1998 Report to APRC on Project SP 110

Phenology of apple sawfly activity

M.G. Solomon
Horticulture Research International-East Malling
Kent ME19 6BJ

Summary

Sawfly flight activity was monitored in a range of apple orchard sites in the south east and west of England, using white sticky traps to which the sawflies are attracted. Total seasonal catches per trap ranged from none at all in some orchards to a maximum of 166 in the orchard with greatest sawfly numbers. Date of first recorded catch ranged from 30th April to 15th May. The accumulated heat sum in day degrees above a threshold of 4°C was calculated for first trap catch and maximum catch in each orchard. The results will be used, together with results from 1999, to examine the relationship between sawfly development and temperature, and decide whether temperature records provide a satisfactory basis for predicting flight activity.

Introduction

Background

The apple sawfly (*Hoplocampa testudinea* (Klug)) is an old pest of apple, in that it was a serious problem in the days before effective insecticides became available. It can cause serious damage to unsprayed apple trees in some years. Now that the routine use of broad-spectrum insecticides has decreased, apple sawfly has again become a serious problem for apple growers. It has been known for 50 years that BHC (gamma-HCH) is effective against apple sawfly, but as this material is no longer registered for use, alternative chemicals are being sought. Insecticides are traditionally applied at petal fall as they are damaging to pollinating insects if applied earlier. Recent work has shown that some fungicides are effective in controlling apple sawfly (Olszak & Maciesiak, 1996; Cross & Jay, 1998). These materials can be applied during the flowering period, and they appear to be most effective if applied when adult sawflies are active. An understanding of the timing of sawfly activity is thus important for several reasons. It will ensure that traps are placed in the orchard before the emergence of the first sawfly adults, it will enable well informed decisions to be made on the need for, and timing of, a pesticide application, and it will increase the effectiveness and extend the useful life of new insecticides.

Biology of apple sawfly

Apple sawfly passes through one generation per year, with the adults flying actively in apple orchards during April and May. A detailed account of the biology of apple sawfly is given by Miles (1932) and Dicker (1953); a brief description is provided here.

Adults mate among the blossoms on apple trees, and the females subsequently lay eggs in the receptacles of the apple flowers just below the stamens. The female has an ovipositor with serrated edges (hence the name ‘sawfly’), and with it she cuts a slit in the receptacle in which she lays her egg. A drop of liquid subsequently exudes from the slit, leaving a brown mark, so that egg laying sites are detectable. The reported total number of eggs laid by one female ranges from thirteen (Velbinger, 1939) to 32 (Dicker, 1953). After hatching from the egg the larva starts burrowing into the fruit, usually starting in the calyx and continuing around the developing fruitlet, just under the skin, before burrowing towards the centre of the fruit and the seeds. Some larvae die before beginning this deeper burrowing and the fruits that develop subsequently exhibit a characteristic ‘ribbon’ scar on the surface. Those larvae that successfully reach and consume the seeds then leave that fruit and attack another, eating their way directly to the seeds. This leaves a large and characteristic entry hole, around which accumulate wet, reddish brown droppings. A few larvae go on to attack a third fruit (Steer & Thomas, 1935). Apples that have suffered damage to the seeds as a result of sawfly feeding usually fall from the tree as part of the ‘June drop’.

After feeding for around four weeks, the mature larva emerges from the fruit and drops to the ground, burrows into the soil, and spins a cocoon within which it remains in the ‘pre-pupal’ stage until the following spring. Several researchers have investigated the depth at which overwintering in this stage occurs, by excavating cocoons from the soil; results indicate variously that most pupae occur between 8 and 23 cm deep (Miles, 1932), in the top 10 cm (Hey & Steer, 1934), and in the top 15 cm

(Dicker, 1953). The depth to which larvae burrow is probably dependent on the penetrability of the soil, but it seems that most pupate within the top 15 cm. In the following spring, adult sawflies emerge from the cocoons, mate and lay eggs in the apple receptacles.

