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Monitoring codling and tortrix moths in United Kingdom apple orchards using pheromone traps

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SUMMARY

Studies of pheromone traps for *Cydia pomonella*, *Archips podana* and *Adoxophyes orana* (Lepidoptera: Tortricidae) were made in United Kingdom apple orchards from 1974 to 1976. Compared with light traps, they proved easier to operate and, with the exception of those set for *Adoxophyes orana*, were more effective monitors. There was considerable site-to-site variation in the pattern of weekly catches, and in total catches for each season, such variability often masking inter-regional differences. The data proved useful for deciding if and when sprays should be applied in individual orchards, and were also used as a basis for district spray warnings. Thresholds below which treatment was generally unnecessary were five moths/trap/wk for *C. pomonella* and 20 moths/trap/wk for *Archips podana*, but results for *Adoxophyes orana* were inconclusive. Fruit damage in monitored orchards sprayed as advised was generally low.

INTRODUCTION

For many years, entomologists in the Agricultural Development and Advisory Service (ADAS) (formerly the National Agricultural Advisory Service) operated light traps to help predict the most suitable time each year for the application of chemical sprays against the codling moth, *Cydia pomonella* (L.) (Lepidoptera: Tortricidae) (Wardlow & Baker, *in litt.*). However, because of the relative inefficiency of such traps in attracting this species, and the generally low populations in many United Kingdom (UK) orchards, forecasts were often based on the capture of very few moths and, therefore, tended to be unreliable.

In 1974, following encouraging developments in North America (Madsen & Vakenti, 1973), France (Milaire, 1973) and England (Cranham, 1973, 1974), members of the Fruit Pests Working Party (FPWP) of the ADAS Entomologists' (Closed) Conference embarked on a collaborative project (also involving workers at East Malling and Long Ashton Research Stations) to investigate pheromone-baited traps as an alternative to light traps for use in a forecasting service to UK apple growers. It was also hoped to discover how such traps could best be operated and their catches interpreted to give predicted information on the need for treatment and the optimum time to apply sprays. Less detailed studies were made on the fruit tree tortrix moth, *Archips podana* (Scop.), and the summer fruit tortrix moth, *Adoxophyes orana* (Fisch. v. Rösl.) (Lepidoptera: Tortricidae). This paper reports the results of the collaborative ADAS work of the FPWP from 1974 to 1976 which, unlike the research station studies, was done in commercial orchards.

MATERIALS AND METHODS

The studies covered a wide variety of commercial apple orchards in the fruit-growing areas of East Anglia, south-central, south-east and south-west England, and the West Midlands, and were based respectively at the following ADAS Regional Centres: Cambridge, Reading, Wye, Bristol and Evesham.

Light traps were of the standard Robinson design, fitted with mercury vapour ultra-violet lamps. They were operated in 1974 without anaesthetic or killing agent from May onwards and were normally emptied daily.

Pheromone traps of the Zoecon Corporation 'Pherocon 1C' 'wing' pattern were used from 1974 to 1976. These consist of weatherproofed paperboard top and sticky base sections, held together by a wire hanger and spacers. In 1974 and 1975, 3-M 'Sectar' paperboard traps were used for *Archips podana*. Synthetic pheromone baits (*ex* Zoecon) consisted of rubber or plastic bungs impregnated with either 1 mg of *trans*-8, *trans*-10 dodecadien-1-ol (Codlemone) (as Murphy Pherocon CM Codling Moth Attractant) for *C. pomonella*, 1 mg of *cis*-11 and 1 mg of *trans*-11-tetradecenyl acetate (Archemone) (as Murphy Pherocon TM Fruit Tree Tortrix Moth Attractant) for *Archips podana*, or 9 mg of *cis*-9 and 1 mg of *cis*-11-tetradecenyl acetate (Adoxomone) (as Murphy Pherocon TM Summer Fruit Tortrix Moth Attractant) for *Adoxophyes orana*. Studies on *Adoxophyes orana* were mainly limited to the south-east.

Single pheromone traps were hung in trees at about head height (1·75 m) and examined at least once a week (on Mondays, to standardise recordings), from May to September, when all moths and other large insects or debris were removed. Fresh baits were provided at 6-wk intervals in line with advice from Zoecon Corporation and available information on their effective life (Minks & Voerman, 1973) (*see also* Maitlen, McDonough, Moffitt & George, 1976). Where necessary, traps or trap bases were renewed at the same time, but more frequently if they showed excessive signs of wear.

