Feed loss per day kg DM	120	20	200
Cost per day – volume of feed loss	£22	£4	£37
Cost per winter – volume of feed loss	£1,987	£331	£3,312
Total costs - per day	**£96.04**	**£35.38**	**£153.03**
Total costs - per winter	**£8,644**	**£3,184**	**£13,772**

Bird numbers required to justify costs	**Average**	**Minimum**	**Maximum**
Bird numbers - eating 20% of bodyweight (20g/bird/day)	13,333	2,222	22,222
Bird numbers - eating 50% of bodyweight (45g/bird/day)	5,926	988	9,877

The cost of feed loss gives a guide as to the potential cost of starlings feeding on a farm but this will be affected by a particular farm's circumstances, in particular the amount of feed exposed to starlings during a 24 hour period. For the example in Table 6.10 it is assumed that the entire ration is exposed to starling feeding. This would correspond to once a day morning feeding.

Table 6.10 also indicates the amount of birds that would need to be on a farm to consume the assumed feed loss in the calculation. This provides justification for the range of feed loss based on the bird number assessments made during this study.

6.6.6 Summary of feed loss

Quantifying the amount and cost of feed consumed by starlings has shown the following:

- Feed loss is dependent on starling numbers but can be as high as 12% of the TMR fed
- Structural change indicated a reduction in the particles associated with the size of maize grain after starling feeding
- Significant losses in feed value from birds feeding on maize silage clamps were recorded
- Losses in feed value up to £0.46/cow/day were recorded
- Calculating feed value loss in terms of milk output forgone equated to a maximum of £1.53/cow/day
- Feed loss calculations do not account for health problems and other issues caused by starling faecal contamination

The data collected has provided some baseline data on the potential cost of starlings feeding on farms. Further work is needed to give more robust figures but the variability across farms will always require a number of assumptions to be made to calculate the cost.

7 DISCUSSION

The migrant starling population on the Somerset levels during the winter of 2011/2012 was lower than in recent years and this, combined with milder than average weather during the study period, reduced the number of starlings feeding on farms. However, this provided an opportunity to assess starling behaviour on dairy farms under these conditions. This scenario probably provided better data on the effects of starling mitigation techniques as the starling flocks were under less feeding pressure, and presumably had a wider choice of feeding options, and were therefore more easily deterred.

The techniques used in this study proved to be effective in gaining an insight into the issues associated with starlings and enabled the objectives of the study to be achieved.

Assessment of the starling mitigation techniques used by the participating farmers provided a good insight into the relative usefulness of most of the techniques common on farms in the UK. The potential effectiveness of these techniques is described in Table 6.5. What was clear from the on-farm assessments was that all techniques to control starlings benefitted from a high level of persistence in their implementation.

Some control methods are not practical on all farms and therefore it would not be appropriate to suggest that all farms can prevent starling infestations. The most effective way to reduce the attraction of starlings was to not feed maize although other techniques requiring a persistent and vigilant human input were also shown to be very effective.

Not feeding maize would represent a major change in the feeding management on dairy farms although herd profitability amongst Kingshay costed herds not feeding maize are comparable to those that do (see Appendices 11.1.6). Substitution of maize in the diet through an alternative energy feed that could also be attractive to starlings would have limited benefit. More work is required on the attractiveness of different feeds to starlings so that the impact of substituting maize in the diet can be assessed.

The cost of implementing control measures varies widely and will depend on the farm layout, building design and labour availability. Saving the costs determined for feed loss alone, discussed in this report, is likely to be more than enough to compensate for the cost of most of the mitigation methods investigated providing that they are fully implemented and prevent starling feeding.

One important factor coming from this study is the reluctance of farms to change their feeding routines to reduce the potential for starlings to eat and contaminate the fed TMR. Feeding once a day in the morning gives the opportunity for starlings to contaminate and feed from the entire ration. By feeding after the birds have left i.e. 5pm any feed consumed by cows between 5pm and 7am will not be contaminated or reduced in value. There is a possibility that farm infestations may be reduced by delaying feeding time in the morning (say 09:30-10:00) until after the starling flocks have selected their first feed source, after leaving the roosts between 07:30-08:00. By changing farm routines the cost of a starling infestation could be reduced even if the on-farm starling numbers were the same.

