# Grower summary

TF 169

Pheromone trap survey of light brown apple moth in UK commercial tree fruit orchards 2006

Final report 2007

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Authentication

I declare this work was done under my supervision according to the procedures described herein and that this report is a true and accurate record of the results obtained.

Signature (project leader) ……..

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## Grower Summary

### Headline

- The light brown apple moth (LBAM, *Epiphyas postvittana*) is more abundant in cherry than apple, pear and plum crops and is a potentially serious problem pest of cherry.

### Background and expected deliverables

The light brown apple moth (LBAM), *Epiphyas postvittana*, is one the most important pests of apple and other tree fruits in Australia and New Zealand, where it has developed resistance to and is difficult to control with insecticides. It was unknown in Europe until 1936 when it was found breeding on ornamental spindle at Newquay, Cornwall. It established on a wide variety of plants in Devon and Cornwall and spread east, but was not known to attack fruit crops. When Cross (1996) carried out a pheromone trap survey of 11 species of tortricid moth, including LBAM, in 10 commercial orchards in Kent, Hereford, Essex, Oxfordshire and Somerset in 1994 no LBAM was recorded.

The moth has two generations per annum in the UK, one in the spring and one in the autumn, though the precise timing and pattern has not been determined. The larvae are somewhat similar in appearance to those of other tortrix moths, and difficult to distinguish from those of summer fruit tortrix moth. In 2005, a severe and extensive attack of LBAM occurred in a commercial cherry orchard at Yalding, Kent, causing considerable fruit losses. Larvae were reared to adult at EMR and identification confirmed by the British Museum. It is suspected that other reported attacks on cherry in 2003 and 2004, believed to be caused by summer fruit tortrix moth at the time, may well have been caused by LBAM. In recent years, the pest has become a significant pest problem in hardy ornamental nursery stock throughout England.

In view of these developments, a sex pheromone trap survey was carried out to determine how widespread this moth species is in commercial tree fruit orchards (apple, pear, plum and cherry) in England. Traps were supplied to selected growers in 2006 under the supervision of consultants and agrochemical merchant representatives. The growers were requested to monitor the traps through the season

with East Malling Research (EMR) staff checking identifications and collating and interpreting results in relation to spray programmes.

The overall aims of the study were to:

- Survey the occurrence of LBAM in apple, pear, plum and cherry orchards in England; determine the relative abundance of adult LBAMs in the different orchards
- Determine the flight dynamic through the growing season
- Investigate relationships between insecticide spray programmes and moth abundance.

## Summary of the project and main conclusions

A pheromone trap survey on commercial fruit trees (apple, pear, plum and cherry) in England was carried out in 2006. In March 2006, growers were supplied with delta traps, LBAM sex pheromone lures and sticky bases for each orchard. The majority of the traps were deployed in early April and monitored weekly by the host grower until the end of September.

Data was obtained from 15 growers and included 13 apple, 12 cherry, 8 pear and 11 plum orchards. The farms were distributed throughout the major fruit growing areas of England (from Suffolk, south, to Somerset). Growers monitored moth numbers through the growing season with EMR staff clarifying identifications. The growers also supplied information on the location, area, age, surrounding habitat and pesticide programme for each orchard. Meteorological records were combined with monitoring trap data from EMR to determine the flight dynamics of the moth through the year.

The LBAM was more abundant on cherry than apple, pear and plum crops. It was most likely that pesticide spray programmes play a role in reducing populations on the latter crops, incidentally reducing LBAM by spraying for other moth caterpillars such as codling, tortrix and plum fruit moth. However, the variation between the number of moths caught on each farm was high. Some farms suffered with high numbers of LBAM on all crops. The reasons for this are unclear, but are likely to be a combination of pesticide spray programmes, geographical location (climatic conditions; the most northerly orchard trapped fewer moths) and surrounding vegetation (immigration from surrounding plants). No one factor alone (including the age or size of orchard) was determined to influence the abundance of LBAM on fruit crops. Equally, no pattern

emerged between LBAM abundance and surrounding vegetation. This is likely to be due to the moths highly polyphagous feeding habits and ability to migrate between habitats. However, the cherry orchards received the fewest insecticide sprays and, therefore, the application of insecticides is likely to be a major factor in LBAM control.

In England the moth had three peak flights in 2006 (first from late May to mid June, second from early August to early September and third in late October). It is likely that the third generation was unsuccessful, as air temperatures dropped soon after, resulting in cessation of the moths' development throughout the winter in the UK. It is possible with climate change and increasing annual temperatures that the LBAM could become more of a pest in cherry, which receive no pesticide protection specifically for caterpillar control.

## Financial benefits

No direct financial benefits to growers resulted from this survey. However, the study highlighted the need for growers to monitor and control LBAM, particularly in cherry, but also in other fruit crops. Such action will substantially reduce losses due to this pest in future. There is a need to identify and gain approval for high specificity insecticides for the control of LBAM in cherry.

## Action points for growers

- UK growers are advised to routinely monitor LBAM populations in apple, pear, plum and particularly cherry orchards using sex pheromone traps.
- Growers need to be aware of the high risk of LBAM attacks in cherry orchards until an effective approved insecticide is available to control the pest on cherry.

# Science Section

## Introduction

The tortricid, *Epiphyas postvittana* (Walker), commonly known as the light brown apple moth (LBAM), is one of the most important pests of apple and other tree fruits in the countries that it occurs. A native of Australia, the moth has been introduced into New Zealand (where it is now the dominant leaf roller in some districts (Shaw *et al*., 1994)), New Caledonia, Hawaii and the British Isles (Geier & Briese, 1981). The moth is of great economical importance to Australian and New Zealand pome fruit exports to northern America and Japan, as consignments of fruit are rejected if they contain LBAM.

The moth was unknown in Europe until 1936, where it was found breeding on ornamental spindle established in Devon and Cornwall (England). It then spread east, but was not known to attack fruit crops at that time. A pheromone trap survey in 10 commercial orchards in Kent, Hereford, Essex, Oxfordshire and Somerset (England) in 1994 revealed no LBAM populations (Cross, 1996). However, in 2005, a severe and extensive attack of the pest occurred in a commercial cherry orchard at Yalding in Kent, causing considerable fruit losses. Larvae were reared to adult and identification confirmed as LBAM. It is suspected that other reported attacks on cherry in 2003 and 2004, believed to be caused by the summer fruit tortrix moth (*Adoxophyes orana* Fischer von Rösslerstamm), may well have been caused by LBAM as the larvae are difficult to distinguish.