Pheromone traps were set within orchards at points convenient to the operators, usually one Codlemone-baited trap per site. When other baits were tested in the same orchard, trap spacing was at least 15 m. Light traps, when used, were placed alongside or within monitored orchards, and usually of necessity close to packing sheds or other available source of mains electricity. Light and pheromone traps were kept about 100 m apart but precise layout of traps was largely governed by circumstances on the farm.

RESULTS

Comparison of light and pheromone traps

Unlike light traps, which attracted males and females of many different moths, pheromone traps caught only males. Although most were the target species, traps were not entirely species-specific. Codlemone-baited traps, for example, attracted small numbers of *Celypha striana* (Denis & Schiff.), *Eucosma campoliliana* (Denis & Schiff.) and *Pammene rhediella* (Clerck) (Tortricidae), while Adoxomone-baited traps caught several specimens of *Ceramica pisi* (L.) (Noctuidae). Distinguishing the target species, however, was not difficult, and the use of pheromone traps (including the weekly sorting and counting of catches) was far simpler and much more convenient than operating and examining light traps that required daily attention.

In 1974, light traps and pheromone traps were compared at 11 sites for *C. pomonella*, seven sites for *Archips podana* and three sites for *Adoxophyes orana*. At all sites, light traps caught fewer specimens of *C. pomonella* and *Archips podana* than pheromone traps but the reverse was true for *Adoxophyes orana* (Table 1). Moths were usually found in light traps about 1 or 2 wk after the first individuals of the same species were caught in pheromone traps at the same site, and their appearance in light traps tended to coincide with a distinct increase in the numbers attracted to pheromone traps. Also, the peak weekly catch usually occurred later in light traps and was often less clearly defined than that of pheromone traps. Catch profiles throughout the season for light and pheromone traps, although sometimes similar, were not identical for any of the monitored species. This was probably due mainly to inherent differences in the operating

Table 1. *Comparison of moth catches in light and pheromone traps, 1974*

Species	Trap	No. of traps	No. of moths caught per trap: Mean	No. of moths caught per trap: Range	No. of moths caught as % of site total: Mean	No. of moths caught as % of site total: Range
Cydia pomonella	Light	11	12·6	0–40	15·7	0–48·9
	Pheromone	11	65·5	4–411	84·7	51·1–100
Archips podana	Light	7	13·9	0–26	13·3	0–30·6
	Pheromone	7	117·6	36–325	86·7	69·4–100
Adoxophyes orana	Light	3	43·3	1–99	73·4	57·6–100
	Pheromone	3	30·3	0–73	26·6	0–42·4

conditions required for the optimum efficiency of the two kinds of traps; light trap records also included females.

Pheromone trap catches

In each year (1974 to 1976), highest catches of *C. pomonella* and *Archips podana* tended to occur in south-west sites (Tables 2, 3 and 4). Data for *Adoxophyes orana* were obtained only from Kent (south-east); although Adoxomone-baited traps were operated in East Anglia, the south-west and West Midlands during 1975, no specimens of this locally distributed species were caught.

C. pomonella

Overall mean weekly catches for 1974 and 1975 were very similar, with a rapid rise in early June and a peak of activity in mid-June (Fig. 1). In both years, average weekly catches remained at about five moths/trap until late July and then declined, with only slight evidence of a partial second generation in mid-August. In 1976, spring activity occurred noticeably earlier, mean weekly catches exceeding 10 moths/trap in early June. A temporary lull in moth activity during mid-June coincided with a brief spell of unfavourable weather. A large second generation of moths emerged during late July–August 1976 and this was clearly indicated by the pheromone trap catches (Fig. 1); subsequently, considerable numbers of larvae were found in maturing apples in unsprayed orchards.

