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Autumn survey of wheat bulb fly incidence 2018

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1. Abstract

All cereals, except oats, can be attacked by wheat bulb fly (WBF). Eggs are laid in late summer in bare soil following fallows or early harvested crops, particularly if fields are cultivated between mid-July and mid-August. Fields cropped with root crops, such as sugar beet, potatoes and onions, are also favoured as egg-laying sites, as the pest can access bare soil between the rows. WBF is most prevalent in eastern England and north-eastern England.

The specific objectives of the project are:

1. To measure the incidence of WBF each autumn in the infested areas
2. To forecast the need for seed treatment

A total of 30 fields were sampled for WBF eggs in September 2018 in areas prone to the pest, with 15 in eastern England and 15 in northern England. The sites were chosen to represent some of the main preceding crops, leading to a risk of WBF damage in each area.

For crops sown in September and October the damage threshold (the egg population that might be expected to have an economic impact on yield) is 250 eggs/m² (2.5 million eggs/ha). In autumn 2018, none of the sampled fields were considered at very high risk (egg numbers >500/m²), one at high risk (egg numbers 250-500/m^2), six at moderate risk (egg numbers 100-249/m^2 and 23 at low risk (egg numbers <100/m^2). This was equivalent to 3%, 30% and 67% of fields in the high, moderate and low risk infestation categories respectively. With only one field was above the 250 eggs/m^2 damage threshold the level of risk is the second lowest recorded since monitoring began in 1984. WBF adults feed on saprophytic fungi in wheat ears. It is possible that rapid progress with the wheat harvest in 2018 meant there was less time for these fungi to develop, which in turn meant less food for adult WBF females and as a result they produced fewer eggs than in a wetter season when their food source is likely to be more plentiful. Average egg numbers in the north were slightly higher than in the east with 82 eggs/m^2 in the north and 62 eggs/m^2 in the east. Over all sites, the highest risk was after potatoes with a mean of 140 eggs/m^2. The next highest risk was after onions with 96 eggs/m^2 although only one site was sampled

Late-sown (November onwards) or slow developing crops are at greater risk from WBF than those that are early sown (September/October) due to slower tiller development. As a result, a lower threshold of 100 eggs/m^2 or 1 million eggs/ha is applicable for these crops. In the north of England 33% of sites were above this level but only 7% were above this level in the east. All fields in the moderate category would benefit from a seed treatment if sown from November onwards.

Crops sown between January and March would benefit from a seed treatment if any WBF eggs are found.

2. Introduction

All cereals except oats can be attacked by wheat bulb fly (WBF). Eggs are laid in late summer in bare soil following fallows or early harvested crops, such as vining peas, particularly if fields are cultivated between mid-July and mid-August. Fields cropped with root crops, such as sugar beet, potatoes and onions, are also favoured as egg-laying sites, as the pest is able to access bare soil between the rows (AHDB, 2016). The pest is most prevalent in eastern England and north-eastern England. In outbreak years, widespread damage can occur.

Eggs are laid in late July and August in England and up to mid-September in Scotland and remain dormant throughout late autumn and early winter. The larvae hatch between January and March. Soon after hatching, they invade shoots of cereal crops and the attacked shoots wither or become yellow and stunted. These symptoms are known as 'deadhearts'.

The level of WBF risk each year fluctuates greatly, due mainly to July and August rainfall (Young & Cochrane, 1993) and the harvest dates of the previous wheat crops. The longer crops remain in the ground, the longer adult flies have to feed on saprophytic fungi within the cereal ears and mature their eggs. Incidence generally increases following a wet harvest period, such as in 2004, and is lowest after a hot, dry summer, such as in 1995. The proportion of fields having an egg count greater than the 250 eggs/m² damage threshold (the egg population that might be expected to have an economic impact on yield) ranged from 3% to 44% in the period 1984–1999 (Oakley & Young, 2000) and from 0% to 50% between 2000 and 2018 (Figure 1).

