Emerald, a post mortem

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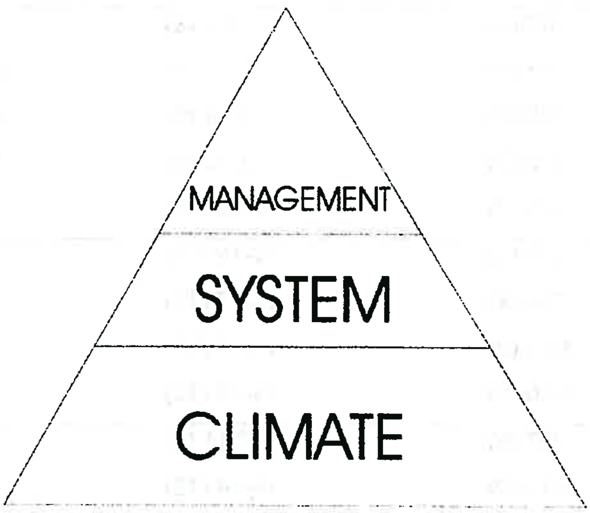
As with all post mortems the aim is to work out what happened and why. By understanding this we will be better able to address the issue of how much of Australia's cotton will be affected by this pest and what is the level of the threat. A good starting point is the basic set of requirements for a silverleaf whitefly outbreak and here we need to consider the "outbreak pyramid" (Fig. 1, modified after Peter Ellsworth, University of Arizona, Maricopa). The two most critical factors are climate and cropping systems, without both of these an outbreak is unlikely.

Figure 1. The outbreak pyramid.



Climate

In the case of climate, a comparison of Emerald with areas of Australia already affected by silverleaf whitefly indicates that the Emerald climate in terms of whitefly suitability, is equivalent to areas in coastal Queensland, eg Bundaberg, Bowen and Ayr (Table 1). This indicates that Emerald has a climate well suited to this pest, but will other cotton growing areas be affected similarly?

If one considers the predicted numbers of silverleaf whitefly generations in a year, of the cotton growing regions, Narrabri has the fewest with an average of 8 generations while Kununurra and Broome have 16 (Table 1). Given that Bundaberg, with an average of 9 generations, has a significant whitefly problem from September through to March, it would not be unreasonable to conclude that Narrabri also faces a reasonable probability of outbreaks occurring. However, the critical factor may not be the number of generations in a year, but rather the length of the longest generation. The reasons are several. Firstly, nymphs are immobile and as such are vulnerable to abiotic events such as rainfall and frosts and so the longer they remain nymphs the greater the risk. Secondly, leaf senescence has been found elsewhere at low temperatures to out-strip development. Finally, the longer the generation time for nymphs the longer the exposure of the nymphs to natural enemies. In combination, these are likely to contribute to substantially more mortality than occurs during the warmer months of the year. Therefore if numbers and lengths of generations are considered in combination, cooler areas such as northern NSW, Darling Downs and St George are likely to be less suitable for whitefly outbreaks whereas the cotton growing regions north of Biloela are predicably more likely to suffer outbreaks.

Table 1. Numbers of generations for silverleaf whitefly across a range of locations.

Location	**Generations[1], Oct – Mar* Mar – Oct ** Mar –Dec*****	**Generations per Year**	**Longest Generation (days, approx)**	
Narrabri*	4-7 (6)	6-9 (8)	122 days	15 Apr - 15 Aug
Goondiwindi*	5-8 (6)	7-10 (8)	118 days	15 May - 10 Sept
St George*	5-8 (7)	7-11 (9)	102 days	1 Jun - 10 Sept
Biloela*	6-8 (7)	7-11 (9)	92 days	1 Jun - 1 Sept
Emerald*	6-8 (7)	9-12 (10)	77 days	15 May - 1 Aug
Richmond**	6-8 (7)	11-15 (13)	61 days	15 May - 15 Jul
Katherine**	7-9 (8)	13-17 (15)	30 days	15 Jun - 15 Jul
Kununurra**	8-10 (9)	14-18 (16)	30 days	15 Jun - 15 Jul
Broome**	9-10 (9)	14-18 (16)	30 days	15 Jun - 15 Jul
Bundaberg***	5-7 (6)	7-11 (9)	87 days	1 Jul – 25 Sept
Bowen***	7-11 (9)	10-14 (12)	45 days	1 Jun – 15 Jul
Ayr***	7-11 (9)	10-14 (12)	45 days	1 Jun – 15 Jul
Gatton***	4-7 (5)	6-10 (8)	108 days	15 May – 1 Sept