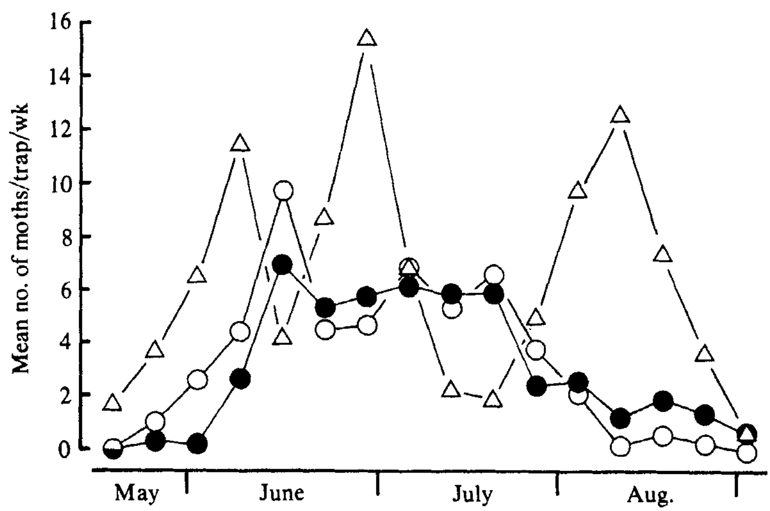

Fig. 1. Mean weekly pheromone trap catches of *Cydia pomonella* for all sites in 1974 (○), 1975 (●) and 1976 (△).

The week in which the first moths were trapped each spring varied considerably from site to site, ranging over 9 wk in 1974 and 1975, and 5 wk in 1976 (Fig. 2). Although in 1974, moths tended to appear earliest in the south-east, and trap catches in the West Midlands and East Anglia (apart from south Essex) tended to be slightly later each year than those in more southern areas, intra-regional site variations masked any differences between regions. The proportion of traps operating for at least 1 wk with nil catches when first set out was 63% in 1974, 92% in 1975 and 53% in 1976, indicating that only in 1975 were traps set early enough to monitor the commencement of moth activity.

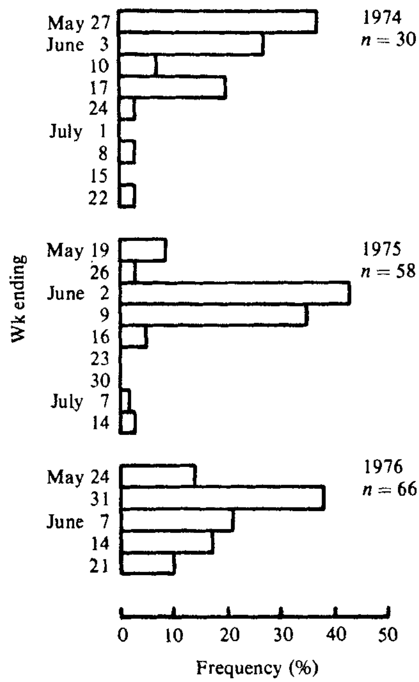

Fig. 2. Frequency distribution showing week in which individual pheromone traps first caught *Cydia pomonella*. Traps set on 20 May 1974, 12 May 1975 and 17 May 1976.

The date of peak first generation catches also showed considerable variation, spreading over 7 or 8 wk (Fig. 3). However, second-generation peaks, which occurred in 1975 and 1976, were less variable. Intra-regional site variations again obscured differences between regions. Nevertheless, in 1974, south-west catches were generally the most advanced but, along with those in the West Midlands, the latest in 1976; also, in both 1975 and 1976, traps in south-central and south-east England tended to show earlier first-generation peak catches than those in other regions.

Archips podana

Each year, numbers of adults trapped rose rapidly in early- to mid-June to reach a peak in late June (1974 and 1976) or early July (1975) (Fig. 4), generally about 1 to 2 wk later than with *C. pomonella*. Dates of peak numbers, however, varied between and within regions. Nevertheless, they were generally earlier in the more western sites (south-west and West Midlands) in 1974 but, compared with central and eastern areas, somewhat later in these sites in 1976. However, as with *C. pomonella*, trap catches within any one region showed considerable variation. Second-generation catches were observed in late August or September 1975 and in August 1976 but not in 1974 (Tables 2, 3 and 4).

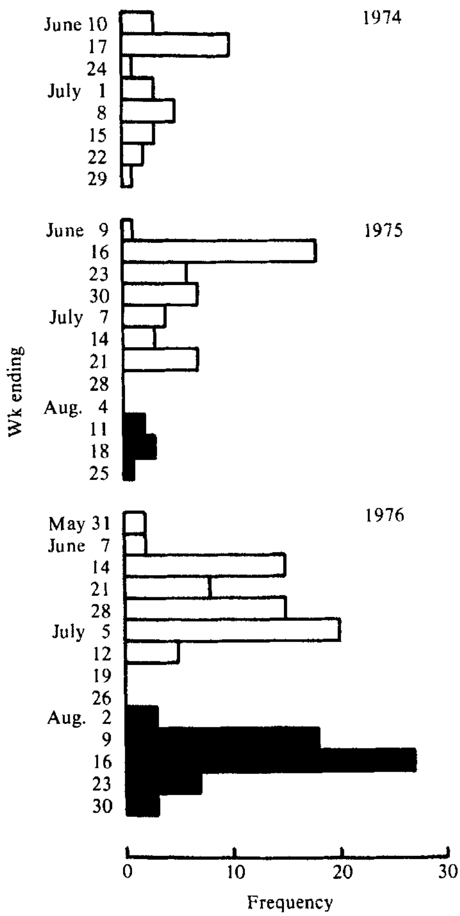

Fig. 3. Frequency distribution showing date when peak weekly pheromone trap catches of first (□) and second (■) generations of *Cydia pomonella* occurred each year.

