Control needs for changing pest distributions

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Summary

Insect pests are cold-blooded. Their biology is driven by prevailing temperature, so relatively small increases in temperature can have profound effects on distribution. The rise in mean annual temperatures, which started in 1988, has changed the importance of several cereal and oilseed rape pests. Wheat blossom midges, for example, have increased significantly in importance. The behaviour of several other pests has also changed: virus vector aphids now continue to breed through the winter and some 'old' pests, such as the turnip sawfly, are once again important through migration from the Continent.

Introduction

Insect pests are cold-blooded, their biology being driven principally by prevailing temperature. Temperature impacts directly on: survival over winter, time of emergence from hibernation in the spring, rate of growth, rate of reproduction and the ability to fly and distance travelled. Pests traditionally encountered in UK agriculture are generally favoured by small increases in temperature. However, very high temperatures may impact adversely on pests adapted to the UK climate. Warm periods may encourage the northerly migration of pests with a more southern distribution.

Temperature also impacts on the pests' natural enemies. In some cases, natural enemy enhancement has been sufficient to prevent pest outbreaks.

Orange wheat blossom midge

The orange wheat blossom midge (owbm, *Sitodiplosis mosellana*) responded to higher temperatures to produce outbreaks, particularly in 1993 and 2003. The level of damage in these outbreaks was far higher than previously recorded, averaging 12% of English wheat grain damaged in both years (Oakley, 1994, Oakley *et al.*, 2005).

OWBM is particularly dependent on climatic factors for four critical phases:

1. Reactivation of hibernating larvae if triggered by soil temperatures rising above 13°C in May and early June (Oakley *et al*., 1998).
2. Pupation follows if the surface inch is or becomes wet within a few weeks of reactivation (Oakley *et al*., 1998).
3. Flight of adult midges and egg-laying occurs when evening temperatures exceed 15°C, with flight between fields if the wind is below 10 km/hr (Pivnik & Labbé, 1993).
4. Flight coinciding with the vulnerable ear emergence stage of wheat (Ding & Lamb, 1999). The timing of heading also varies with temperature (Hu *et al.,* 2005).

An outbreak occurs when these four factors synchronise favourably for several years in sequence, progressively building up numbers. Each female can lay 80 eggs (Pivnik & Labbé, 1993) and build-up can be quite rapid if conditions are particularly suitable. Outbreaks may therefore appear over a wide scale with little prior warning, as in 1993.

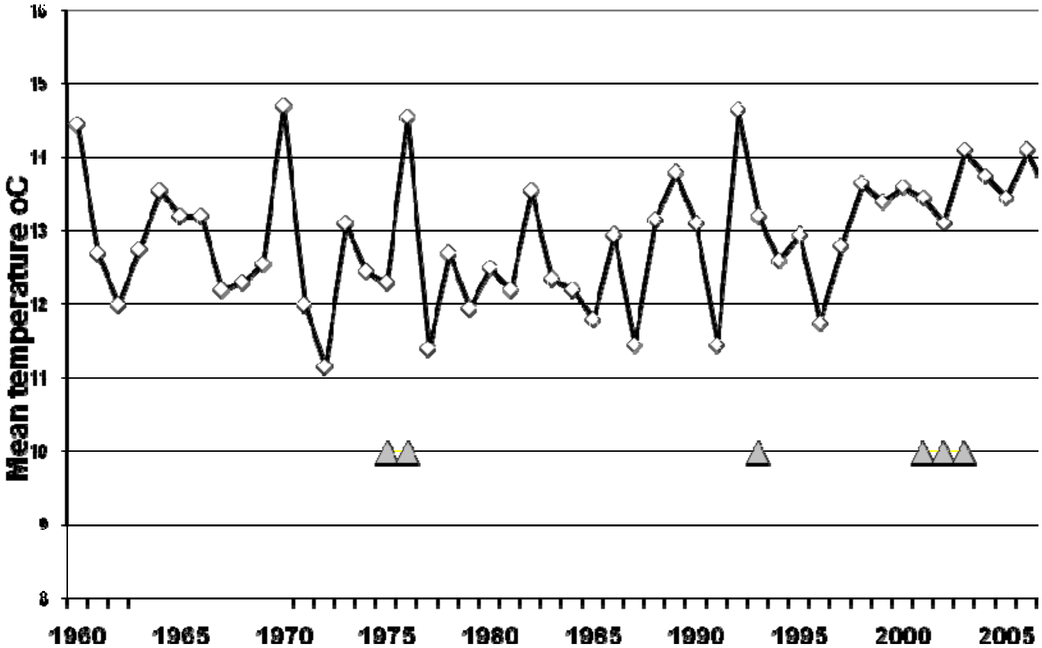

Figure 1. Mean May and June temperatures in Central England from 1960-2007 and main outbreak years (△).