The hot dry summer meant an early start to the wheat harvest which was 25% complete by 2 August. Progress was good throughout the rest of the month and by the end of August about 96% of the crop had been harvested. By 13 September the wheat harvest was all but complete. This suggested that the risk from wheat bulb fly would be low again as in the last two years and this survey will help determine if this is the case and provide valuable information on the potential risk from the pest for the 2018/19 season.

The overall objective of the project is to establish the annual incidence of wheat bulb fly in the autumn to allow farmers to decide on the need for seed treatment in late-sown crops. Specific objectives are:

1. To measure the incidence of WBF each autumn in the infested areas.
2. To forecast the need for seed treatment.

Egg numbers can be estimated by soil sampling and related to damage threshold levels of 250 eggs/m² (2.5 million eggs/ha) for crops sown in September or October, or 100 eggs/m² (1.0 million eggs/ha) for crops sown from November onwards. At lower infestation levels, economic damage is less likely, although winter cereal crops sown from November onwards or those sown in spring before the end of March can be particularly vulnerable. Larvae attack shoots of wheat, barley and rye from January to April, with yield loss depending on tiller density at the time of attack. Crops still at the single shoot stage in February are most vulnerable and may be completely destroyed (Young, 2000). Yield losses of up to about 4 t/ha have been recorded following severe damage (Young & Ellis, 1996).

The options for control of WBF have been reduced by pesticide reviews and withdrawals and are currently limited to a tefluthrin + fludioxinil seed treatment (Austral Plus) and a cypermethrin seed treatment (Signal 300 ES). In 2016 uses of chlorpyrifos-ethyl or products containing chlorpyrifos-ethyl were lost due to a non-dietary risk review of current uses, as a result of the reduction of the toxicological reference values recommended by EFSA. Consequently, chlorpyrifos can no longer be used as an egg hatch spray against wheat bulb fly larvae.

Seed treatment is the most effective option for late-sown crops, for example those at risk following potatoes, sugar beet, onions or red beet. Young (1992) demonstrated that November and December drillings of winter wheat were more vulnerable to WBF damage than earlier sowings and are, therefore, more likely to benefit from the use of a preventive insecticidal seed treatment.

3. Materials and methods

A total of 30 fields were sampled in September 2018 in areas prone to WBF, with 15 in eastern England and 15 in northern England (Table 1). The survey was stratified to represent some of the main preceding crops (Table 2) leading to a risk of wheat bulb fly damage in each area.

For each field sampled, 32 cores each of 7.2 cm diameter or 20 cores each of 10 cm diameter were taken to cultivation depth. Fields were sampled in a standard W sampling pattern. WBF eggs were extracted following soil washing and flotation in saturated magnesium sulphate. Egg numbers were expressed as number of eggs per m^2.

Table 1. Location of sampling sites, by region and county.

Region	County	Number of fields sampled
Eastern England	Cambridgeshire	9
	Norfolk	5
	Suffolk	1
	Total	15
Northern England	East Yorkshire	11
	North Yorkshire	4
	Total	15

Table 2. Preceding crop for sampled fields.

Preceding crop	Eastern England	Northern England
Fallow	1	0
Maize	3	0
Onions	1	0
Peas (vining)	1	9
Potatoes	3	4
Potatoes (seed)	0	2
Sugar beet	6	0
Total	15	15

4. Results

In autumn 2018, none of the 30 surveyed fields was considered at very high risk (egg numbers>500/m^2, Figure 1) and only one at high risk (3%, egg numbers between 250/m^2 and 500/m^2). A total of six fields (20%) were considered at moderate risk, containing egg numbers between 100/m^2 and 249/m^2 and 23 fields (77%) were considered at low risk, containing egg numbers less than 100/m^2. The overall risk in 2018 is the second lowest recorded since monitoring began in 1984 and on a par with 2005, 2012, 2014, and 2016. It is possible that the rapid winter wheat harvest meant there was little time for saprophytic fungi to develop in cereal ears, which in turn meant less food for adult WBF females. As a result they produced less eggs than in a wetter season their fungal food source is more plentiful.