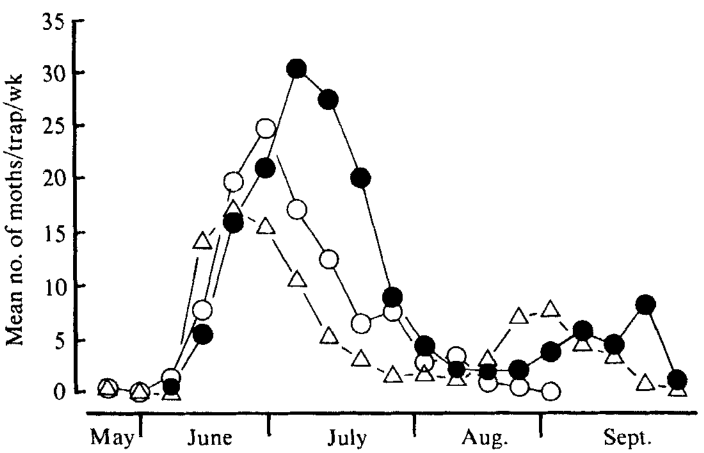

Fig. 4. Mean weekly pheromone trap catches of *Archips podana* for all sites in 1974 (O), 1975 (●) and 1976 (△).

Table 2. *Mean weekly moth catches per pheromone trap, 1974*

	Cydia pomonella				*Archips podana*				*Adoxophyes orana*
	E. Anglia	South-east	South-west	W. Midlands	E. Anglia	South-east	South-west	W. Midlands	South-east
Number of traps	4	13	3	10	4	2	3	5	9
Date traps examined									
27 May	0	2	2	0	0	0	0	0	0
3 June	1	4	5	1	0	0	0	0	11
10	2	8	7	0	1	0	1	1	28
17	3	7	45	6	8	12	12	4	11
24	2	3	15	5	5	19	33	24	1
1 July	1	5	11	4	10	15	60	19	0
8	1	6	23	5	16	20	20	16	0
15	2	6	6	7	13	12	11	14	0
22	2	5	22	5	3	6	20	1	0
29	4	3	12	2	4	2	30	0	0
5 Aug.	3	2	5	2	0	1	11	0	0
12	1	1	1	1	1	4	10	0	2
19	1	0	2	0	0	2	4	0	3
26	1	0	1	0	0	1	1	0	45
2 Sept.	0	0	0	0	0	0	0	0	25
9	—	—	—	—	—	—	—	—	12
16	—	—	—	—	—	—	—	—	11
23	—	—	—	—	—	—	—	—	5
Mean no. moths/trap	23·8	52·1	155·3	37·3	58·5	91·0	211·3	78·6	156·0
S.D.±	24·6	32·6	181·4	16·8	20·3	11·0	95·6	38·8	70·2
Range	1–65	5–116	9–411	4–58	36–89	80–102	91–325	31–142	62–325