[1] Generations from 1st of the month to 1st of the month.

Cropping System

The availability of hosts is a key factor in outbreaks. The more continuous the supply, the higher the probability of outbreak. Of the current cotton growing regions, Emerald faces the greatest risk given the availability of horticultural crops, wide areas of native and exotic pasture legumes (e.g. glycines and butterfly pea), grain legumes and sunflowers for a considerable portion of the year. In all there is barely a two month period when suitable crops are not available. This makes Emerald exceptional when compared with other cotton production areas and lowers the relative risk posed to all other areas. Potential production areas to the north of Emerald such as Kununurra will face a similar risk of outbreak to Emerald due to the near continuous availability of suitable hosts.

The combination of cropping system and climate would suggest that northern NSW and the Darling Downs faces a low risk of outbreak. St George, due to the presence of horticulture faces a somewhat higher risk, but the cooler winters makes outbreaks less likely. Central Highlands will have outbreaks, the extent of which will vary depending on host continuity.

Emerald 2001/2002, a brief outline with implications for the future

Infestations of several late crops in the 2000/2001 season first raised the spectre of an imminent outbreak in the following season. Surveys of regrowth cotton in July and August confirmed the presence of widespread, but low populations of silverleaf whitefly across the Emerald Irrigation Area (Fig. 2). Further, whiteflies were distributed widely on sow thistle, a common weed across the area (Fig. 3) and patches of winter vegetable crops such as potato and pumpkin provided small high density populations of whitefly along the eastern edge of the Emerald township.

Figure 2. The mean number of silverleaf whitefly eggs and nymphs on regrowth cotton.

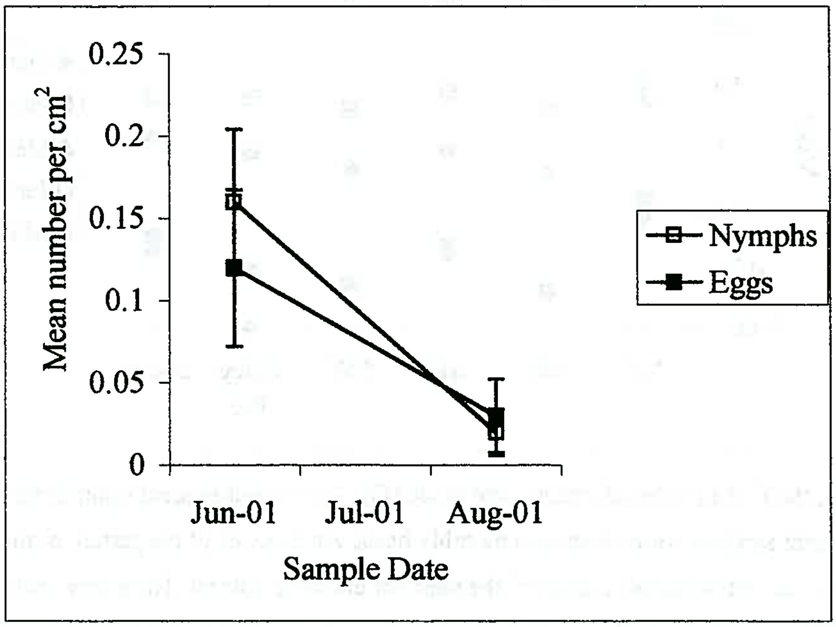


Figure 3. The mean number of silverleaf whitefly eggs and nymphs on sow thistle.