In Australia the moth can have 4-5 generations per year. Specialist lepidopterists in the UK report that the LBAM has spread throughout England where it has become common and in recent years and become a significant pest problem in hardy ornamental nursery stock throughout England. The moth is able to adapt different strategies for different local climates (phenotypic plasticity) enabling it to transfer to cooler climates (Gu & Danthanarayana, 2000).

*E. postvittana* is highly polyphagous and although the moth is believed to have evolved as a feeder on herbaceous plants (Danthanarayana *et al*., 1995), the species is known to feed on over 120 dicotyledonous plant species (e.g. poplar, willow, alder, clover, gorse, broom, dock, plantain (Venette *et al*., 2003; Suckling *et al*., 1998)), including various fruits (e.g. apples, pears, apricots, kiwifruit, cirus fruits, grapevines

and cherries). The moth is also a pest on cut flowers (Karunaratne *et al*., 1997) and hop cones (pers. comm. C. Campbell). Female moths are stimulated to oviposit in the presence of a foodplant (Foster & Howard, 1999a) by plant volatiles (Suckling *et al*., 1996) and tactile cues (Foster *et al*., 1997; Foster & Howard, 1998).

Larvae react to chemical cues and colour from fruit and leaves, actively moving towards favoured food plants before 'spinning down' and beginning to feed (Suckling & Ioriatti, 1996; Harris *et al*., 1999; Foster & Howard, 1999b). Damage to the foliage by early feeding larval instars is caused by feeding on the leaf mesophyll under silken webs (Harris *et al*., 1995). Later larvae construct feeding niches between adjacent leaves and/or fruit (Lo *et al*., 2000), in the developing bud, or on a single leaf (leaf rolling). Late stages feed on all leaf tissue except for the main veins. The fruit suffers from superficial damage particulary in compact cluster (short stalked) apple varieties. Larvae may spin silk, binding leaves to the fruit. Internal damage to fruit is less common, but a young larva may enter fruit through the calyx of pome fruit (Van der Geest & Evenhuis, 1991).

The LBAM female sex pheromone is a mixture of (E)-11-tetradecenyl acetate and (E,E)-9,11-tetradecadianyl acetate (Bellas & Bartell, 1983). This pheromone is used for monitoring purposes and has been successfully applied in mating disruption trials in fruit orchards in New Zealand (e.g. Suckling & Clearwater, 1990; Suckling & Shaw, 1995; Suckling & Angerilli, 1996; Mo *et al*., 2006 a&b) and trials with combinations of insecticides and mating disruption (McLaren *et al*., 1998; Nicholas *et al*., 1999) aimed at reducing pesticide usage in fruit crops (Suckling & Shaw, 1995).

No resistance to pyrethroids has been observed. However, resistance to pesticides such as azinphos-methyl has occurred in LBAM (Armstrong & Suckling, 1988; Suckling *et al*., 1989). Azinphos-methyl resistant LBAM were also cross-resistant to phosmet, chlorpyrifos and carbaryl (Suckling & Khoo, 1990). It is suspected that the moth may be a particular problem on cherry, but not other tree fruits in the UK, because insecticides that are active against caterpillar pests are not used on cherry in the UK. Currently, no insecticides, other than *Bacillus thuringiensis* (Bt) (Dipel DF), pirimicarb (Aphox) and thiacloprid (Calypso) are approved for use post blossom on cherry in the UK. Pirimicarb and thiacloprid are unlikely to have activity against tortricid caterpillars.

In this project, the abundance and distribution of the moth in commercial orchards of the four principal UK tree fruit crops, apple, pear, plum and cherry, was surveyed using pheromone traps. Specific objectives were to determine the relative abundance of adult moths in the different orchards, investigate the flight dynamic through the growing season and examine the relationships between insecticide spray programmes and LBAM abundance.

## Methods and Materials

A pheromone trap survey of the light brown apple moth (LBAM), *E. postvittana* on commercial fruit trees (apple, pear, plum and cherry) in England was carried out in 2006. On 03 March 2006 growers were supplied, free of charge, with a standard white delta sex pheromone trap, 4 lures and 8 sticky bases per orchard for the season. The majority of the traps were deployed in early April and monitored weekly by the host grower under the supervision of consultants and agrochemical merchant representatives. Of the 18 commercial farms originally involved in the survey, data was obtained from 15 (Table 1, Appendix). These included 13 apple, 12 cherry, 8 pear and 11 plum orchards. The orchards were distributed throughout the major fruit growing areas of England (Fig. 1).


Figure 1. Location of the counties (encircled) in England where the light brown apple moth sex pheromone traps were deployed (by kind permission of Penny Greeves)

*Monitoring and Data Collection*

At each farm, one trap was placed in the centre of each crop type, where available, and monitored weekly by the growers until the end of September. The sex pheromone lures were changed every 6 weeks as per the manufacturers' instructions (Agrisense BSC Ltd). At East Malling Research (EMR) two traps were placed in mixed variety cherry orchards, one in a bird net covered plot and one in an uncovered plot.

The identification of LBAM larvae is problematical as they are very similar to the larvae of other leaf rollers. In the adults the forewing is characteristically curved (Figs 2 and 3). Male moths are 6-10 mm long, with the anterior part of the forewing generally much lighter than the posterior, which is rusty dark red/brown (Fig. 2, Bradley, 1973). Much lighter forms may also be found. The females are larger than the males (7-13 mm long) and are more difficult to identify as colour varies from a uniform light yellowish brown with almost no distinguishing marks (www.hortnet.co.nz). However, they do have a small dark spot, centrally, on the forewings when at rest (Fig. 3).

Colour pictures of the moths were provided (Box 1, Appendix) to the growers to assist with LBAM identification and growers were encouraged to contact EMR to confirm identifications. EMR collated the trap catches and the grower's insecticide spray programmes. Where significant outbreaks of caterpillars occurred, samples were taken and reared to adult to confirm species identification.

Figure 2. Male light brown apple moth reared from cherries

Figure 3. Female light brown apple moth reared from cherries

Growers were contacted by post and email, and given written instruction on how to carry out the survey (Appendix 2). Growers were also supplied with orchard (Appendix 3) and trap data sheets (Appendix 4). The orchard sheets requested details of the location, area, age, surrounding vegetation and pesticide programme of each orchard. The pest management intensity was measured as; 0 = no insecticide, 1 = <2 insecticide, 2 = 2-4 insecticide, 3 = >4 insecticide sprays per year at the orchard.

*Meteorological records*

Full meteorological records for the duration of the EMR trial were available from the EMR Meteorological Station. Minimum and maximum daily air temperatures were obtained for use with the EMR moth flight dynamics data.