Table 3. *Mean weekly moth catches per pheromone trap, 1975*

	Cydia pomonella					*Archips podana*					*Adoxophyes orana*
	E. Anglia	South-central	South-east	South-west	W. Midlands	E. Anglia	South-central	South-east	South-west	W. Midlands	South-east
Number of traps	8	7	25	9	12	8	7	26	8	12	19*
Date traps examined											
19 May	0	—	0	0	0	—	—	0	0	—	0
26	0	0	0	1	1	—	0	0	0	0	0
2 June	0	0	0	0	0	0	0	0	0	0	0
9	1	5	1	10	1	0	0	0	1	0	0
16	9	16	3	13	4	1	18	1	20	1	1
23	7	10	2	7	10	13	47	8	33	8	2
30	2	5	1	13	14	9	54	12	28	25	0
7 July	3	9	1	14	12	19	62	25	24	36	0
14	7	4	1	11	12	24	31	11	91	25	0
21	7	5	5	8	6	21	18	16	40	19	0
28	2	3	2	3	3	6	11	7	19	6	0
4 Aug.	6	3	2	3	2	5	4	3	11	2	0
11	1	3	1	5	0	1	2	3	5	1	0
18	0	4	1	5	2	1	0	2	5	2	3
25	0	5	0	3	1	0	3	1	11	1	1
1 Sept.	0	2	0	2	1	1	11	1	14	3	2
8	—	—	—	—	—	—	32	2	7	—	1
15	—	—	—	—	—	—	13	3	—	—	0
22	—	—	—	—	—	—	19	1	—	—	—
29	—	—	—	—	—	—	3	0	—	—	—
Mean no. moths/trap	40·6	73·6	18·1	98·2	67·8	96·4	317·7	95·1	299·8	124·5	12·1*
S.D.±	33·7	67·8	16·1	68·5	42·3	35·8	78·2	43·0	94·1	27·1	20·4
Range	2–119	18–154	0–65	6–240	20–144	27–143	158–423	9–176	127–409	62–152	1–45*

* Excludes seven with nil catches.

Table 4. *Mean weekly moth catches per pheromone trap, 1976*

	Cydia pomonella					*Archips podana*				*Adoxophyes orana*
	E. Anglia	South-central	South-east	South-west	W. Midlands	South-central	South-east	South-west	W. Midlands	South-east
Number of traps	4	7	32	11	12	7	28	10	12	25
Date traps examined										
24 May	1	14	—	1	1	0	—	0	0	—
31	2	12	2	5	3	0	0	0	0	1
7 June	12	12	3	9	5	1	0	1	0	6
14	16	21	6	16	14	22	18	14	1	14
21	5	5	5	9	7	21	20	21	6	2
28	14	15	5	22	14	13	10	27	22	1
5 July	6	11	4	34	35	8	7	16	16	0
12	2	7	2	12	16	1	3	5	12	0
19	1	2	1	10	3	1	2	7	3	0
26	0	5	1	4	1	0	2	1	2	2
2 Aug.	1	14	3	8	3	0	3	1	1	11
9	7	19	4	23	7	1	1	3	1	11
16	5	36	6	22	8	4	2	5	1	8
23	2	28	4	10	4	13	4	13	4	3
30	—	14	2	2	2	9	9	10	3	1
6 Sept.	—	2	1	0	0	3	11	3	2	0
13	—	—	—	—	—	3	5	—	—	—
20	—	—	—	—	—	1	—	—	—	—
27	—	—	—	—	—	1	—	—	—	—
Mean no. moths/trap	66·5	204·6	46·6	182·6	104·3	102·7	83·8	127·7	70·8	59·3
S.D.±	71·9	123·9	44·4	91·9	74·3	47·3	48·8	77·3	36·0	94·1
Range	23–99	43–445	3–251	45–320	22–267	45–204	8–219	42–311	32–177	1–300

Adoxophyes orana

In all three seasons, distinct peak first-generation catches occurred in early to mid-June and were followed by distinct second-generation peaks in August (Tables 2, 3 and 4). On average, second-generation catches were almost twice as large as the first (means of 45·8 and 24·4 moths/trap respectively) and exceeded them in number in 34 out of 42 instances. Few moths were trapped outside the two main flight periods for each year.

Pheromone trap catches and temperature

In 1975 and 1976, records were kept of accumulated day-degrees in excess of 10 °C threshold summed from 1 January each year. This temperature is widely accepted as the lower threshold for the development of eggs, larvae and pupae of *C. pomonella* (e.g. Hagley, 1973); a similar threshold has been demonstrated for eggs of *Adoxophyes orana* (Minks & de Jong, 1975) and *Archips podana* (Cranham, *in litt.*).

Accumulated day-degrees of temperature were obtained by summing:

$$\frac{\text{daily maximum} + \text{daily minimum}}{2} - 10\ ^\circ\text{C}$$

and were obtained from meteorological stations at ADAS laboratories and experimental centres, or local aerodromes, as near as possible to where traps were situated.

It was expected that a rapid build-up of moth numbers in the traps would coincide with a value of 150 day-degrees of temperature and that catches would then have reached about 40–50% of the likely first generation for the season (Cranham, 1974). However, our results showed considerable variation. In 1975, at 49 sites, catches at 150 day °C averaged 24·1% of total first-generation catches (range, 0–94%). In only nine instances (eight in 1975 and one in 1976) did catches at 150 day °C equal 40–50 ($\pm$ 5)% of the total first generation. Not surprisingly, moth totals at 150 day °C showed no relationship to subsequent fruit damage at harvest on unsprayed sites.