Cattle health issues resulting from faecal contamination of feed and the housed environment were not assessed in this study but all of the participating farms considered this to be a major cost to their business. Opening up this issue through further research would need to be handled carefully, from a public perspective point-of-view and developing effective control methods would still be the solution.

The climatic conditions and migrant flock numbers influencing this study are reflected in the results and future assessments in different conditions would help to improve the depth of understanding of starling behaviour and their effect on dairy farms.

8 RECOMMENDATIONS

Recommendations arising from this report:

KT to Farmers

- Control methods can reduce starling numbers see (Table 6.5)
- The most effective approach is to integrate the use of several methods of mitigation simultaneously or sequentially
- Implement completely and persistently from the start of starling activity – do not wait until the problem is out of hand
- Consider changing feeding times to twice a day or once a day after the starlings have left in the afternoon. It is not advisable to change the inclusion rates of different feeds in TMR during a 24 hour period to deter starlings as this can reduce cow performance
- Consider not feeding maize. This may be a last resort and needs to be discussed with a good nutritionist to ensure that the desired cow performance is not compromised. Alternative feeds need to be considered carefully to avoid the attraction of starlings

Government agencies should be encouraged to provide financial support to farms on this issue. The potential implications for animal and human health are sufficient to warrant funding for starling mitigation projects alongside other government funding initiatives that aim to improve cattle health and welfare.

8.1 Potential further Work

- Animal health issues. Analysing faecal contamination and the effect on animal health
- Increased data to provide more robust figures. To get a fuller view of the nature of the starling problem the study should be repeated particularly to account for climatic and seasonal differences
- Evaluation of starling feed choice for the separate ingredients of the TMR feed
- Further study on different feeding times could evaluate the effect on bird numbers and starling feed site choice
- Testing feed additives e.g. Blast (Active Flavour Technology Ltd), both by integration of product while ensiling maize or using as an additive to the TMR. This type of product could offer a solution to bird control although it has so far proven ineffective, largely through lack of product development
- Monitoring starling movements by radar tracking with mobile equipment with FERA (Food & Environment Research Agency). More detailed monitoring of starling movements could be undertaken with radar tracking, with either a 5 day or 10 day radar deployment and data analysis. Deployment could include using colour markings and radio tracking on individual starlings to monitor flock behaviour more closely. This would determine bird movements from roosts to farms and between farms and would determine where flocks were visiting, their daily movements and whether the same birds frequented individual sites regularly or consistently
- This study was not commissioned until after the migrant starlings had already arrived. Any further studies should be commissioned to start well in advance of the expected arrival dates. If research is commissioned to test feed additives, this also needs planning before the maize silage harvest

9 CONCLUSIONS

Starling numbers are declining across Europe and in recent years in the Somerset region. This is occurring despite the increase in maize production in the region, although the area of permanent pasture is in decline as are the number of dairy holdings. A range of other factors are responsible for the decline in bird numbers which are beyond the control of dairy farmers and are not the result of any changes in farming practice.

Starling infestation levels on farms in the Somerset Levels were found to be variable between the farms investigated. This was due to three main factors. 1) lower numbers of starlings on the Levels during the study period which provided the starlings with a greater choice of feeding sites, 2) the above average winter temperatures giving a greater opportunity for starlings to feed on insects in the fields and 3) the degree of attractiveness of the farms to feeding which was dependant on the feeds on offer and control methods in place.

Lower than average numbers of starlings in the region during the study period enabled the effective evaluation of starling control measures. The results showed that farms with a more enthusiastic attitude to mitigation controls tended to have lower populations of visiting birds. Cow diet management, i.e. not feeding maize, was particularly effective at reducing starling feeding activity, although human activity was also a large deterrent.