*Statistical analysis*

Data were collated in Excel spread sheets. This study was a survey and not intended for statistical analysis. However, where analyses were possible, count data were $\log_{10}(n+1)$ transformed to stabilise variances and subjected to analysis of variance (ANOVA). Regression analyses between moth numbers and environmental variables were also carried out. To obtain the mean peak flight dates, dates were first converted to Julian days.

## Results

*Abundance and distribution of the moth in commercial orchards of the four principal UK tree fruit crops*

LBAM was more abundant on cherry crops than apple, pear and plum (Fig. 4). However, there was high variation between crop types (ANOVA d.f. = 3, F-Prob 0.115, SED = 0.32) and farms (Table 2, Appendix) and the result was not significant statistically. In Table 2 (Appendix), the farms are ranked in order of the total number of moths caught (highest first) throughout the survey. There was a tendency for the cherry orchards to have higher trap catches. The pear orchards tended to be towards the bottom of Table 2 (Appendix) with lower trap catches.

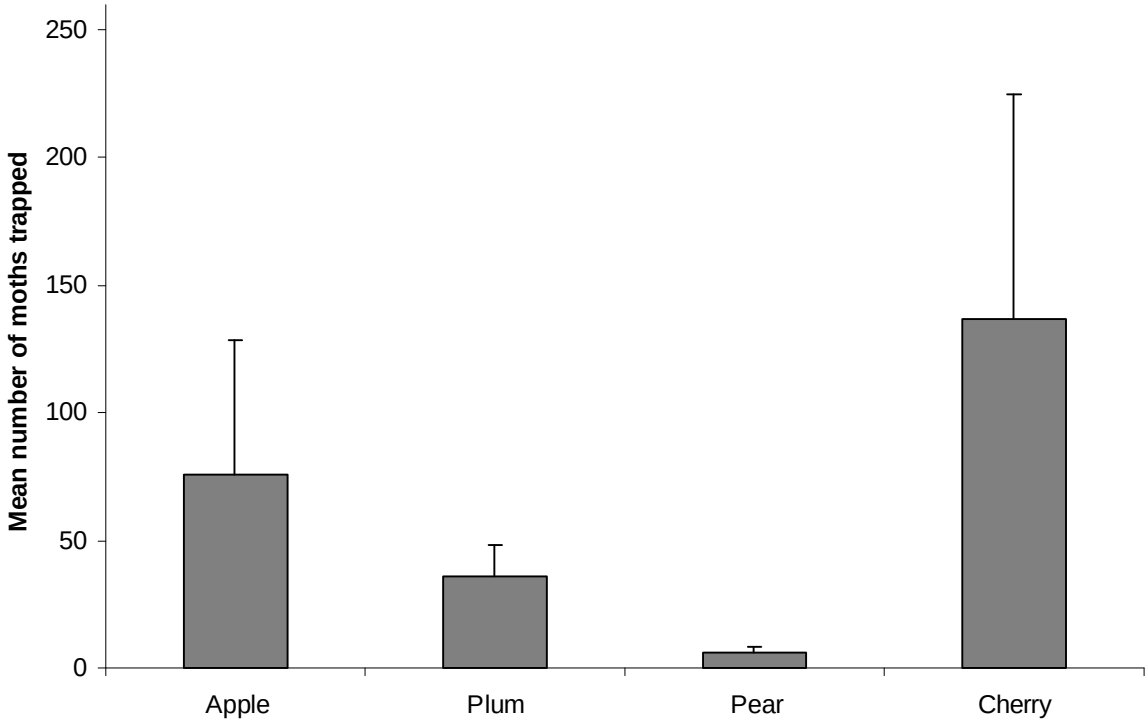


Figure 4. Mean number of light brown apple moth caught in pheromone traps on different fruit crops in England. Data from April – September 2006

*Relative abundance of adult moths in the different orchards*

Farms influenced the total catch of LBAM. For example, Court Lodge Farm, EMR and New Cross Farm had high trap catches, whereas, the most northerly orchard (Peter Wheldon Ltd., Suffolk) had fewer trapped moths (bottom of Table 2, Appendix).

However, another northerly located farm (Man of Ross Ltd, Hereford), had a high abundance of moths in a plum orchard which received more than 4 pesticide sprays per year. Therefore, the influence of latitudinal location of an orchard was inconclusive.

In addition, there was no correlation between the number of male moths caught in the traps and the size of the orchards (regression analysis; F-Prob = 0.756, d.f. = 42), nor the age of the orchard (regression analysis; F-Prob = 0.381, d.f. = 40) (analyses on all crop types combined).

The habitat surrounding the orchards also gave no explanation as to the abundance of LBAM in each orchard (Table 3). Most of the orchards are surrounded by other fruit crops and hedgerows. The LBAM is polyphagous (>120 dicotyledonous food plants) and able to migrate into orchards by flight enabling it to disperse easily to neighbouring habitats.

*Relationships between insecticide spray programmes and abundance*

There was no correlation between the number of male LBAMs caught in the traps and the number of insecticide sprays applied across all of the orchards (regression analysis; F-Prob = 0.813, d.f. = 42). Most of the apple orchards received more than 2 insecticide sprays per year (Table 4). Only one apple orchard received one insecticide application; an organic orchard sprayed with pyrethrum. The number of moths trapped in this orchard was 89, possibly a reflection of the low insecticide input.

Three of the cherry orchards received no insecticide sprays with only one orchard receiving more than 4 sprays (Table 4). Most often, Aphox and Calypso were used for aphid control, whilst chlorpyrifos, cypermethrin and *Bacillus thuringiensis* were used against caterpillars. The low number of insecticide applications applied to cherry orchards could account for the higher (although not significant, Fig. 4) number of moths trapped in these orchards.

Pear orchards appeared more frequently towards the bottom of Table 2, with low moth trap catches. The LBAM in apple and pear crops is probably kept under control by sprays aimed at codling moth and other tortix species (e.g. Runner, chlorpyrifos, Insegar). Pears were additionally sprayed to control pear sucker with products such as Insegar and Equity. Plum crops were sprayed with chlorpyrifos and Dimilin to control the plum fruit moth. Even when the crops types were subjected to regression analyses alone no significant differences were apparent (Apple F-Prob = 0.463, d.f. =

11; Cherry F-Prob = 0.746, d.f. = 10; Pear F-Prob = 0.227, d.f. = 6; Plum F-Prob = 0.572, d.f. = 9).