Although accumulated temperatures usually reached the 150 day °C threshold in June, there was sometimes considerable site-to-site variation, particularly between regions, with a notably wide range from 8 June to 5 July in 1975. Even within a region, variations of a week were not uncommon; in 1975, a range of 23 days (12 June to 5 July) occurred in the south-east.

Damage assessment

In 1975 and 1976, assessments were made at harvest of the extent of codling moth and tortrix moth damage in samples of 1000 or 1200 fruits from each of several orchards monitored by pheromone traps. (Some counts were also made of damage in fallen fruit during mid-August. However, the latter data proved inconvenient to obtain and were very incomplete; they added nothing of value to the analyses and are, therefore, excluded.)

C. pomonella

Fruit damage at harvest on unsprayed sites in 1975 and 1976 averaged 0·97 $\pm$ 1·27 and 2·05 $\pm$ 2·81% respectively, and tended to be highest in orchards where pheromone trap catches were greatest (Table 5). The closest correlations occurred between first generation peak weekly trap catches and damage at harvest (Fig. 5). Growers not wishing to apply blanket or routine spray programmes were usually prepared to accept up to 1% fruit damage. This level was therefore taken as a convenient economic threshold, and was only exceeded once where peak weekly catches were below five moths (Table 5).

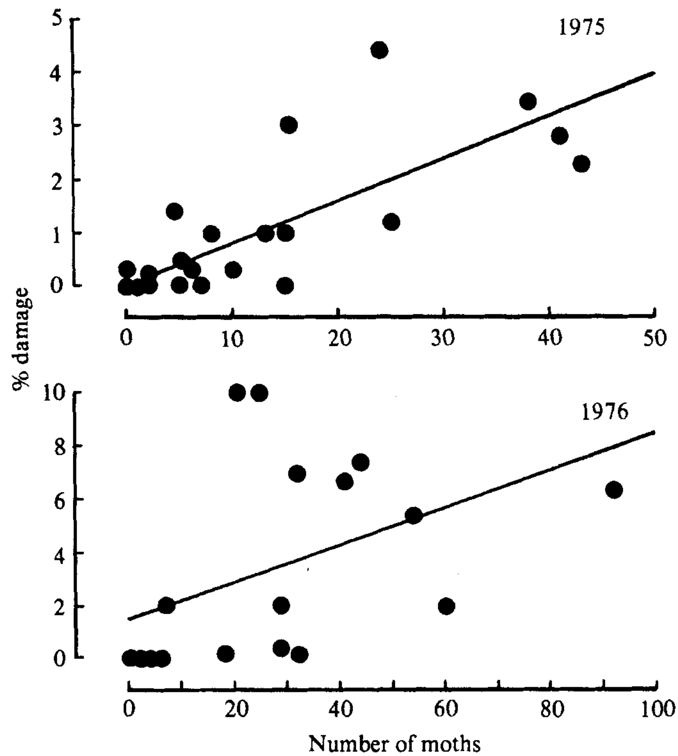

Fig. 5. Relationship between peak weekly pheromone trap catches of *Cydia pomonella* and fruit damage at harvest. 1975, $b = 0{\cdot}08 \pm 0{\cdot}01$ $r = 0{\cdot}78$; 1976, $b = 0{\cdot}07 \pm 0{\cdot}03$ $r = 0{\cdot}47$.

Archips podana

Fruit damage in unsprayed orchards averaged 1·6 ± 1·8% in 1975 (22 sites) and 1·5 ± 1·5% in 1976 (17 sites) and, with the exception of one site in 1975 and four sites in 1976, only exceeded 1% following first generation peak weekly trap catches of 20 or more moths and total catches for the season above 99 moths (Table 6). However, trap data showed no significant correlation with subsequent damage levels at harvest.