The cost of starlings on farms in terms of milk and feed loss amounted to a maximum of:

- £153 per day per 100 cows
- £13,772 cost per 90 days winter per 100 cows

Further work needs to be done to determine the effect on cow health and the financial consequences.

Changing feeding times and reducing the amount of feed that the starlings had access to was suggested as a way of reducing the extent of the financial cost of starlings.

Whilst the financial impact on affected farms is significant, with appropriate controls the worst effects of the problem can be reduced. However, this does not mean that year to year variations in starling population numbers could result in significantly higher costs to farmers than those measured during this study.

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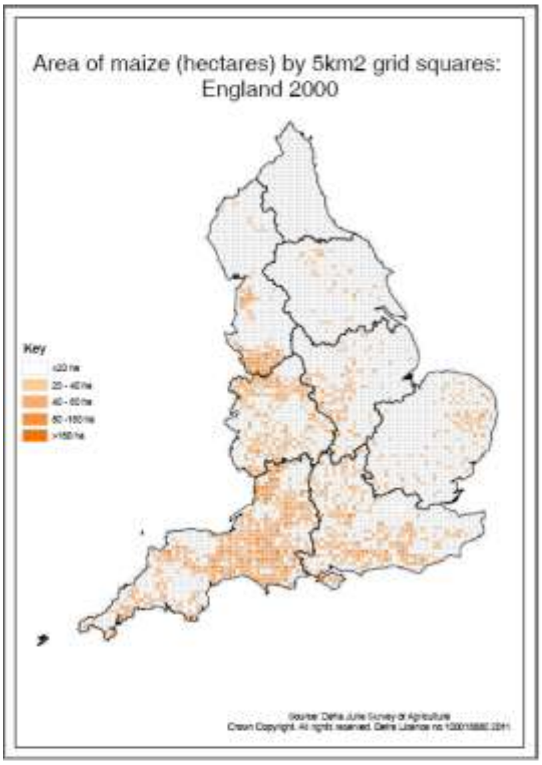
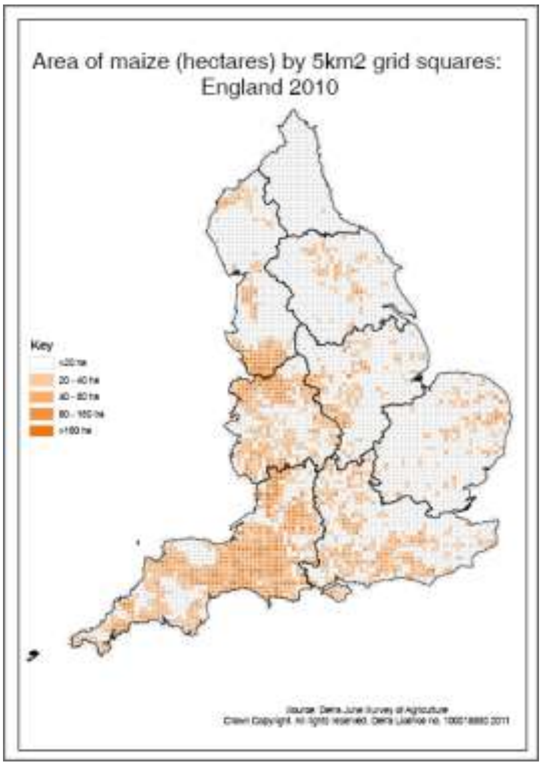
11 APPENDICES