*Flight dynamics through the growing season*

The data suggests that the peak flight for the first generation on cherry at EMR in 2006 was at the end of May or earlier (Fig. 5). There appeared to be further generation peaks, the first in mid August and the second in mid September. The interval between the peaks is too short for two generations and on closer inspection it can be seen that there was a rise in the temperature at the end of August causing the increase in male moth numbers at this time. At 20°C, the development time from egg to adult can take around 55 days and is longer at reduced temperatures (Van der Geest, & Evenhuis, 1991). It is likely that the fourth flight peak in October is a third generation (from adults which mated in August). This is more generations than previously reported for the UK and it is possible that increasing average annual temperatures associated with climate change may increase the number of generations per year in the region. The lower temperature threshold for the moth to develop is 7-7.5 °C (Van der Geest, & Evenhuis, 1991), so it is unlikely, at present, that the moth will be capable of continued development throughout the winter in the UK.

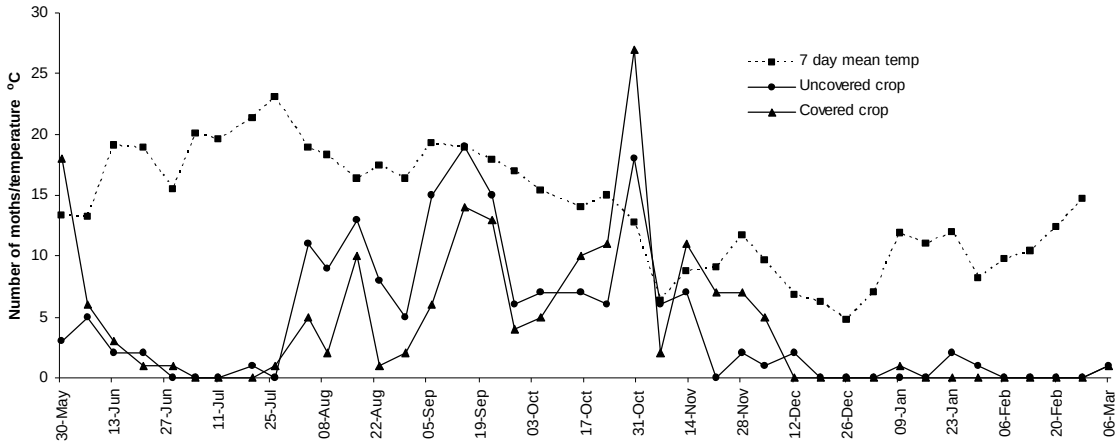


Figure 5. Total number of male moths caught weekly (2006-2007, solid lines) in pheromone traps in cherry orchards at EMR (covered crop - ▲, uncovered crop – ●). The mean air temperature 7 days prior to the recording of male moth numbers (■ dashed lines) is also shown for each data point. The netting was removed from the covered crop on 15 September 2006

When all of the LBAM catch data was combined for each crop type (Table 4, Appendix and Fig. 6) there was a flight peak (mean date) in late May to mid June. The next flight peaks ranged from early August to early September. The peaks are more clearly defined in apple and cherry owing to the higher numbers of moths caught in these crops.

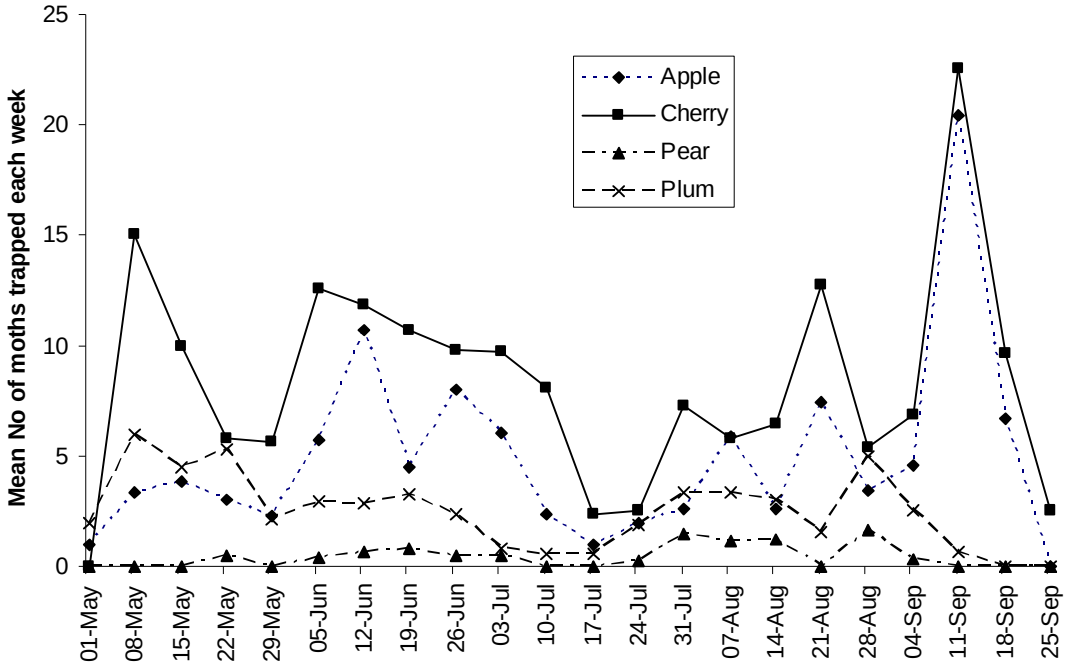


Figure 6. Mean number of male moths caught weekly in pheromone traps in all of the surveyed apple, cherry, pear and plum orchards between May and September 2006

## Conclusions

- LBAM was more abundant on cherry than apple, pear and plum crops in 2006. It is very probable that pesticide spray programmes for other moth caterpillars such as codling, tortrix and plum moth played a role in reducing populations in the latter crops, incidentally reducing LBAM. However, the variation between the number of moths caught on each farm was high and, therefore, the result was not significant.
- Pear orchards were the least susceptible to LBAM.
- Some farms suffered with high numbers of LBAM on all crops. The reasons for this are unclear, but are likely to be a combination of pesticide spray

programmes, geographical location (climatic conditions; the most northerly orchard had fewer trapped moths) and surrounding habitat (immigration from surrounding plants). No one factor alone was identified that determined the abundance of LBAM on fruit crops.

- There was no correlation between the number of male moths caught in the traps and the size of the orchards, the age of the orchard, surrounding habitat or the pesticide management programme.
- However, the cherry orchards received the fewest insecticide sprays and, therefore, the application of insecticides was likely to be a major factor in LBAM control.
- The LBAM in England had three peak flights in 2006. It is likely that the 3rd peak was unsuccessful, as air temperatures dropped soon after, resulting in a cessation of the moths development throughout the winter in the UK.
- The 1st peak flight of LBAM was late May to mid June, with the 2nd from early August to early September.
- It is possible with climate change and increasing annual temperatures that the LBAM could become more of a problem in cherry, which receive no protection from moth caterpillars.