Table 5. *Comparison of pheromone trap catches of* Cydia pomonella *and fruit damage at harvest on unsprayed sites, 1975 and 1976*

	No. of sites		Damage (%)	
Total catch	Examined	With >1% damage	Mean	Range
0–19	9	0	0·08	0–0·3
20–49	16	3	1·08	0–10·0
50–99	4	2	1·38	0·1–2·0
>99	14	13	4·63	0·2–10·0
Peak weekly catch				
0–4	13	1	0·14	0–1·4
5–9	7	1	0·55	0–2·0
10–19	6	1	0·9	0–3·0
>19	17	15	4·54	0·2–10·0

Table 6. *Comparison of pheromone trap catches of* Archips podana *and fruit damage at harvest on unsprayed sites, 1975 and 1976*

	No. of sites		Damage (%)	
Total catch	Examined	With >1% damage	Mean	Range
0–49	4	2	0·96	0–1·63
50–99	11	3	0·75	0–3·5
100–199	14	6	2·1	0–7·0
>199	10	7	2·0	0–3·9
Peak weekly catch				
0–19	6	3	0·87	0–1·63
20–39	12	2	0·82	0–4·8
40–59	12	6	2·28	0–7·0
>59	9	7	2·07	0·6–3·8

Adoxophyes orana

Damage on seven unsprayed sites and 12 receiving either a codling moth or tortrix moth treatment, averaged 0·09 ± 0·20 and 0·06 ± 0·1% respectively, but showed no correlation with pheromene trap catches. In unsprayed orchards, the only damage seen (0·05 and 0·57%) occurred where total trap catches were three and 10 moths respectively, yet no damage was recorded where moth populations ranged from 2–104 orchard.

Spray warnings

The dates suggested for applying the first spray against *C. pomonella* in the various regions from 1974 to 1976 are shown in Table 7. The warnings were issued by ADAS entomologists and were based on trap data obtained during the present study. Regional spray dates for any one year were very similar, although for the more northern regions (East Anglia and West Midlands) it was suggested that spray programmes should commence about a week later than elsewhere (Table 7).

Table 7. *Mean fruit damage caused by* Cydia pomonella, *and dates suggested for commencement of spray programmes*

			No. of sites		Damage (%)	
Year	Region	Suggested spray date	Sprayed	Unsprayed	Sprayed	Unsprayed
1974	East Anglia	24 June	—	—	—	—
	South-central	17 June*	—	—	—	—
	South-east	17 June*	—	—	—	—
	South-west	21 June	—	—	—	—
	West Midlands	24 June	—	—	—	—
1975	East Anglia	27 June	5	3	0	1·0
	South-central	20 June	6	4	0·02	0·6
	South-east	20 June	9	6	0·5	1·2
	South-west	21 June	1	6	0	2·0
	West Midlands	26 June	5	8	0·9	2·3
1976	East Anglia	21 June	3	—	0·03	—
	South-central	14 June	3	2	2·2†	0·4
	South-east	14 June	14	7	0·2	0·4
	South-west	15 June	—	8	—	4·7
	West Midlands	21 June	5	5	0·6	20·7

* Date amended to 24 June following spell of cold weather.
† Due to 6·4% damage on one site (see text).

Table 8. *Mean fruit damage caused by* Cydia pomonella *on various apple cultivars at Luddington Experimental Husbandry Station*

	Damage (%)			
	1975		1976	
Cultivar	Sprayed	Unsprayed	Sprayed	Unsprayed
Cox's Orange Pippin	1·3	3·5	—	—
Discovery	—	—	1·1	9·2
Egremont Russet	0·3	5·0	0·6	26·0
Golden Delicious	—	—	0·9	22·0
Worcester Pearmain	—	—	0·2	10·3

When sprays such as azinphos-methyl, carbaryl, fenitrothion or phosalone were applied as suggested, and no gap was left in the spray programme when high moth populations were present, damage in treated orchards was generally light, exceeding 1% on only six out of 51 sites (mean damage, 0·43%) compared with more than 1% damage on 24 out of 49 unsprayed sites (mean damage, 3·84%) ($P = 0{\cdot}001$) (Table 7). On only one sprayed site was serious damage noted. This was in a fenitrothion-sprayed orchard in south-central England in 1976 with a very high *C. pomonella* population (first generation peak of 92 moths/wk) and 6·4% damage at harvest. Here, 42 adults were trapped before the end of May, which suggests that a spray was required well in advance of the general regional forecast. (Apparently, this grower usually applies sprays later than advised by ADAS.) The site also carried a very large second generation (peak catch of 126 moths/wk). As a result of the high catches, a third spray was applied specifically against the second generation; without it, damage would probably have been even greater.

Surveys of fruit damage on sprayed (with azinphos-methyl) and unsprayed trees of various cultivars at the Luddington Experimental Husbandry Station in 1975 and 1976 also indicated the benefits of insecticidal treatment (Table 8).