Predicting future risk is complex as the four climatic factors need to coincide to create an outbreak. There has been a recent trend for the annual fluctuations in mean temperature for May and June to stabilise, as exemplified in the Central England Temperature series (Parker *et al.*, 1992; Figure 1). Temperature is less likely to be the controlling factor under these circumstances and soil moisture has been the main limiting factor in owbm emergence. In such seasons the spatial pattern of emergence has proved to be very variable both on a field-by-field and national scale, reflecting the distribution of thunderstorms. In 2003, very heavy rainfall in May synchronised a mass emergence of owbm with wheat ear emergence, resulting in very high damage levels. In subsequent years, owbm emergence tended to be late relative to wheat ear emergence, resulting in lower damage levels in southern England. However, damage increased in northern England and in Scotland, where ears emerge later.

The patchy distribution of risk makes predicting control needs difficult. Pheromone traps were developed to enable low risk to be established at a local level (Oakley *et al.*, 2005). However, variation in migration patterns between fields confuses the relationship with damage levels in crops and field inspection is still required when potentially damaging infestations are detected to determine which fields may need treatment. A level of 30 owbm over two nights in a pheromone trap suggests a need for evening assessment of nearby wheat crops at the ear emergence stage for the next week. If conditions for flight are poor, no action is needed unless more than 100 are caught over the same period. Crop inspection also allows for the detection of other pests that may attack crops at this time. The action thresholds for treatment remain at one owbm per three ears for feed wheat and one per six ears for milling and seed crops.

Plant breeders have identified a resistance gene within UK wheat breeding programmes. This gene is now incorporated within a range of feed wheat varieties in the HGCA Recommended List (Oakley *et al.*, 2005). Further resistant varieties are now reaching the market. The resistance results in the death of larvae feeding on the crop, which remains attractive to egg laying adults. Resistant varieties therefore act as trap crops, providing a means to reduce infestation levels. OWBM problems tend to develop on farms growing wheat on more than 25% of their area, making it likely that a wheat crop is always available adjacent to 'source' fields in wheat the previous year. The introduction of resistant varieties provides a means of breaking this vicious circle. Resistant varieties have occupied around 20% of cropped area for the past two years and are already contributing to a decline of infestations in previous 'hot spots'. With further varieties becoming available it should be possible to increase this to around 50% of wheat crops, providing an ongoing level of population control. A higher proportion of resistant crops could be undesirable, increasing the chances of owbm overcoming the resistance. A proportion of susceptible crops would reduce this risk and maintain a reservoir of the owbm's natural enemies (Lamb *et al.*, 2004).

Yellow wheat blossom midge

The yellow wheat blossom midge (ywbm, *Contarinia tritici*) is also increasing in prevalence due to favourable climatic changes. This pest is assisted by the same climatic factors as owbm, but attacks crops slightly earlier. Eggs are laid at the early stages of ear emergence (GS 51-53) and the larvae feed on the stigma and anthers, preventing grain formation. Unfortunately, owbm-resistant varieties are still susceptible to attack by ywbm. If the climate continues to warm a reduction in pesticide use against owbm through the use of resistant varieties, could allow ywbm to develop to problem levels. This already seems to be happening in some areas. The threshold for treating crops against ywbm is higher than that for owbm at one midge per ear.

The impact of milder winters

In the past, the survival of many pests in the UK was inhibited by cold winter weather. Some pests could survive through milder winters, but would suffer local extinction in a cold winter.

An example is the bird-cherry aphid (*Rhopalosiphum padi*), an important vector of BYDV. Harrington (2003) identified a mean winter (December-February) temperature of 4.6°C as critical to the survival of the strains of *R. padi* which overwinter asexually on cereals and grasses, spreading BYDV to winter cereals. In colder winters the more frost-susceptible holocyclic strains die out and only the sexual strains that overwinter as frost-resistant eggs on bird-cherry trees survive. Oakley and Young (2000) found that a very similar temperature cut-off was important to the overwinter breeding success of the grain aphid (*Sitobion avenae*), the other main vector in the UK.

The incidence of mild winters with mean temperatures across England and Wales above 4.6°C has increased. The areas achieving this degree of mildness now often extend into the Midlands and beyond; they were previously restricted to the extreme south and west coastal strips and the Thames Valley. Some extension of affected areas now also occurs in Scotland.