## Future work

It would be advisible to identify and gain approval for high specificity insecticides for the control of LBAM in cherry.

## Acknowledgements

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Table 1. Names, locations and crop type of farms and orchards involved in the light brown apple moth survey, ordered by latitude (north to south)

| Grower | Farm | County | Grid ref | Latitude N | Longitude | Crop |
|---|---|---|---|---|---|---|
| S Wheldon | P Wheldon Ltd | Suffolk | TL901409 | 52:02:10 | 0:46:21E | Pear |
| S Wheldon | P Wheldon Ltd | Suffolk | TL908404 | 52:01:44 | 0:47:02E | Plum |
| S Wheldon | P Wheldon Ltd | Suffolk | TL904391 | 52:01:09 | 0:46:18E | Apple |
| M Bentley | Castle Fruit Farm | Glos | SO709292 | 51:57:32 | 2:25:05W | Apple |
| M Bentley | Castle Fruit Farm | Glos | SO709292 | 51:57:32 | 2:25:05W | Cherry |
| M Bentley | Castle Fruit Farm | Glos | SO709292 | 51:57:32 | 2:25:05W | Pear |
| M Bentley | Castle Fruit Farm | Glos | SO709292 | 51:57:32 | 2:25:05W | Plum |
| A Jackson | Man of Ross Ltd | Hereford | SO600241 | 51:54:52 | 2:34:57W | Apple |
| A Jackson | Man of Ross Ltd | Hereford | SO600241 | 51:54:52 | 2:34:57W | Cherry |
| A Jackson | Man of Ross Ltd | Hereford | SO600241 | 51:54:52 | 2:34:57W | Pear |
| A Jackson | Man of Ross Ltd | Hereford | SO600241 | 51:54:52 | 2:34:57W | Plum |
| R. Fryer | Hull Farm | Essex | TM041275 | 51:54:33 | 0:58:00E | Cherry |
| R. Fryer | Hull Farm | Essex | TM041275 | 51:54:33 | 0:58:00E | Pear |
| R. Fryer | Hull Farm | Essex | TM041275 | 51:54:33 | 0:58:00E | Plum |
| R. Fryer | Hull Farm | Essex | TM065273 | 51:54:23 | 1:00:06E | Apple |
| R. Napper | Q' gardens | Oxfordshire | SU477910 | 51:36:43 | 1:18:33W | Apple |
| R. Napper | Q' gardens | Oxfordshire | SU477910 | 51:36:43 | 1:18:33W | Plum |
| R. Napper | Q' gardens | Oxfordshire | SU479899 | 51:36:26 | 1:18:21W | Pear |
| R. Napper | Q' gardens | Oxfordshire | SU483896 | 51:36:11 | 1:17:51W | Cherry |
| R Thompson | Garson Farm | Surrey | TQ124638 | 51:21:47 | 0:23:08W | Apple |
| R Thompson | Garson Farm | Surrey | TQ124638 | 51:21:47 | 0:23:08W | Cherry |
| R Thompson | Garson Farm | Surrey | TQ124638 | 51:21:47 | 0:23:08W | Plum |
| P Mansfield | Broad Oak Farm | Kent East | TR917606 | 51:17:31 | 0:59:00E | Apple |
| P Mansfield | Broad Oak Farm | Kent East | TR962501 | 51:17:31 | 0:59:00E | Cherry |
| P Mansfield | Broad Oak Farm | Kent East | TR914602 | 51:17:31 | 0:59:00E | Pear |
| P Mansfield | Broad Oak Farm | Kent East | TR917604 | 51:17:31 | 0:59:00E | Plum |
| J L Pemberton | Torry Hill | Kent North | TQ917583 | 51:17:24 | 0:44:48E | Cherry |
| EMR | EMR | Kent Mid | TQ706572 | 51:17:19 | 0:26:45E | Cherry |
| EMR | EMR | Kent Mid | TQ706572 | 51:17:19 | 0:26:45E | Cherry |
| H Chapman | Broadwater Farm | Kent Mid | TQ688567 | 51:17:04 | 0:25:12E | Apple |
| H Chapman | Broadwater Farm | Kent Mid | TQ688567 | 51:17:04 | 0:25:12E | Cherry |
| H Chapman | Broadwater | Kent Mid | TQ688567 | 51:17:04 | 0:25:12E | Pear |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Farm | | | | | |
| H Chapman | Broadwater Farm | Kent Mid | TQ688567 | 51:17:04 | 0:25:12E | Plum |
| D Worley | Court Lodge Farm | Kent Mid | TQ696504 | 51:13:40 | 0:25:44E | Apple |
| D Worley | Court Lodge Farm | Kent Mid | TQ696504 | 51:13:40 | 0:25:44E | Cherry |
| P Barwick | Blackmoor Estates | Hants Mid | SU774328 | 51:05:23 | 0:53:46W | Apple |
| P Barwick | Blackmoor Estates | Hants Mid | SU774328 | 51:05:23 | 0:53:46W | Apple |
| P Barwick | Blackmoor Estates | Hants Mid | SU774328 | 51:05:23 | 0:53:46W | Plum |
| P Ward | Hartley Lands | Sussex East | TQ767345 | 51:04:59 | 0:31:19E | Apple |
| P Ward | Hartley Lands | Sussex East | TQ767345 | 51:04:59 | 0:31:19E | Plum |
| P. Ward | Hartley Lands | Sussex East | TQ765345 | 51:04:59 | 0:31:08E | Pear |
| M Nash | Pixford Fruit Farm | Somerset | ST157305 | 51:04:06 | 3:12:16W | Cherry |
| W Hebdidtch | New Cross Fruit | Somerset | ST411454 | 50:58:05 | 2:49:55W | Apple |