Archips podana

For many years, ADAS spray warnings for this species have usually been combined with those for *C. pomonella*, growers being advised to delay the first codling moth spray by about a week if previous experience on the farm suggests that 'tortrix moth' is the more important pest.

In 1975 and 1976, fruit damage exceeded 1% in 19 out of 46 unsprayed sites but in only four out of 44 sprayed sites ($P = 0{\cdot}001$) (Table 9), the pest tending to be least important in the east of the country (East Anglia and south-east) where adults were generally less numerous in pheromone traps (Tables 3 and 4).

Table 9. *Mean fruit damage caused by* Archips podana *in 1975 and 1976*

		No. of sites		Damage (%)	
Year	Region	Sprayed	Unsprayed	Sprayed	Unsprayed
1975	East Anglia	5	3	0	0
	South-central	6	4	0·4	1·8
	South-east	9	6	0·5	0·8
	South-west	0	6	—	1·3
	West Midlands	5	8	1·2	3·3
1976	East Anglia	4	2	0	0
	South-central	3	2	0·4	0·4
	South-east	12	7	0·3	0·7
	South-west	0	8	—	2·5

Adoxophyes orana

Specific ADAS spray warnings for this local species are not issued. Damage in 12 sprayed and seven unsprayed orchards in Kent during 1976 averaged 0·06 and 0·15% respectively.

DISCUSSION AND CONCLUSIONS

Pheromone traps are now widely used in place of light traps for monitoring *C. pomonella* and certain other tortricid moths in UK orchards (Brakefield & Bartlett, 1975; Alford, 1978). They are more sensitive indicators of adult *C. pomonella* and *Archips podana* activity and are, therefore, a better basis for spray warnings, particularly when moth numbers are low. However, there are still difficulties associated with the interpretation of trap catches which, as discussed in detail by Riedl & Croft (1974), are influenced by many factors. Data presented here for UK orchards suggest possible treatment thresholds of five moths/trap/week for *C. pomonella* and 20 moths/trap/week for *Archips podana*. However, decisions on whether sprays are required are also biased by individual grower attitudes to pest control, past history of pest incidence and damage in the orchard, level of fruit set, weather conditions, and so on. The same difficulties arise in deciding how many sprays should be applied. Even where the suggested thresholds are exceeded for several weeks, as happened with *C. pomonella* in 1976 (and again in 1977 – unpublished FPWP data), it is unlikely that more than the normal two- or three-spray programme would be required, according to the pesticide used. Generally low populations might require only a single spray or none at all. Although further damage assessment data from orchards with low moth populations are desirable, adoption of these thresholds has not resulted in economic damage in ADAS field trials on the supervised control of apple pests, where rational use of pesticides and minimum spray programmes are being encouraged (Carden, 1977).

In the present studies, sprays against *C. pomonella* were generally applied about 10–14 days after evidence of the onset of the main flight period, but delayed if cool weather intervened. This policy appeared effective, as sprays generally gave good control. However, refinements are desirable in establishing the most suitable spray dates, particularly the consideration of threshold temperatures for moth activity, mating and egg-laying, and temperature sums for egg incubation. Pheromone trap catches considered in isolation are liable to lead to poor spray timing. For example, growers operating their own traps sometimes become concerned by the mere appearance of several moths on the sticky plates and may then spray far too soon for maximum effect. Also, if traps are placed in orchards after adult emergence has begun, the first counts are likely to be unreliably high indices of activity and, again, this may result in premature spraying if such catches are misinterpreted.

An important feature of our pheromone trap data is the considerable site-to-site variation in both moth emergence rates and catch profiles throughout the season. Some of this variability was probably due to individual orchard microclimates and differences in regional weather patterns, particularly temperature, but much is unexplained. The data on accumulated temperatures also showed considerable variation and we could not confirm the near linear relationship between *C. pomonella* catches at 150 day °C and damage at harvest demonstrated by Solomon & Cranham (1976) at East Malling Research Station.

District weather data can be used in a general spray warning service but a close relationship between moth emergence, flight and mating activity and temperature is only likely to be obtained with local, preferably 'on-site', records. Similarly, because of the variations in the size and patterns of trap catches from site to site, regional forecasts issued by ADAS can only be taken as a guide; in any one orchard, the spray date suggested for an area could be wrong by up to 2 weeks or even more. More accurate data on moth activity, essential for precise spray timing, may be obtained from pheromone traps set in individual orchards, and these can be used to modify the general district forecasts.

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