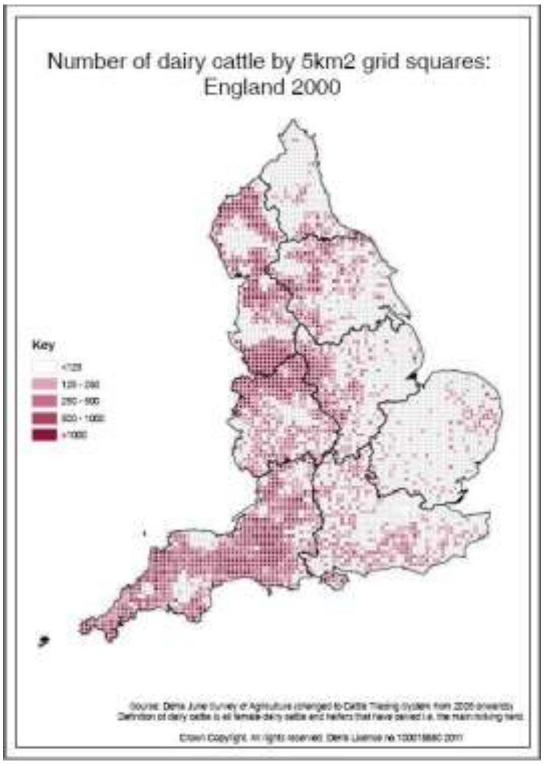
11.1 Supporting data

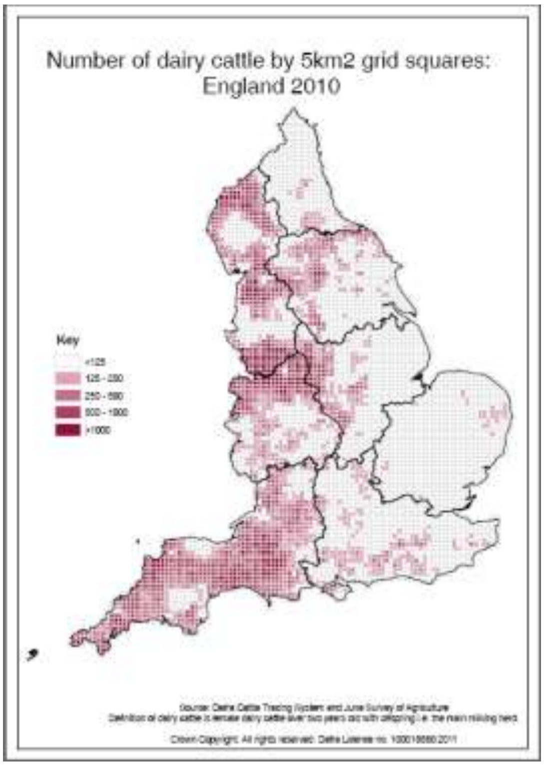
11.1.1 Area of maize (ha) 2000 and 2010



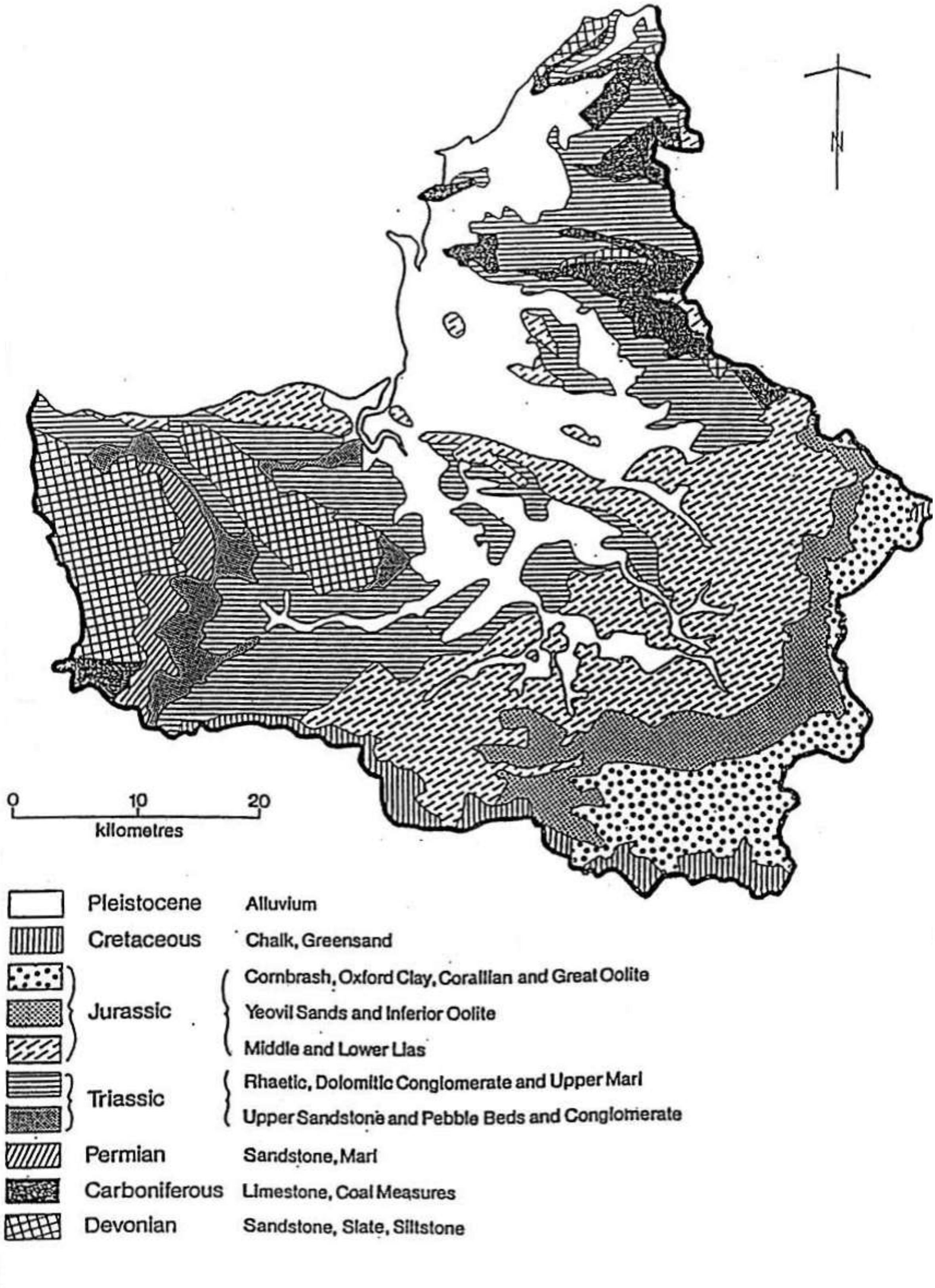


11.1.2 Number of dairy cattle 2000 and 2010





11.1.3 **Geology of the Somerset Levels & Moors**

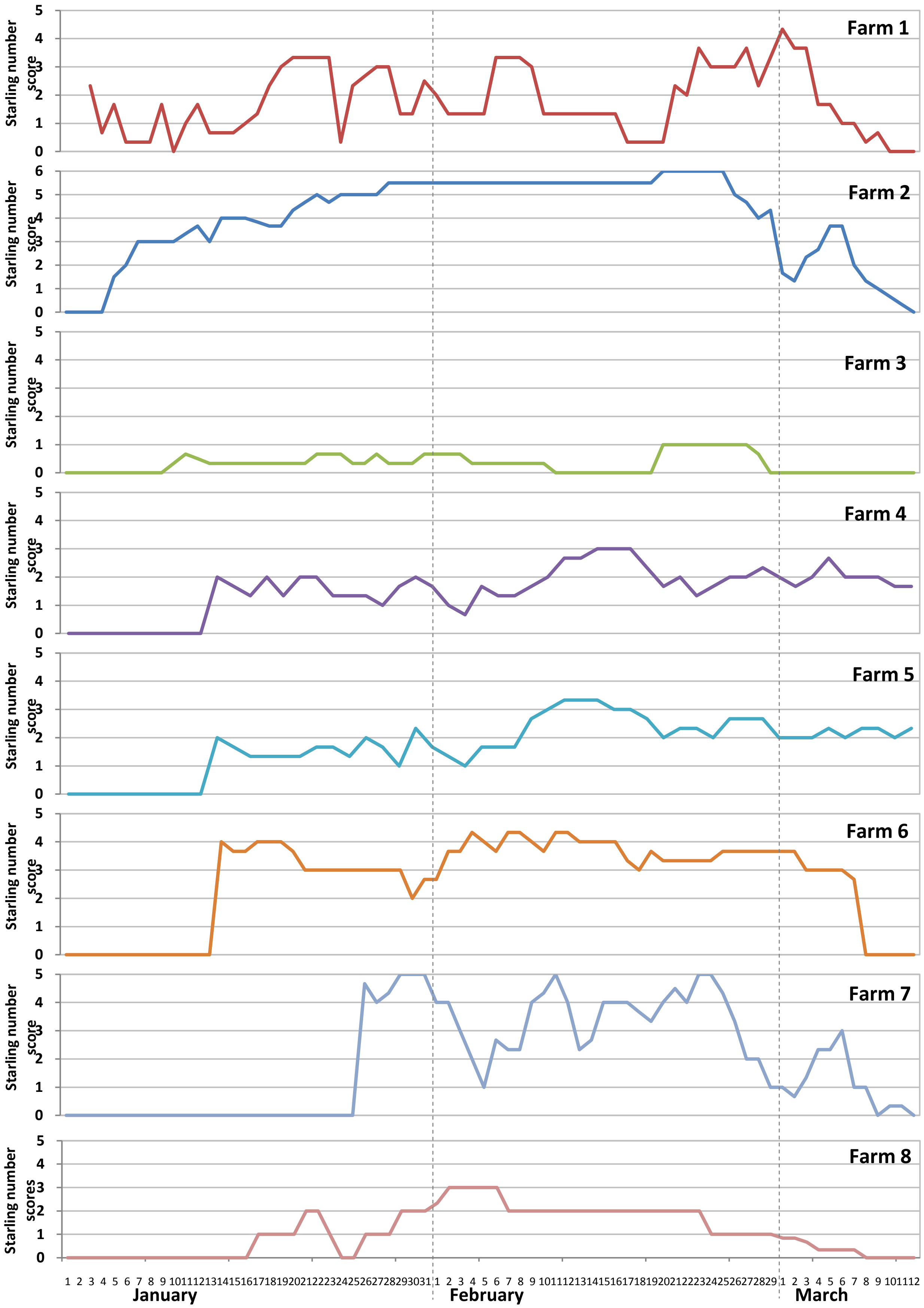


Map 3

The geology of the Somerset Levels and Moors

ENGLISH NATURE

11.1.4 All farms starling number scores January to March 2012



* Farm 2 experienced exceptionally high bird numbers in February outside the normal scoring range adopted by all farms. A score level of 6 was allocated to reflect this which related to a flock size of 50,000.

11.1.5 **Shooting licence application form**