Average egg numbers in the north of England were 82/m^2 which is higher than in the east of England where 62/m^2 were recorded. Over all sites, the highest risk was after potatoes (Figure 2), with a mean of 140 eggs/m^2. The next highest risk was after onions, with 96 eggs/m^2 although only one site was sampled. The highest individual count was 322 eggs/m^2 after potatoes in Cambridgeshire.

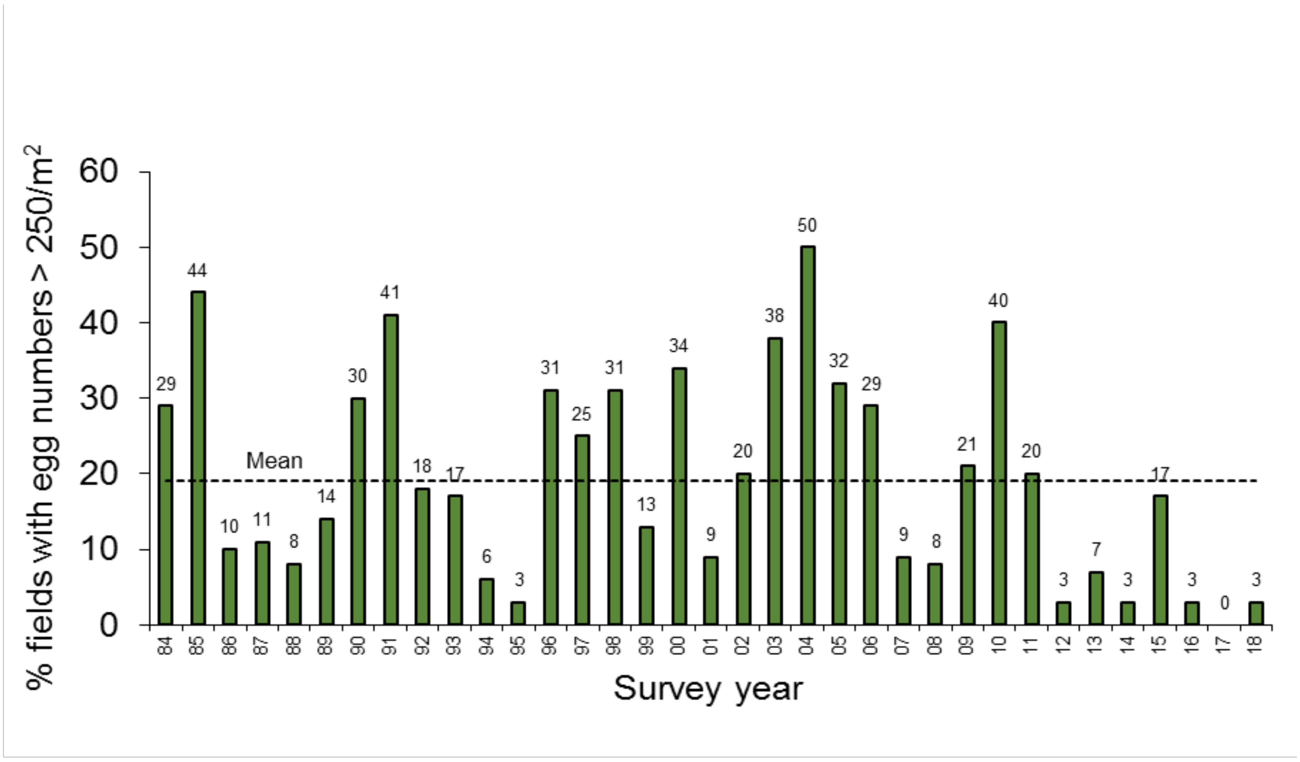

Figure 1. Wheat bulb fly annual risk levels 1984–2018 and overall mean (dashed line). Fields at risk have >250 eggs/m²