Monitoring apple sawfly emergence

Adult sawflies are attracted by the white colour of the apple flowers. Owens & Prokopy (1978) analysed the spectral reflectance of apple blossoms and subsequently designed effective sticky traps to catch apple sawfly adults based on a white colour with negligible reflectance in the UV range (300-400 nm) but large reflectance in the remainder of the insect-visible spectrum (400-650 nm). Subsequent research in Switzerland (Wildbolz & Staub, 1984;1986) led to the commercial production of the 'Rebell' white sticky traps for sawfly assessment.

The timing of adult flight activity, and of egg laying in the flower receptacles, varies from year to year, and is not reliably synchronised with the flowering period of any particular apple variety. The rate at which the sawfly pupae develop, and hence the timing of adult emergence, are functions of the temperature of the soil where the pupae are located in their cocoons. The ability to predict the timing of the period of flight activity would allow growers to place white sticky traps in the orchard at the correct time to intercept the first adult activity, and would define the timing of peak flight activity, so that well informed conclusions can be reached about the size of the population in the orchard. In this way the best possible decision can be made on the need for, and timing of, a pesticide application.

Materials and Methods

At a range of orchard sites, small electronic temperature loggers ('Gemini Tinytag') were used to record air and soil temperatures. The air temperature loggers were enclosed within a 'mini-Stevenson screen', and the remote probes for the soil temperature loggers were buried at a depth of 10 cm. Loggers were downloaded periodically, and readings were integrated to derive daily mean temperatures. The threshold temperature below which no development of the sawfly pupa takes place has been shown to be 4°C (Graf *et al*., 1996a). The amount by which each daily mean temperature exceeded this figure was added to an accumulating day-degree heat sum.

Sawfly adult activity was monitored by placing white sticky 'Rebell' traps at a height of approximately 1.5 m in trees in the apple orchards. Traps were placed in six orchards at Home Farm, HRI-East Malling, four orchards at Rocks Farm, East Malling, four farms elsewhere in Kent, and three orchards in the West Midlands. Depending on the geographical location, traps were examined and sawfly numbers counted at intervals of one or two days or a week.

Results

The numbers of apple sawfly adults caught in each sticky trap are given in Table 1. There was clearly a great range of catches from one site to another; the maximum total aggregate catch for one trap for the season was 166, and at other locations none at all were caught. For those sites where catches were great enough to be meaningful, the dates of first catch and maximum catch are given in Table 2.

The accumulated soil and air temperature day degree heat sums above the 4°C threshold are given for each site, on the dates of first and maximum sawfly catches, in Tables 3 and 4. Two heat sums are given, one derived from starting the temperature accumulation from 1st January (Table 3), and the other from1st March (Table 4).

Discussion

Sawfly pre-pupae overwinter in the soil, and then begin pupal development. Insects do not thermoregulate; their temperature is dependent on that of their surroundings. The rate of development of the pupa is a function of temperature, so one would expect soil temperatures at pupation depth to give the best indication of speed of development, and ultimately of the time of adult emergence. Based on the results in Table 3, first catches were in the range 323-525 day degrees, and peak catches in the range 402-700 day degrees. Soil temperature is not, however, a convenient parameter for everyone to record. Air temperature is simpler to measure, and more growers are likely to have this information available. There is a reasonably consistent seasonal relationship between air temperature and soil temperature (see Figure 1), so accumulated air temperatures may give as good a guide to development and emergence of sawfly (Table 3).

In common with many overwintering stages of insects, sawfly pre-pupae enter a state of diapause in autumn, and remain in this condition during the winter. During the time that an insect is in diapause, it does not develop even if the temperature rises above the normal threshold for development. There is evidence that overwintering sawfly pre-pupae remain in diapause until early March (Graf *et al.*, 1996b; Zijp & Blommers, 1997). Temperatures earlier than this may thus be irrelevant to the development of the pupae. One would then expect the relationship between heat sum and adult emergence dates to be better if day degrees are accumulated from 1st March rather than 1st January. Heat sums for first catch then become 216-410 day degrees for soil temperature and 225-382 day degrees for air temperature (Table 4). Results from a single year do not provide a sufficient basis for a decision on the relative merits of soil or air temperatures or the different starting dates for heat sum accumulation.