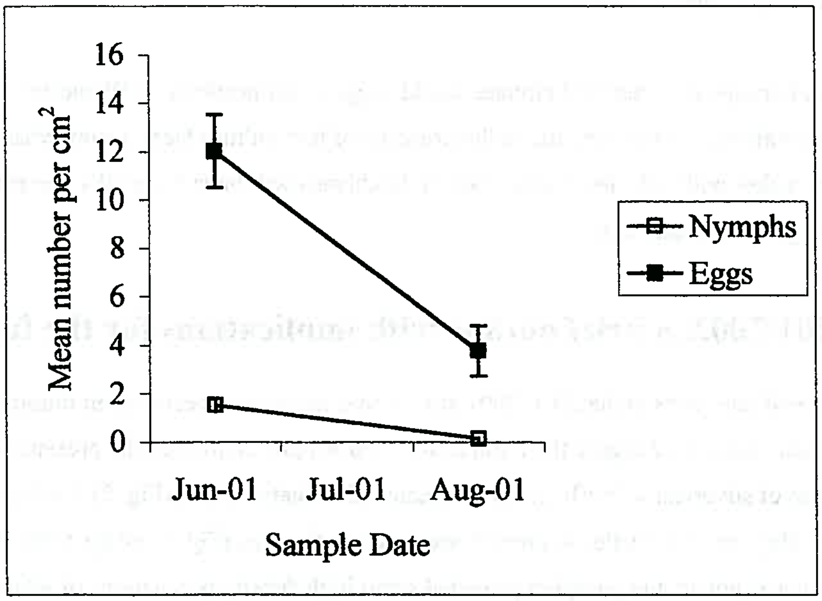
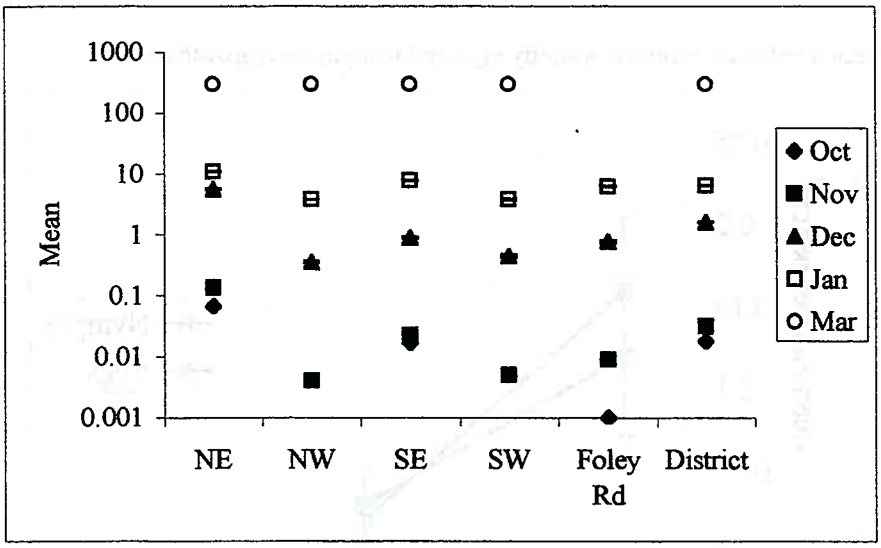
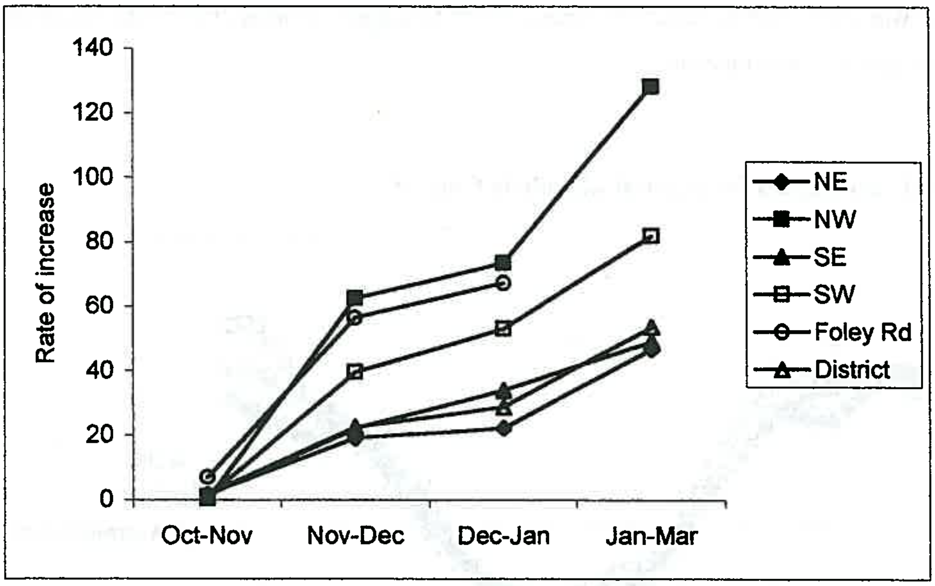