Wildlife and Countryside Act 1981

Licence Application Form
Use this form if you want a licence to:

- **kill or take wild birds,**
- **use a method that is prohibited by this Act, or**
- **disturb wild birds listed on Schedule 1 of this Act**

NATURAL ENGLAND

- Please complete this application form using **dark ink** and BLOCK CAPITALS
- All questions must be answered. The completed application should be sent to Natural England at the address given opposite. Note you can complete this form electronically and email it to us.
- Natural England will aim to determine whether a licence should be issued within 30 working days of receipt of the completed application.

If you experience any problems completing this application, please contact the Wildlife Licensing Unit (details opposite).

Wildlife Licensing Unit
Natural England
First Floor
Temple Quay House
2 The Square
Bristol BS1 6EB
T. 0845 601 4523
F. 0845 601 3438

For Office Use Only

WILD Ref No:

Charter Deadline:

Useful Links

Website: www.naturalengland.org.uk/ourwork/regulation/wildlife/licences/applicationforms.aspx

Email the Wildlife Licensing Unit: wildlife@naturalengland.org.uk

Explanatory Notes:

Section 1 of the Wildlife and Countryside Act 1981 **protects all wild birds as well as their eggs and nests.** It also gives extra protection to the rare bird species listed on Schedule 1 of the Act.