There is clearly a wide spread of heat sums corresponding to first catches and peak catches at the different locations. The relatively low total catches at most sites, and the seven day intervals between trap inspections at some sites, no doubt contributed to a weakening of the relationship between heat sums and timing of sawfly development. In particular, catches at the Ightham site occurred at lower heat sums than elsewhere. This was also the site with the largest sawfly catches, and the fact that catches started at a lower heat sum may be partly an effect of the population size. However, the period of peak catches at Ightham also occurred at a relatively low heat sum.

Further data are required for a more detailed examination of the relationship between temperature and adult activity, and an assessment of the best way to use temperature data as a guide to the timing of sawfly activity. The 1999 report of the continuing project will include trapping data for 1999, and also some historic data, so that a greater range of years can be examined.

References

Cross, J.V. & Jay, C.N. 1998. Effects of fungicides against apple sawfly. *Report to APRC 1998*. 5pp.

Dicker, G.H.L. 1953. Some notes on the biology of the apple sawfly, *Hoplocampa testudinea* (Klug). *Journal of Horticultural Research* **28**, 238-245.

Graf, B., Höhn, H. & Höpli, H.U. 1996a. The apple sawfly, *Hoplocampa testudinea*: a temperature driven model for spring emergence of adults. *Entomologia Experimentalis et Applicata* 78, 301-307.

Graf, B., Höpli, H.U. & Höhn, H. 1996b. Modelling spring emergence of the apple sawfly *Hoplocampa testudinea* Klug (Hymenoptera, tenthredinidae). *Acta Horticulturae*, **416**, 263-271.

Hey, G.L. & Steer, W. 1934. Experiments on the control of the apple sawfly (*Hoplocampa testudinea* Klug). *Report of East Malling Research Station for 1933*, 197-216.

Miles, H.W. 1932. On the biology of the apple sawfly, *Hoplocampa testudinea* Klug. *Annals of Applied Biology*, **19**, 420-431.

Olszak, R.W. & Maciesiak, A. 1996. Preliminary investigations on apple sawfly control with fungicides. *Brighton Crop Protection Conference-Pests & Diseases 1996*, 331-336.

Owens, E.D. & Prokopy, R.J. 1978. Visual monitoring trap for European apple sawfly. *Journal of Economic Entomology* **71**, 576-578.

Steer, W. & Thomas, F.J.D. 1935. Field spraying and dusting trials on the control of apple blossom weevil and of apple sawfly in 1934. *Report of East Malling Research Station for 1934*, 194-204.

Velbinger, H. 1939. Beitrag zur Biologie und Bekämpfung der Apfel- und Birnensägewespe (*Hoplocampa testudinea* Klug, *Hoplocampa brevis* Klug) (Hym. Tenthr.). *Gartenbauwissenschaft*, **13**, 492-566.

Wildbolz, Th & Staub, A. 1984. Űberwachung der Sägewespen mit Eiablagekontrollen, Befallskontrollen und weissen Fallen. *Schweiz. Z. Obst- Weinbau* **120**, 228-232.

Wildbolz, Th & Staub, A 1986. Fang der Pflaumensägewespen *Hoplocampa minuta* und *H. flava* und der Apfelsägewespe *H. testudinea* mit weissen Fallen.-Einfluss von Temperatur, Blütezeit und Fallenposition. *Mitt. Schweiz. Ent. Ges.* **59**, 289-296.

Zijp, J.P. & Blommers, L.H.M. 1997. Prediction of flight of apple sawfly, *Hoplocampa testudinea*, using temperature sums. *Entomologia Experimentalis et Applicata* 84, 71-75.

Location of		April								May							June		
orchards	27	29	30	5	6	8	11	12	13	15	18	19	20	22	26	2	5	9	12
E. Malling-Home																			
Deadman 1		*			0			3				1			0	0	0	0	0
Deadman 2		*			5			5				9			4	0	0	0	0
East Egham 1		*			0			2				6			3	0	0	0	0
East Egham 2		*			0			3				1			0	0	0	0	0
Church West 1		*			3			2				2			0	0	0	0	0
Church West 2		*			3			7				11			0	0	0	0	0
E. Malling-Rocks																			
Tomlins Land		*			6			10				11			0	0	0	0	0
Hazzards Gate 1		*			0			0				0			0	0	0	0	0
Hazzards Gate 2a	*		0	1		0	0		0	0	0		0		0			0	
Hazzards Gate 2b	*		1	1		1	2		0	1	0		0		0			0	
Hazzards Gate 2c	*		0	0		0	1		0	0	0		0		0			0	
Total			**1**	**2**		**1**	**3**		**0**	**1**	**0**		**0**		**0**			**0**	
Ightham a	*		4	1		1	85		39	29	7		0		0			0	
Ightham b	*		1	0		2	15		16	18	9		1		0			0	
Ightham c	*		0	2		2	13		12	8	3		4		0			0	
Total			**5**	**3**		**5**	**113**		**67**	**55**	**19**		**5**		**0**			**0**	