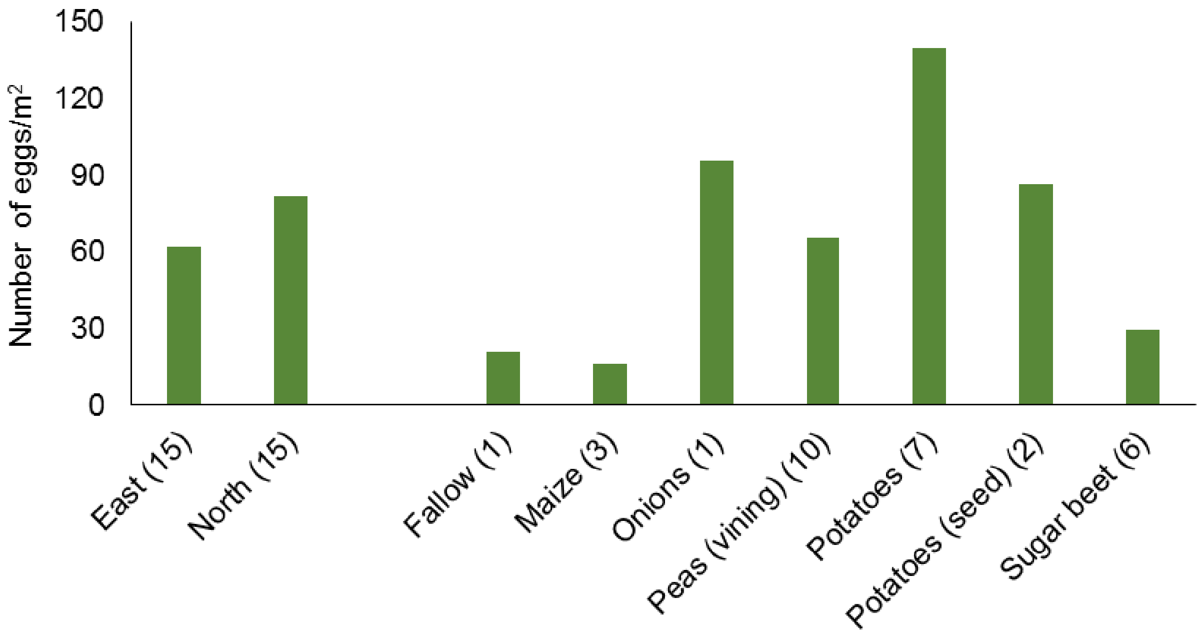

Figure 2. Average egg counts by region and previous crop in autumn 2018 (number of sites in brackets).

4.1. Eastern England

The mean egg number was 62 eggs/m² for sites sampled in eastern England. This is the third lowest count since 2010 with lower numbers of eggs recorded in 2017 (55/m^2) and 2014 (46/m^2). Therefore, the potential for WBF damage in eastern England is low. However, late-sown crops, which are likely to have few tillers at the time of egg hatch, could still be at risk. The highest egg population of 322 eggs/m² was after potatoes in Cambridgeshire. In total 13 of the 15 sites sampled had egg numbers lower than 100 eggs/m². Potatoes had the highest mean number of eggs of all crops sampled (153 eggs/m², Table 3). This value was heavily influenced by the high count of 322/m². A total of three potato fields were sampled.

Table 3. Mean eggs/m² and preceding crops in eastern England in autumn 2018 (range in brackets).