Figure 4. The mean number (log scale) of adult, third and fourth instars per leaf.



In October 2001, the first samples of cotton were made (Fig. 4) with subsequent samples taken in the ensuing months. Subsequent samples were taken on a monthly basis. An analysis of the pattern of the outbreak reveals the area-wide implications in terms of the need for effective control. The eastern side of the irrigation area (NE and SE) are areas where the greatest concentration of vegetable horticulture takes place and where the highest numbers of whiteflies were found. There were also areas of more heavily infested crops in the Foley Road area and the underlying cause is not known, but may indicate pockets of whiteflies persisting on non-crop hosts such as pasture legumes. The October and November samples revealed low numbers which had not increased to any great extent, but by December numbers had increased by an order of magnitude and the outbreak had spread to all parts of the irrigation area (Fig. 4 & 5).

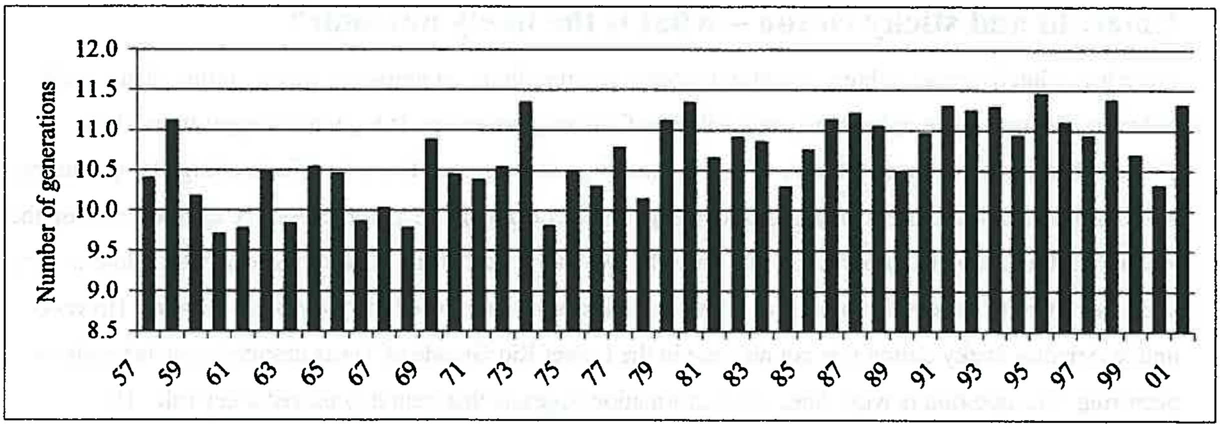
Figure 5. The cumulative rate of increase of silverleaf whitefly across the Emerald irrigation area.