**Table 2.** Orchard location, county, age, crop type, and pest management programmes (0 = no insecticide, 1 = <2 insecticide, 2 = 2-4 insecticide, 3 = >4 insecticide sprays) ranked in order of total moth catch, highest first, over the trapping period (April – September 2006)

| Farm | County | Latitude | Longitude | Crop | Area (ha) | Orchard age (years) | Pest Manage | Total moth catch |
|---|---|---|---|---|---|---|---|---|
| Court Lodge Farm | Kent Mid | 51:13:40N | 0:25:44E | Cherry | 4.0 | 4 | 2 | 1095 |
| Court Lodge Farm | Kent Mid | 51:13:40N | 0:25:44E | Apple | 3.0 | 30 | 2 | 706 |
| EMR | Kent Mid | 51:17:19N | 0:26:45E | Cherry | 0.7 | 8 | 0 | 158 |
| EMR | Kent Mid | 51:17:19N | 0:26:45E | Cherry | 0.8 | 7 | 0 | 142 |
| New Cross Fruit Fm | Somerset | 50:58:05N | 2:49:55W | Plum | 2.6 | 8 | 2 | 109 |
| Man of Ross Ltd | Hereford | 51:54:52N | 2:34:57W | Plum | 5.0 | 25 | 3 | 93 |
| New Cross Fruit Fm | Somerset | 50:58:05N | 2:49:55W | Apple | 3.2 | 10 | 2 | 91 |
| Hartley Lands Farm | Sussex East | 51:04:59N | 0:31:19E | Apple | 2.1 | 8 | 1 | 89 |
| Broadwater Farm | Kent Mid | 51:17:04N | 0:25:12E | Cherry | 2.5 | 12 | 0 | 77 |
| Garson Farm | Surrey | 51:21:47N | 0:23:08W | Plum | 0.9 | 6 | 3 | 67 |
| Broadwater Farm | Kent Mid | 51:17:04N | 0:25:12E | Plum | 4.2 | 15 | 1 | 66 |
| Q' gardens | Oxfordshire | 51:36:11N | 1:17:51W | Cherry | 2.0 | 25 | 2 | 43 |
| Garson Farm | Surrey | 51:21:47N | 0:23:08W | Apple | 0.7 | 21 | 3 | 41 |
| Garson Farm | Surrey | 51:21:47N | 0:23:08W | Cherry | 0.9 | 3-6 | 3 | 41 |
| Broad Oak Farm | Kent East | 51:17:31N | 0:59:00E | Cherry | 1.0 | 4 | 2 | 37 |
| Hartley Lands Farm | Sussex East | 51:04:59N | 0:31:19E | Plum | 2.1 | 7 | 0 | 29 |
| Man of Ross Ltd | Hereford | 51:54:52N | 2:34:57W | Pear | 7.2 | 55 | 1 | 17 |
| Pixford Fruit Farm | Somerset | 51:04:06N | 3:12:16W | Cherry | 2.0 | - | 2 | 15 |
| Broadwater Farm | Kent Mid | 51:17:04N | 0:25:12E | Apple | 6.6 | 16 | 3 | 13 |
| Castle Fruit Farm | Glouc | 51:57:32N | 2:25:05W | Apple | 0.7 | 10 | 2 | 13 |
| Hull Farm | Essex | 51:54:33N | 0:58:00E | Cherry | 1.0 | 7 | 1 | 12 |
| Q' gardens | Oxfordshire | 51:36:43N | 1:18:33W | Plum | 1.0 | 25 | 2 | 12 |

**Table 2.** Orchard location, county, age, crop type, and pest management programmes (0 = no insecticide, 1 = <2 insecticide, 2 = 2-4 insecticide, 3 = >4 insecticide sprays) ranked in order of total moth catch, highest first, over the trapping period (April – September 2006)

| Farm | County | Latitude | Longitude | Crop | Area (ha) | Orchard age (years) | Pest Manage | Total moth catch |
|---|---|---|---|---|---|---|---|---|
| Man of Ross Ltd | Hereford | 51:54:52N | 2:34:57W | Cherry | 4.8 | 15 | 1 | 11 |
| Broadwater Farm | Kent Mid | 51:17:04N | 0:25:12E | Pear | 3.9 | 55 | 2 | 11 |
| Q' gardens | Oxfordshire | 51:36:43N | 1:18:33W | Apple | 2.0 | 20 | 2 | 10 |
| Castle Fruit Farm | Glos | 51:57:32N | 2:25:05W | Cherry | 0.3 | 4 | 1 | 10 |
| Broad Oak Farm | Kent East | 51:17:31N | 0:59:00E | Plum | 0.4 | 5 | 2 | 10 |
| Man of Ross Ltd | Hereford | 51:54:52N | 2:34:57W | Apple | 8.0 | 40 | 3 | 8 |
| Hull Farm | Essex | 51:54:33N | 0:58:00E | Pear | 1.5 | 30+ | 2 | 7 |
| Castle Fruit Farm | Glos | 51:57:32N | 2:25:05W | Plum | 1.2 | 18 | 2 | 7 |
| Q' gardens | Oxfordshire | 51:36:26N | 1:18:21W | Pear | 5.0 | 60 | 2 | 6 |
| Blackmoor Estates | Hants Mid | 51:05:23N | 0:53:46W | Apple | 4.8 | - | 2 | 5 |
| Hartley Lands Farm | Sussex East | 51:04:59N | 0:31:08E | Pear | 1.0 | 40 | 1 | 5 |
| Castle Fruit Farm | Glouc | 51:57:32N | 2:25:05W | Pear | 2.3 | 27 | 1 | 5 |
| Hull Farm | Essex | 51:54:23N | 1:00:06E | Apple | 6.5 | 20 | 3 | 3 |
| Blackmoor Estates | Hants Mid | 51:05:23N | 0:53:46W | Plum | 2.1 | 8 | 2 | 2 |
| Blackmoor Estates | Hants Mid | 51:05:23N | 0:53:46W | Apple | 1.9 | 24 | 2 | 1 |
| Broad Oak Farm | Kent East | 51:17:31N | 0:59:00E | Apple | 6.3 | 15 | 3 | 1 |
| Broad Oak Farm | Kent East | 51:17:31N | 0:59:00E | Pear | 1.7 | 18 | 3 | 1 |
| Hull Farm | Essex | 51:54:33N | 0:58:00E | Plum | 1.0 | 20 | 3 | 1 |
| Peter Wheldon Ltd | Suffolk | 52:01:09N | 0:46:18E | Apple | 20.0 | 17 | 2 | 0 |
| Torry Hill | Kent North | 51:17:24N | 0:44:48E | Cherry | 4.4 | 11 | 2 | 0 |
| Peter Wheldon | Suffolk | 52:02:10N | 0:46:21E | Pear | 20.0 | 15 | 2 | 0 |

**Table 2.** Orchard location, county, age, crop type, and pest management programmes (0 = no insecticide, 1 = <2 insecticide, 2 = 2-4 insecticide, 3 = >4 insecticide sprays) ranked in order of total moth catch, highest first, over the trapping period (April – September 2006)

| Farm | County | Latitude | Longitude | Crop | Area (ha) | Orchard age (years) | Pest Manage | Total moth catch |
|---|---|---|---|---|---|---|---|---|
| Ltd | | | | | | | | |
| Peter Wheldon Ltd | Suffolk | 52:01:44N | 0:47:02E | Plum | 4.0 | 20 | 1 | 0 |