Section 5 of the Wildlife and Countryside Act 1981 **prohibits the use of the following methods of killing or taking wild birds**: traps, nets, snares, hooks, bird-lime or similar substance, gas or smoke, chemical wetting agents, electrical devices for killing, stunning or frightening, bows, crossbows, explosives (other than ammunition for a firearm), automatic or semi-automatic weapons, shot guns with an internal diameter at the muzzle of more than 44 mm (1¾ inches), devices for illuminating a target or sighting device for night shooting, artificial lights, mirrors or other dazzling devices, sound recordings, live birds or other animals as a decoy where the decoy is tethered or secured by braces or a similar device or is blind, maimed or injured, and mechanically propelled vehicles in immediate pursuit.

Natural England, under powers conferred by the Secretary of State, has authority under section 16(1) of the Act to grant licences to permit the killing or taking of wild birds, viable eggs, and nests under construction or in use, to disturb Specially Protected birds listed on Schedule 1 of the Act, and to permit the use of prohibited methods of killing or taking, for the following purposes:

- preventing serious damage to livestock, food for livestock, crops, vegetables, fruit, growing timber, fisheries or inland waters,
- preventing the spread of disease,
- preserving public health or public or air safety,
- conservation of wild birds.

For licences to **prevent serious damage**, applicants should be able to demonstrate that:

- evidence that serious damage caused by a bird species is occurring or is likely to occur,
- non-lethal methods of preventing damage have been tried but have proved to be either ineffective or impracticable,
- the proposed licensed action will reduce, or prevent from increasing, the level of damage.

Applications will not be considered without the required supporting information. Advice on the information required to apply for a licence is given in Natural England's advisory leaflets:

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11.1.6 **Table of Mitigation Costs Summary. Cost of equipment**

Product	Company	Type of device	Cost
Gas gun	Astwells	Auditory. Selectabang	£330
Gas gun	CG Engineering	Auditory. Rotobang	£450
Air Horn	Ecoblast	Auditory. Rechargable	£21-29
Hawk Kite	Allsop Helikies Ltd	Visual. Helium filled balloon or kite	£93-113
Scary Man	Claratts Ltd	Visual. Electronic inflatable scarecrow	£320
Sky Rockets	EcoPro Ltd	Auditory	£158 for 100
Rope Bangers	EcoPro Ltd	Auditory	£34.50 for 12
Distress & Predator Calls	Martley Electronics	Auditory	£219-439
Robotic Bird	Robop Ltd	Robotic bird (Peregrine)	€ 3,200
Scarecrow Patrol 2	Scarecrow Bio-Acoustic Systems Ltd	Visual & Auditory	£735
Scarecrow Compact	Scarecrow Bio-Acoustic Systems Ltd	Auditory	£1,990
Shot	Scarecrow Bio-Acoustic Systems Ltd	Auditory. Automatic & random play	£820
Wailer	Scaringbirds.com	Auditory. Master Unit	£459
Wailer	Scaringbirds.com	Auditory. RC Transmitter	£175
Water Pest Repeller 650	Various	Water Repellant	£20
Distress Calls	Wingaway	Auditory. 60W	£895
Distress Calls	Wingaway	Auditory. 100W	£1,320
Bird Netting <28mm	Various	Physical	£10 for $25m^2$
Bird Netting	Farm 3	Physical. Roof ridges, gaps & doors	£2000 p/a
Bird Netting	Farm 4	Physical. Door panels	£200-300 each
Human Activity	Farm 9	Employed person to shoot to scare with shotgun	£4,000
Bird of prey - Harris Hawk	Farm 2	Live bird training & equipment	£300 £1,700

11.1.7 Kingshay Dairy Manager Costings

Kingshay DAIRY MANAGER — Winter Forage Use (South West Region) — March-12 — ANNUAL RESULTS