Preceding crop	Number of fields sampled	Mean number of eggs per m²
Fallows	1	21
Maize	3	16
Onions	1	96
Peas (vining)	1	123
Potatoes	3	153
Sugar beet	6	30
Mean egg count		62 (0–322)

In eastern England, none of the sampled fields were in the very high risk and only one in the high risk category (Table 4). Of the remaining 14 sites one was in the moderate category and 13 in the low category. Overall, only 87% of the fields sampled contained egg populations in the low risk category. This is a low level of infestation.

Table 4. Infestation categories and preceding crops in eastern England in autumn 2018.

Preceding crop	Number of fields by rotation and risk category			
	Low (<100 eggs/m²)	Moderate (100–249 eggs/m²)	High (250–499 eggs/m²)	Very high (>500 eggs/m²)
Fallows	1	0	0	0
Maize	3	0	0	0
Onions	1	1	0	0
Peas (vining)	0	1	0	0
Potatoes	2	0	1	0
Sugar beet	6	0	0	0
Total	13	1	1	0
% of fields by infestation category	87	7	6	0

4.2. Northern England

The mean egg number was 82 eggs/m² for northern England (Table 5). This is the third lowest count since 2011 (2017 67 eggs/m², 2016 89 eggs/m², 2015 168 eggs/m², 2014 125 eggs/m², 2013 129 eggs/m^2, 2012 79 eggs/m^2, 2011 161 eggs/m^2). The highest egg population of 197 eggs/m² was recorded in East Yorkshire after potatoes. The highest overall risk was also after potatoes with 130 eggs/m^2. In northern England none of the sampled fields was in the very high or high risk categories (Table 6), five were in the moderate category (33%) and 10 were in the low category (67%).

Table 5. Numbers of eggs/m² and preceding crops in northern England in autumn 2018 (range in brackets).

Preceding crop	Number of fields sampled	Mean number of eggs per m²
Peas (vining)	9	130
Potatoes (ware)	4	87
Potatoes (seed)	2	59
Mean egg count		82 (0–197)

Overall, five fields (33%) were in risk categories of moderate or above, which is the second lowest recorded since 2009 (2017 27%, 2016: 27%, 2015: 87%, 2014: 53%, 2013: 40%, 2012: 27%, 2011: 60%, 2010: 60% and 2009: 47%). This represents a relatively low risk to crops sown after November.

Table 6. Infestation categories and preceding crops in northern England in autumn 2018.

Preceding crop	Number of fields by rotation and infestation category			
	Low (0–100 eggs/m²)	Moderate (100–250 eggs/m²)	High (250–500 eggs/m²)	Very high (>500 eggs/m²)
Peas (vining)	7	2	0	0
Potatoes (ware)	1	3	0	0
Potatoes (seed)	2	0	0	0
Total	10	5	0	0
% of fields by infestation category	67	33	0	

5. Discussion

Egg populations above 250 eggs/m² present a risk of economic damage to winter wheat crops drilled in September and October. Egg numbers above 100 eggs/m² justify the use of seed treatment on the late-drilled crops of winter wheat or barley sown from November onwards.

5.1. Early sown crops (September/October)

In 2018, only one of the fields sampled was over the 250 eggs/m^2 threshold (2.5 million eggs/ha) for crops sown in September or October. The overall risk in 2018 is the second lowest recorded since monitoring began in 1984. It is possible that this is due to a low level of saprophytic fungi in the wheat ears which provide food for wheat bulb fly adults. The levels of fungi in the ears is likely to be influenced by whether the harvest was early or late. If wet weather delays the harvest this would provide the environmental conditions and the time necessary for the development of saprophytic fungi. The harvest in 2018 was very quick as a result of the dry summer so there was little time and insufficient moisture for fungal development. With a limited food supply WBF adults will produce fewer eggs than in a season in which their food is plentiful.

Mean egg numbers in the north were slightly higher than in the east with 82 eggs/m^2 in the north and 62 eggs/m^2 in the east.