**Table 3.** Surrounding vegetation and habitat of the orchards ranked from highest number of moths caught throughout the growing season

| Farm | County | Crop | Total moth catch | Surrounding habitat |
|---|---|---|---|---|
| Court Lodge Farm | Kent Mid | Cherry | 1095 | Lavender north, cherries south, set-aside and poplar hedge east, cherries west |
| Court Lodge Farm | Kent Mid | Apple | 706 | Lavender north, apples south and east, and woodland west |
| EMR | Kent Mid | Cherry | 158 | Surrounded with poplar windbreaks and apple and soft fruit orchards |
| EMR | Kent Mid | Cherry | 142 | Surrounded with poplar windbreaks and apple and soft fruit orchards, covered with net during growing season |
| New Cross Fruit Fm | Somerset | Plum | 109 | Surrounded by alder and poplar windbreaks with adjoining cropping of blackcurrants, asparagus, cider apples. Local hedges of hawthorn and blackthorn |
| Man of Ross Ltd | Hereford | Plum | 93 | Hawthorn hedgerow north, hawthorn and hazel hedgerow east, hedgerow and crab apples south, hedgerow and crab apples west |
| New Cross Fruit Fm | Somerset | Apple | 91 | Surrounded with blackthorn and hawthorn hedges with ash and oak trees and arable land and vegetable crops |
| Hartley Lands Farm | Sussex East | Apple | 89 | Organic fruit farm |
| Broadwater Farm | Kent Mid | Cherry | 77 | Surrounded by apple and pear plots, and alder and conifer windbreaks |
| Garson Farm | Surrey | Plum | 67 | Multicropping system with adjacent hedges and grassland |
| Broadwater Farm | Kent Mid | Plum | 66 | Surrounded by apple and pear plots and alder windbreaks |
| Q' gardens | Oxfordshire | Cherry | 43 | To south plums; to west grass and alder; to north grass with alder windbreak; to east asparagus and willows |
| Garson Farm | Surrey | Apple | 41 | Multicrop farm with river and dense woodland bordering |
| Garson Farm | Surrey | Cherry | 41 | Multicropping farm with alder and birch windbreak perimeter |
| Broad Oak Farm | Kent East | Cherry | 37 | Surrounded by other cherry orchards |
| Hartley Lands Farm | Sussex East | Plum | 29 | Grassland and apples |
| Man of Ross Ltd | Hereford | Pear | 17 | To north hedgerow mixed *Prunus*, *Betula*, *Salix* etc: to east birch and hedgerow with |

**Table 3.** Surrounding vegetation and habitat of the orchards ranked from highest number of moths caught throughout the growing season

| Farm | County | Crop | Total moth catch | Surrounding habitat |
|---|---|---|---|---|
| | | | | *Prunus*, hazel and elm: to south birch windbreak: to west crab apples, mixed woodland, hawthorn |
| Pixford Fruit Farm | Somerset | Cherry | 15 | Public road with high hedges and two pasture fields bordering. Young cherry orchard one field away |
| Broadwater Farm | Kent Mid | Apple | 13 | Surrounded by apple and pear plots and alder windbreaks |
| Castle Fruit Farm | Glouc | Apple | 13 | No data |
| Hull Farm | Essex | Cherry | 12 | Other fruit orchards |
| Q' gardens | Oxfordshire | Plum | 12 | To south gardens; to west arable; to north apples; to east blackberries and apples |
| Man of Ross Ltd | Hereford | Cherry | 11 | To north birch windbreak: to east birch windbreak: to south birch windbreak: to west young hedgerow of hawthorn, nut, maple etc |
| Broadwater Farm | Kent Mid | Pear | 11 | Surrounded by apple and pear plots and alder windbreaks |
| Q' gardens | Oxfordshire | Apple | 10 | To south plums; to west arable and chestnut windbreak; to north arable and poplar; to east plums and alder |
| Castle Fruit Farm | Glouc | Cherry | 10 | No data |
| Broad Oak Farm | Kent East | Plum | 10 | Surrounded by other apple and plum orchards. Alder windbreak on one side |
| Man of Ross Ltd | Hereford | Apple | 8 | To north hedgerow with crab apples: to east hedgerow with crab apples: to south overgrown wild hawthorn embankment: to west mixed deciduous woodland |
| Hull Farm | Essex | Pear | 7 | Gala orchard and open ground |
| Castle Fruit Farm | Glouc | Plum | 7 | No data |
| Q' gardens | Oxfordshire | Pear | 6 | To south maize: to west vegetables: to north and east grass |
| Blackmoor Estates | Hants Mid | Apple | 5 | Ancient woodland on two sides, apple to east, hawthorn windbreak to north |
| Hartley Lands Farm | Sussex East | Pear | 5 | Hedges and derelict orchards |
| Castle Fruit Farm | Glouc | Pear | 5 | No data |

**Table 3.** Surrounding vegetation and habitat of the orchards ranked from highest number of moths caught throughout the growing season

| Farm | County | Crop | Total moth catch | Surrounding habitat |
|---|---|---|---|---|
| Hull Farm | Essex | Apple | 3 | Mainly farmland, a few mature surrounding gardens |
| Blackmoor Estates | Hants Mid | Plum | 2 | Apple all round, two lime, one hawthorn and one mixed species of windbreak |
| Blackmoor Estates | Hants Mid | Apple | 1 | Hawthorn, beech and lime windbreaks. Pear to south, plum to west and apple to north and east |
| Broad Oak Farm | Kent East | Apple | 1 | Alder windbreaks surround orchard with other apple orchards on all sides |
| Broad Oak Farm | Kent East | Pear | 1 | Surrounded by other orchards of apple, plum and pear, no windbreaks |
| Hull Farm | Essex | Plum | 1 | Other fruit orchards |
| Peter Wheldon Ltd | Suffolk | Apple | 0 | Orchards to north and east Conference, Comice and Concorde. Orchards to south Cox and Russet. Field to north turnips and damson hedge |
| The Estate Office | Kent North | Cherry | 0 | Chestnut coppice to east and south, arable to north, rough grass to west. Hedge to north and west |
| Peter Wheldon Ltd | Suffolk | Pear | 0 | Orchard to east Cox, E. Windsor and Spartan. Orchard to west Russet and Meridian. Horse paddock to north. Open field grubbed orchard to south. |
| Peter Wheldon Ltd | Suffolk | Plum | 0 | Grubbed orchard to north. Soft fruit to east. Orchard to south Cox and Discovery. Road and golf driving range to west |