Table 1. Numbers of apple sawfly caught in Rebell traps 1998 (* indicates date when trap installed in orchard).

Location of	April			May												June			
orchards	27	29	30	5	6	8	11	12	13	15	18	19	20	22	26	2	5	9	12
Teynham a	*			1		0	0		0	2	0		0		0				
Teynham b	*			1		0	0		0	0	1		0		0				
Teynham c	*			0		0	0		0	0	0		0		0				
Total				**2**		**0**	**0**		**0**	**2**	**1**		**0**		**0**				
Linton a	*				0	0	0		0	0	0		0		0				
Linton b	*				0	0	0		0	0	0		0		0				
Linton c	*				0	0	0		1	0	0		0		0				
Total					**0**	**0**	**0**		**1**	**0**	**0**		**0**		**0**				
Coxheath a	*				0	0	0		0	0	0		0		0				
Coxheath b	*				0	0	0		0	0	0		0		0				
Coxheath c	*				0	0	2		0	1	0		0		0				
Total					**0**	**0**	**2**		**0**	**1**	**0**		**0**		**0**				
Dormington a			*			0			1		4			1	0				
Dormington b			*			0			2		3			5	0				
Dormington c			*			0			0		1			0	0				
Total						**0**			**3**		**8**			**6**	**0**				
Hereford a			*			0			1		1			0	0				
Hereford b			*			0			3		13			1	0				
Hereford c			*			0			0		3			1	0				
Total						**0**			**4**		**17**			**2**	**0**				

Table 1 continued. Numbers of apple sawfly caught in Rebell traps 1998 (* indicates date when trap installed in orchard).

Location of	April			May												June			
orchards	27	29	30	5	6	8	11	12	13	15	18	19	20	22	26	2	5	9	12
Westhope a			*			0			0		0			0	0				
Westhope b			*			0			0		0			0	0				
Westhope c			*			0			0		1			0	0				
Total						**0**			**0**		**1**			**0**	**0**				
Stewley a			*			0				0				0					
Stewley b			*			0				0				0					
Stewley c			*			0				0				0					
Total						**0**				**0**				**0**					

Table 1 continued. Numbers of apple sawfly caught in Rebell traps 1998 (* indicates date when trap installed in orchard).

Location of orchards	Date of first catch	Dates of peak catch
East Malling-Home	6 May	12-19 May
East Malling-Rocks	30 April	12-19 May
Ightham	30 April	11-15 May
Teynham	5 May	-
Dormington	15 May	18-22 May
Hereford	15 May	18 May

Table 2. Dates of first and peak catches of apple sawfly (excluding sites with very low catches).

Location of orchards	Soil temperature, accumulated day degrees		Air temperature, accumulated day degrees	
	First catch	Peak catch	First catch	Peak catch
E. Malling-Home	509	584-700	493	556-639
E. Malling-Rocks	466	584-700	457	556-639
Ightham	323	402-455	379	463-516
Dormington	509	542-585	543	577-623
Hereford	525	568	552	588

Table 3. Accumulated heat sums (day degrees from 1st January 1998) at the times of first and peak catches.

Location of orchards	Soil temperature, accumulated day degrees		Air temperature, accumulated day degrees	
	First catch	Peak catch	First catch	Peak catch
E. Malling-Home	393	469-584	323	386-470
E. Malling-Rocks	350	469-584	288	386-470
Ightham	216	295-348	225	309-362
Dormington	393	426-469	373	408-454
Hereford	410	452	382	419

Table 4. Accumulated heat sums (day degrees from 1st March 1998) at the times of first and peak catches.