5.2. Late-sown crops (November onwards)

Late-sown (November onwards) or slow developing crops are at greater risk from WBF attack than those that are early sown (September/October) due to slower tiller development. As a result, a lower threshold of 100 eggs/m^2 or 1 million eggs/ha is applicable for these crops. In the north of England 27% of monitored fields (five fields) were above this level and in the east 13% of fields were above this level. All fields in the moderate infestation category would benefit from a seed treatment if sown after November.

A summary of control strategies for WBF in relation to egg numbers and sowing date is given in Table 7.

Table 7. Wheat bulb fly egg numbers that would justify a seed treatment in crops sown between September and March.

Risk category	Sowing date		
	Sep–Oct	Nov–Dec	Jan–Mar
Low (<100 eggs/m^2)	Economic damage unlikely; no treatment	Economic damage unlikely; no treatment	Seed treatment
Moderate (100–249 eggs/m^2)	Economic damage unlikely; no treatment	Seed treatment	Seed treatment
High (250–500 eggs/m^2)	No available treatment	Seed treatment	Seed treatment
Very high (>500 eggs/m^2)	No available treatment	Seed treatment	Seed treatment

5.3. Chemical control

Seed treatment (tefluthrin + fludioxinil, Austral Plus or Cypermethrin, Signal 300 ES) is effective on late-sown crops (November onwards) and is the recommended treatment for late autumn or winter sowings of wheat and barley made before the end of egg hatch in areas and rotations at risk from WBF. Treated seed should be drilled at a recommended maximum depth of 4 cm in a firm, even seedbed. It is important to note that seed treatments may not be sufficiently persistent to fully protect crops sown in September or October.

If plants are well-tillered by the time that WBF larvae hatch between January and March, it is possible that they will be able to tolerate some pest attack.

5.4. Non-chemical control

With the loss of chlorpyrifos egg hatch sprays non-chemical control of WBF is likely to become increasingly important, particularly for those crops sown before November for which seed treatments will have limited efficacy. Seed treatments are the only chemical control option currently available for WBF and these are only effective for crops sown after November. As only a small proportion of wheat crops are sown after this date alternative control strategies are urgently required for this pest.

The impact of WBF can be reduced by sowing early and increasing the seed rate. This is likely to result in a more robust crop which is well tillered before the start of WBF egg hatch and so can tolerate and compensate for larval invasion. Taking account of crop tolerance is fundamental to improving pest risk assessment and achieving a rational approach to pesticide use which is cost effective and minimises the impact on the environment and the potential for the development of resistance (Ellis *et al*., 2009). This approach was the subject of an AHDB Cereals & Oilseeds funded project entitled 'Crop management guidelines for minimising wheat yield losses from wheat bulb fly' (RD 2140047118). This project has developed a threshold scheme for the pest which is reliant on manipulating sowing date and/or target plant population (through seed rate) in order to produce a crop which is sufficiently robust to tolerate pest attack. Such an approach has involved the collaboration of both plant physiologists and entomologists and takes advantage of the fact that wheat crops often produce more shoots than are required to achieve potential yield. Consequently these excess shoots can be sacrificed to pests without affecting yield. It should be stressed that the threshold model used to predict sow dates and changes in target plant population is a prototype and is likely to go through further iterations of testing and development before it is finalised. Nonetheless it is an important step in the sustainable management of WBF and follows on from the work to re-evaluate thresholds for pollen beetle in oilseed rape which also took advantage of the fact that this crop produces more buds than it needs to achieve potential yield.

Being able to predict sowing date and target plant population to produce crops that are tolerant of WBF attack effectively provides another control method for this pest. It is conceivable that manipulation of sowing date and/or plant population could be used instead of seed treatments for late sown crops although the relative economics of these control options will need to be evaluated. In those situations where cropping decisions are made too late for application of seed treatments the current threshold model will at least provide the opportunity to assess the likely cost of manipulating seed rate so that it could be compared with potential options for spring cropping.