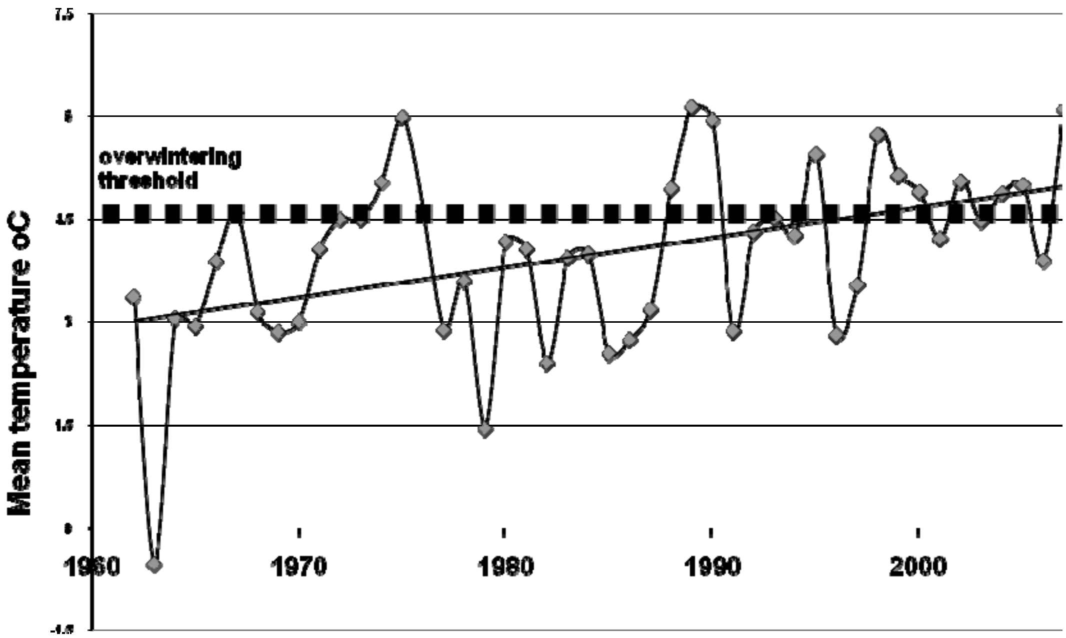

Figure 2. Mean winter temperature for England and Wales from 1960–2007 (Meteorological Office).

The advantage of milder winters is that the aphids' parasitoids are better able to overwinter, providing control before infestations reach damaging levels the following summer (Hondelmann & Poehling, 2007). Warmer weather also allows for an earlier migration of hoverflies from southern areas enhancing natural controls (Vemon *et al.*, 2004). Due to these effects summer aphid problems on cereals have declined, the last serious outbreak having been in 1995.

Impact on migratory pests

As with owbm, all flying insects have a minimum temperature threshold for flight. Warmer seasons may bring additional migrations of pests and of predators, to the UK. A case in point is the turnip sawfly (*Athalia rosae*). This pest is important in the warmer parts of Europe and does particularly well in hot, dry summers, when large-scale migrations occur. In the warm autumn 2006, turnip sawfly swarms infested many oilseed rape crops, often requiring an insecticide treatment to save the crop. Historically such infestations have persisted until a colder winter has killed the overwintering larvae (Curtis, 1883). Survival was good in the winter of 2006-07 with adults migrating from oilseed rape crops in the spring to infest cruciferous salad crops.

Another migration-related problem has been the spread of insecticide resistant pollen beetles from the European Continent. Resistance was found to be widespread in the UK in the spring of 2007. With high temperatures as in April 2007, long distance flights from hibernation sites become possible and the Channel is no longer an effective barrier. Reports of unusually severe stem weevil problems in oilseed rape crops on the Essex coast in 2007 suggest that the more damaging rape stem weevil (*Ceutorhynchus napi*) may also have migrated to the UK. This species is a serious pest in Germany but did not previously occur in the UK. The extensive use of pyrethroids to control this pest resulted in the development of insecticide resistance in pollen beetle.

Other migrants pose a sufficient threat to attract statutory control measures, such as the western corn rootworm (*Diabrotica virgifera virgufera*) on maize. Ever increasing international trade provides many opportunities for accidental imports. The establishment of such pests on silage and game cover crops could impact on the introduction of grain maize as a 'new' crop. Migrant pests may well travel without their natural enemies and thrive in their new location,

Conclusions

As temperatures rise, the pest situation in the UK is likely to become more dynamic with new pests arriving and old ones changing in status. Identifying new pests is not easy: they may not appear in UK textbooks and specialist services should be used to verify pests that do not behave as expected. New strategies will be required to control old pests which cease to follow established patterns of behaviour.

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