Crops particularly affected were late sown crops which acted as whitefly sinks. The build up and subsequent spread of whiteflies across the district indicates the need to focus early on whitefly infestations and to act before numbers become unmanageable. The aim should be to suppress populations early and to plant in as narrow a window as possible.

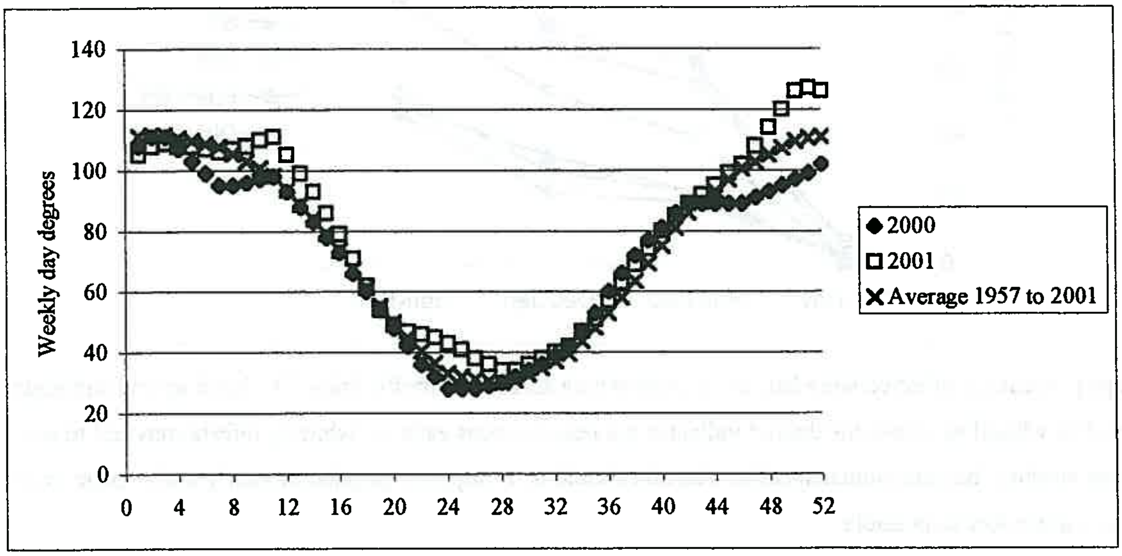
One question that remains is was this season a one off or is it a sign of things to come? While Emerald experienced a extremely hot year, it is a sobering thought to bear in mind that since 1985, 10 years have been sufficiently warm to enable 11 generations to develop. This includes 2001 and suggests that conditions for outbreaks are likely to be an ongoing occurrence.

Figure 6. Number of generations of silverleaf whitefly based on 365 day degrees per generation.



An analysis of the weekly day degree patterns further highlights the role of the high summer temperatures in November and December in accelerating the outbreak (Fig. 7). It is during this period that the extra generation experienced in 2001 develops and gives added impetus to the outbreak. This suggests that management of whiteflies must be effectively implemented to suppress numbers before the November-December acceleration in development.

Figure 7. Weekly day degrees for silverleaf whitefly in Emerald.



The take home message is that conditions in Emerald are likely to persist for the foreseeable future. In fact, it is likely that without effective areawide management, numbers of whitefly across the region will steadily increase with the real prospect that numbers going into the next season will be higher than those in preceding years. The net effect will be to create a bank of generations so that by planting there will be several generations of whiteflies in terms of numbers waiting to invade young crops. The key will be to get in early and manage on an areawide basis.

Emerald and sticky cotton – what is the likely outcome?