Predicting the annual risk of WBF attack is crucial to making early decisions on WBF control, whether this be to use a seed treatment for late sown crops or manipulate sowing date and/or seed rate for those sown at a more conventional timing. Soil sampling is effective but laborious and often too late to influence decisions for winter wheat crops. Risk prediction for WBF is an important area for future research and could involve water trapping for adult WBF, analysis of suction trap data or even the development of pheromone traps for the pest.

An important component of IPM is knowing when not to treat and understanding the inherent tolerance of crops to pests. The presence of damage does not always equate to loss of yield. This concept is likely to become increasingly important as the insecticidal armory continues to decline. Whilst the science involved with the development of models to predict sowing date and target plant population in the case of WBF or re-evaluation of thresholds for pollen beetle may be complex it is vital that its implementation is ultimately simple for farmers and agronomists. This will ensure wide scale adoption of these novel ideas. This is likely to involve a more interactive format, for example via a website or mobile application. This will be the challenge for future research.

Parasites and predators can also have an impact on numbers of WBF eggs and larvae and contribute to an integrated pest management (IPM) strategy for the pest. Ground beetles and their larvae are the main predators of WBF eggs and the larvae may be parasitised by small rove beetles (Staphylinidae) particularly *Aleochara bipustulata*. Levels of up to 50% parasitism have been recorded. Rational insecticide use could therefore help to protect these beneficial species which in turn could contribute to natural control of WBF eggs and young larvae.

Young and Cochrane (1993) showed that WBF egg numbers were negatively correlated with departure from average July temperatures and positively correlated with August rainfall. This is in line with suggestion that egg numbers are likely to be higher in years when harvest is late rather than early. A model was proposed to help predict WBF egg laying. This model has rarely been used and yet might provide a useful early warning of wheat bulb fly risk ahead of monitoring exercises aimed at counting numbers of eggs or adults. The model could be validated using the existing WBF data set collated over 13 years of AHDB funded monitoring of the pest. An effective model would help to improve the precision and timeliness of risk assessment and together with the revised threshold scheme developed in project RD 2140047118, go some way towards an IPM strategy for WBF.

6. References

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Appendix A

Egg populations ranked in descending order for 15 fields sampled in eastern England in autumn 2018

County	Previous crop	Number of eggs (number/m²)	Risk category
Cambridgeshire	Potatoes	322	High
Cambridgeshire	Peas	123	Moderate
Cambridgeshire	Onions	96	Low
Cambridgeshire	Potatoes	82	Low
Norfolk	Sugar beet	69	Low
Cambridgeshire	Sugar beet	55	Low
Suffolk	Potatoes	55	Low
Norfolk	Sugar beet	41	Low
Cambridgeshire	Maize	27	Low
Cambridgeshire	Maize	21	Low
Cambridgeshire	Fallow	21	Low
Norfolk	Sugar beet	14	Low
Cambridgeshire	Maize	0	Low
Norfolk	Sugar beet	0	Low
Norfolk	Sugar beet	0	Low
Mean		62	

Appendix B

Egg populations ranked in descending order for 15 fields sampled in northern England in autumn 2018

County	Previous crop	Number of eggs (number/m²)	Risk category
East Yorkshire	Potatoes	197	Moderate
North Yorkshire	Potatoes	123	Moderate
East Yorkshire	Vining peas	123	Moderate
North Yorkshire	Potatoes	111	Moderate
North Yorkshire	Vining peas	105	Moderate
North Yorkshire	Potatoes	93	Low
East Yorkshire	Seed potatoes	93	Low
East Yorkshire	Seed potatoes	80	Low
East Yorkshire	Vining peas	62	Low
East Yorkshire	Vining peas	56	Low
East Yorkshire	Vining peas	56	Low
East Yorkshire	Vining peas	49	Low
East Yorkshire	Vining peas	43	Low
East Yorkshire	Vining peas	37	Low
East Yorkshire	Vining peas	0	Low
Mean		82	