Table 4. Pesticide management programmes (0 = no insecticide, 1 = <2 insecticide, 2 = 2-4 insecticide, 3 = >4 insecticide sprays) of the orchards in the survey and the average date of the first catch, first peak flight and second peak flight of the male LBAM moth

| | Pest Manage | No. orchards treated | Total catch (S.E.) | Mean Date | | |
|---|---|---|---|---|---|---|
| | | | | 1st catch | 1st flight peak | 2nd flight peak |
| Apple | 0 | 0 | - | - | - | - |
| | 1 | 1 | 89 | 31 May | 14 Jun | 02 Aug |
| | 2 | 7 | 118 (98.7) | 02 Jun- | 13 Jun | 31 Aug |
| | 3 | 5 | 13 (7.3) | 17 Jun- | 20 Jun | 05 Aug |
| Cherry | 0 | 3 | 126 (24.8) | 01 Jun | 03 Jun | 01 Sep |
| | 1 | 3 | 11 (0.6) | 06 Jun | 05 Jun | 09 Aug |
| | 2 | 5 | 238 (214.0) | 24 May | 16 Jun | 17 Sep |
| | 3 | 1 | 41 | 24 May | 31 May | 16 Aug |
| Pear | 0 | 0 | 0 | - | - | - |
| | 1 | 3 | 9 (4.0) | 09 Jun | 16 Jun | 19 Aug |
| | 2 | 4 | 6 | 17 Jun | 22 Jun | 03 Aug |
| | 3 | 3 | 1 | 06 Sep | | 06 Sep |
| Plum | 0 | 1 | 29 | 14 Jun | 21 Jun | 02 Aug |
| | 1 | 2 | 33 (33.0) | 05 Jun | 05 Jun | 07 Aug |
| | 2 | 5 | 28 (20.3) | 09 Jun | 16 Jun | 25 Aug |
| | 3 | 3 | 54 (27.4) | 17 Jun | 09 Jun | 18 Aug |

Appendix 1.

Illustrations of male light brown apple moth supplied to the grower

## Light Brown Apple Moth, male (length approx. 8 mm)

Appendix 2.

Letter of instruction posted to growers with the pheromone traps and lures

2 May 2006

Dear *[insert growers name]*

Thank you for agreeing to take part in the HDC pheromone trap survey of Light Brown Apple Moth in one apple, one pear, one plum and one cherry orchard on your farm in 2006. The traps you require are enclosed. Each trap set contains 4 pheromone lures which are to be changed at 6 week intervals. Please store the replacement lures in the freezer or fridge until needed.

Please deploy the trap in the centre of the orchard (s) by mid-May and monitor weekly, recording the catch of light brown apple moths in each trap each week until early September.

A photograph of light brown apple moth is included to help identification. The traps only really catch the light brown apple moth, but occasionally another species, *Pyrausta purpuralis* which has purple wings with gold markings, is captured. If in doubt, email a digital photo or send a sample on a sticky base (packed in a polythene bag in a box) to me, or give the sample to your advisor, for confirmation if necessary.

Please complete a form giving details of each orchard, and a form giving the record of the trap catches, returning to me at the end of the season. Hard copies are enclosed but you should receive an electronic copies by email which are preferred.

If possible, I would appreciate receiving the electronic orchard detail forms now, with an update with the 2006 insecticide spray programme at the end of the season. Also, an email of the trap catches from time to time on the electronic form would be useful.

Thank you very much for your help.

Yours sincerely

Dr Jerry Cross
Entomologist
Jerry.cross@emr.ac.uk

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Fax: +44 (0) 1732 849067

Appendix 3.

Orchard detail record sheet supplied to growers

| | | | | |
|---|---|---|---|---|
| Light Brown Apple Moth Pheromone trap survey 2006<br><br>Details of orchards where pheromone traps deployed<br>(complete 1 sheet for each orchard) | | | | |
| Name: | | | | |
| Company name: | | | | |
| Address for correspondence: | | | | |
| | | | | |
| Post Code: | | | | |
| Office Phone: | | Mobile phone: | | |
| Email: | | | | |
| | | | | |
| Orchard details | | | | |
| Name | | Crop: Apple / pear / plum / cherry | | |
| Area: ha | | Approx age: years | | |
| Main variety: | | | | |
| Pollinator varieties: | | | | |
| Address of orchard location: | | | | |
| | | Post code | | |
| National Grid Reference (e.g. TQ 396 485): | | | | |
| OS Landranger map No. | | | | |
| Describe surrounding habitats in each direction, including other orchards, crops, hedgerows woodland, gardens giving dominant woody plant species where possible | | | | |
| Have you seen significant tortrix moth caterpillar infestation or damage in the orchard? Describe | | | | |
| Insecticide spray programme 2005 | | | | |
| Date | Growth Stage | Product | Rate/ha | Target pest(s) |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Insecticide spray programme 2006 | | | | |
| Date | Growth Stage | Product | Rate/ha | Target pest(s) |
| | | | | |
| | | | | |

Appendix 4. Trap catch record sheet supplied to the growers

| HDC Light Brown Apple Moth pheromone trap survey in tree fruit orchards 2006 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name: | | | Address: | | | | |
| Week no | Starting Monday | Record date | Number of light brown apple moths captured per week | | | | |
| | | | Apple | Pear | Plum | Cherry | Date traps deployed and lures changed |
| 18 | 01-May | | | | | | |
| 19 | 08-May | | | | | | |
| 20 | 15-May | | | | | | |
| 21 | 22-May | | | | | | |
| 22 | 29-May | | | | | | |
| 23 | 05-Jun | | | | | | |
| 24 | 12-Jun | | | | | | |
| 25 | 19-Jun | | | | | | |
| 26 | 26-Jun | | | | | | |
| 27 | 03-Jul | | | | | | |
| 28 | 10-Jul | | | | | | |
| 29 | 17-Jul | | | | | | |
| 30 | 24-Jul | | | | | | |
| 31 | 31-Jul | | | | | | |
| 32 | 07-Aug | | | | | | |
| 33 | 14-Aug | | | | | | |
| 34 | 21-Aug | | | | | | |
| 35 | 28-Aug | | | | | | |
| 36 | 04-Sep | | | | | | |
| 37 | 11-Sep | | | | | | |
| 38 | 18-Sep | | | | | | |
| 39 | 25-Sep | | | | | | |
| Please email to: jerry.cross@emr.ac.uk or post to J V Cross, East Malling Research, New Road, East Malling, Kent ME19 6BJ<br>Tel. office direct: 01732 523748 Mob: 07732761488 | | | | | | | |