Silverleaf whitefly poses a threat to cotton production primarily as an impact on quality rather than a yield reduction factor. Unlike aphid honeydew, silverleaf whitefly honeydew is high in the sugar trehalulose. Silverleaf whitefly produces trehalulose as a means of protecting itself from the effects of high temperatures. Trehalulose is, like sucrose, composed of two sugar molecules, glucose and fructose, the difference being the location of the carbon to carbon bond that links the two monosaccharides. Unlike sucrose, trehalulose is very sticky and hard to remove from the lint. It was this stickiness that created the problem in Arizona. However, unlike Arizona, sticky cotton was not an issue in the Lower Rio Grande of Texas despite heavy infestations occurring. The question is why. Anecdotal information suggests that humidity played a key role. The Maricopa Valley in Arizona is hot and arid whereas the Lower Rio Grande in Texas is hot and humid. It is thought that humidity helps break or hydrolyse the bond linking the glucose and fructose monosaccharides.

Table 2 outlines the quantities of trehalulose to sucrose, glucose and fructose. For fresh honeydew, trehalulose makes up the vast majority of the sugars found in the honeydew e.g. there is 3.58 times more trehalulose than glucose in fresh honeydew. In contrast, honeydew on lint contains much lower relative quantities of trehalulose e.g. the relative quantity of trehalulose to glucose declines by a factor of 10. This decline is matched by an equivalent decline in the actual amounts of trehalulose present.

Table 2. The relative quantity of trehalulose with respect to sucrose, glucose and fructose.

	Sucrose	Glucose	Fructose
Fresh honeydew	2.66	3.58	1.76
Lint, sooty mould	nil	0.37	0.43
Lint, no sooty mould	0.99	0.42	0.43

This suggests that in the field trehalulose is being hydrolysed and that over time one might expect a considerable reduction in the quantity present on the lint. While this is only preliminary, there are a number of factors that need to be thought about. Firstly, the thresholds in operation in Emerald are based on Arizona data. Given the differences in climates, they may not be appropriate. Secondly, if numbers of whitefly are directly linked to the quantities of trehalulose and stickiness is not sufficient to lead to downgrades this season, then one might reasonably expect whiteflies to be manageable for the foreseeable future. Finally, and linked to the second point, growers may be able to tolerate much higher numbers of whiteflies without running the risk of penalties. However, key factors need to be better understood,

- The role of humidity in facilitating the degradation of disaccharides,
- Is there a temperature/humidity relationship,
- What is the relationship between whitefly numbers, honeydew production, temperature, humidity and the risk of stickiness.

These factors will no doubt require some follow up work, but there are now hints that silverleaf whitefly may not pose the level of threat that was originally thought – only time will tell.

Summary

The following are the key points related to silverleaf whitefly outbreaks,

- Climate, in particular temperature and the duration of the longest generation time over winter are critical for an outbreak. It is estimated that the longest generation time needs to be shorter than 100 days and probably closer to 90 days.
- Continuity of suitable hosts. Long periods of continuous availability of suitable hosts is essential for whitefly outbreaks. The discontinuity of host availability in northern NSW and the Darling Downs is a major factor in reducing the likelihood of outbreaks. In contrast, the almost continuous availability of suitable hosts in the Emerald Irrigation Area acts synergistically with climate to make further outbreaks probable.

- **The probable degradation of disaccharides under the hot, humid conditions found in Emerald may reduce the problem of sticky cotton and enable growers to tolerate higher whitefly densities.**
- **Based on our experience with silverleaf whitefly one would not anticipate outbreaks in northern NSW or the Darling Downs. St George is borderline as are Biloela and Theodore due to the lack of winter heat units in St George and the lack of host continuity in Biloela and Theodore. Emerald is highly likely to experience future outbreaks on a regular basis while Comet, due to the lack of continuous hosts may is likely to experience outbreaks only when conditions are particularly favourable.**