ANNUAL ROLLING RESULTS

Holstein/Friesian, Non Organic Herds		Average	All Grass	Grass/Maize	Grass/W'crop	Grass/Maize/ W'crop
Cows in herd		166	132	174	177	224
Stocking rate	cows/ha	2.19	2.24	2.14	2.63	2.59
MILK PRODUCTION						
Yield per cow	litres	**8,177**	**7,849**	**8,288**	**7,571**	**8,530**
Yield from all forage per cow	litres	2,867	3,031	2,912	2,778	2,492
% of total yield from forage		35%	39%	35%	37%	29%
Butterfat	%	4.07	4.14	4.04	4.17	4.01
Protein	%	3.26	3.28	3.25	3.30	3.23
Bactoscan		30	29	29	30	31
Cellcount		186	177	189	195	181
Milk Price	p	**28.02**	**27.98**	**28.15**	**28.16**	**27.60**
Total milk value per cow	£	2,291	2,196	2,333	2,132	2,354
FEED						
Total concentrate use	tonnes	400	300	419	399	602
Concentrate use per cow	kg	**2,413**	**2,273**	**2,409**	**2,261**	**2,684**
Concentrate use per litre	kg	0.30	0.29	0.29	0.30	0.31
Concentrate price per tonne	£	226	227	228	225	220
Other purchased feed cost per cow	£	60	33	65	29	92
Total purchased feed cost per cow	£	604	550	613	537	682
Total purchased feed cost / litre	p	**7.39**	**7.01**	**7.40**	**7.09**	**8.00**
All P Feed @ 86% DM	k	**2635**	**2397**	**2,665**	**2,428**	**2,972**
MARGINS						
MOPF per cow	£	**1,687**	**1,646**	**1,720**	**1,595**	**1,672**
MOPF per litre	p	20.63	20.97	20.75	21.07	19.60

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Kingshay DAIRY MANAGER — Winter Forage Use (SW Region) High Yield — March-12 — ANNUAL RESULTS

ANNUAL ROLLING RESULTS

Holstein/Friesian, Non Organic Herds		Average	All Grass	Grass/Maize	Grass/Maize/ W'crop
Cows in herd		211	208	195	286
Stocking rate	cows/ha	2.32	2.37	2.16	2.77
MILK PRODUCTION					
Yield per cow	litres	**9,571**	**9,485**	**9,580**	**9,706**
Yield from all forage per cow	litres	2,687	3,279	2,693	2,122
% of total yield from forage		28%	35%	28%	22%
Butterfat	%	3.98	4.09	3.96	3.93
Protein	%	3.21	3.24	3.21	3.19
Bactoscan		23	22	23	24
Cellcount		164	162	169	157
Milk Price	p	**28.53**	**29.41**	**28.58**	**27.87**
Total milk value per cow	£	2,731	2,790	2,738	2,705
FEED					
Total concentrate use	tonnes	623	583	571	897
Concentrate use per cow	kg	**2,950**	**2,809**	**2,922**	**3,130**
Concentrate use per litre	kg	0.31	0.30	0.31	0.32
Concentrate price per tonne	£	228	225	236	217
Other purchased feed cost per cow	£	115	69	115	164
Total purchased feed cost per cow	£	786	702	805	843
Total purchased feed cost / litre	p	**8.21**	**7.40**	**8.40**	**8.69**
All P Feed @ 86% DM	k	**3361**	**2995**	**3,382**	**3,657**
MARGINS					
MOPF per cow	£	**1,945**	**2,088**	**1,933**	**1,862**
MOPF per litre	p	20.32	22.01	20.18	19.18

Kingshay can accept no responsibility for the information supplied to it. Every care will be taken by Kingshay to produce an accurate report but it does not accept any liability for any loss (whether direct or consequential) arising from any defect in the report.

11.2 Photographs

11.2.1 Starling Infestation

Plate1. Infestation in cow building during feed trial

Plate 2. Starlings on feed trial area (See attached Video)

Plate 3. Starling infestation on exposed silage face

Plate 4. Starlings perching inside cubicle building and on roof

Plate 5. Fouling on cow backs and surfaces

Plate. Accumulated fouling on rails in cow building

11.2.2 **Mitigation**

Plate 1. Ineffective mesh panels, gaps providing access in to building

Plate 2. Effective netting applied to all openings including roof ridge

Plate 3. Roll down nets providing some degree of protection

Plate 4. Effective covering of silage face

Plate 5. Scarecrow used in different locations on farm on time lapse.

Plate 6. Part of starling flock collecting together for return migration