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Eggfruit Caterpillar [Sceliodes cordalia (Double Day)] pheromone development and control methods

John Brown
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Project Number: VG96008

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EGGFRUIT CATERPILLAR
[*Sceliodes cordalis* (Doubleday)]

PHEROMONE DEVELOPMENT

AND

CONTROL METHODS.

Project No. VG 96008

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A final report prepared for the Horticultural Research and Development Corporation.

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INDUSTRY SUMMARY

Following the isolation of the sex pheromone produced by female eggfruit caterpillar moths in attracting male moths for mating, the identification of those compounds that make up this pheromone was made. Knowing what compounds are involved in this pheromone allowed mixing of different proportions or ratios of these compounds to see if they could be produced into an artificial pheromone that would also be effective in attracting the male moths. Evaluation of these mixtures was initially made in the laboratory and as these showed a positive result their attractiveness to male moths was then evaluated in the field.

Field trials were undertaken to evaluate this artificial pheromone as a mating disruption tool and as a monitoring tool in helping to develop management strategies. Though trapping techniques the artificial pheromone was shown to be able to reduce the number of male moths attracted to caged virgin female moths. This showed that the artificial pheromone was effective in attracting male moths over female moths. In mating disruption trials large numbers of traps with the artificial pheromone were placed around and through blocks of eggplants. The results from these trials were encouraging in that the amount of damage to fruit was reduced but not at a significant level above non-trapped areas.

Monitoring of eggfruit caterpillar populations was completed and the results showed that the most responsive period of female moths in attracting male moths was during their first 5 days. Eggfruit caterpillar activity appeared to be present all year with increased populations of this pest occurring as the season progressed. There were no beneficial insects collected from populations of eggfruit caterpillars and the percent of fruit damaged over the three years ranged from 43 to 58%.

Biology studies showed that the development of this insect occurred within a range of temperatures that are experienced throughout all major eggplant production areas. This means that eggfruit caterpillar populations would be capable of successive generations throughout the year in all eggplant producing areas.

TECHNICAL SUMMARY

Development of an artificial pheromone based on the compounds (E) - 11 - hexadecen - 1 - yl acetate and (E) - 11 - hexedecen - 1 - ol were made and through trials proved that they were attractive in capturing male moths. From the early development work evaluating the different ratios of acetates and alcohols identified in the compounds, the 5:2 ratio collected more moths than the 5:1 ratio while the 1:1 ratio didn't attract many male moths and the 4:1 ratio collect the largest number of moths.

Different dose rates, 0.025, 0.375, 0.5 and 1g of pheromone/metre of rubber tubing was tested. The effectiveness of this artificial pheromone was compared to virgin female moths in the number of male moths that were attracted (trapped) to each of them. The dose rate of 0.025g/metre for baits proved to be effective whereas the dose rate of 0.5g/metre proved to be effective in a mating disruption trial to mask the bait lures. Another trial showed that traps with 0.375g/m pheromone also masked the attractiveness of virgin female moths in luring male moths. In another trial the number of male moths attracted showed an increase in catches at the artificial pheromone traps by a factor of 10 over the virgin female traps. The data from this trial did not show a significant difference between the artificial pheromone and virgin female moths. Some of the variation experienced in these trials could been due to the inability to uniformly impregnating the rubber which carries the pheromone.

In all trials the position of the traps had no real effect though some of the variations was probably due to this inability to uniformly impregnate the rubber. Pheromone bait traps attracted male moths up to 25 metres from the crop.

In assessing the effectiveness of the pheromone a number of studies were completed. Studies showed that the most attractive period for female moths in luring male moths to mate is during their first 5 days after emergence though the majority of males were attracted to the females during day 3 to 5. This also coincided with female survival, where 91% survived to the first three days and tapered from 77.6% in day 4 to 32.7% in day 6. The survival of females after day 6 was only for a few individuals.

Population monitoring showed that the percentage of fruit damaged was estimated to reach 43% during 1997, 58% during 1998 and reached 45% in 1999. The seasonal activity of moths could not be completed but on the data acquired it could be expected that eggfruit caterpillar activity is dependent of the food source. The increase in pest populations corresponded to the seasonal cropping periods and this population increase corresponds to increased fruit damage.

Development of eggfruit caterpillar eggs occurs under a wide range of temperatures from 36^{0}C to 17^{0}C, larvae to pre-pupa 37^{0}C to 16^{0}C, pre-pupa to pupa and pupa to adult 37^{0}C to 22^{0}C. No parasites were identified from this pest and an unnamed species was bred from eggplant fruit.

1. INTRODUCTION:

1.1 General

Eggfruit caterpillar _Sceliodes cordalis_, is a major insect pest of eggplant fruit (Davis 1964) and pepino (Galbreath & Clearwater 1983). It is also known to be a pest in a number of other crops especially the Solanum species, all of which are grown for the fresh food market. Damage to eggfruit is caused by the immature stages (larvae) feeding internally on the flesh and chewing holes through the skin on exiting the fruit to pupate. Fruit damage in eggplants is not evident until the fruit is cut open or holes are visible in the fruit caused by larvae exiting to pupate. Because mature fruit with larvae present internally is not always detectable at the farm gate, the fruit can be rejected at the market. This occurs as during transport and storage the larvae can exit the fruit to pupate and these exit holes become noticeable. Another major problem occurs when the consumer after buying what appears to be sound produce, cuts it open and detects the damaged flesh.

At present, scheduled applications of pesticides are employed to control this pest in preventing heavy losses in eggplant crops. These applications are applied from fruit set until fruit maturity. The need for early spray coverage following fruit set is aimed at controlling the young eggfruit caterpillar larvae emerging from eggs before they tunnel into the fruit. Eggfruit caterpillar moths lay their eggs around the calyx and on the fruit surface of eggplant and on larvae emerging, immediately tunnel into the fruit leaving little evidence of their presence. Once the larvae are inside the fruit they can complete their development unaffected by pesticides.

This project was developed to evaluate the role of a pheromone in helping to manage this pest. Pheromones have been developed for a number of insect pests including some of the following moths (Lepidoptera): Oriental fruit moth, Malik et al (1991), Orange tortrix moth, Hill et al (1975) and _Sceliodes cordalis_, Clearwater et al (1986).

The use of pheromones can be of value in a number of ways. As reported by Trammel (1976) he states that there are two major roles for pheromones in orchard pest management. The first is that of a pest population monitoring and assessment and the second as a direct control through disruption of mating process. Suckling et al (1990) also evaluated pheromones as a mating disruption tool in managing resistance and McLaren & Suckling (1993) used pheromones to monitor orchard lepidopterous pests in reducing pesticide useage.

With the development of a specific pheromone for _Sceliodes cordalis_, this would allow us to evaluate its potential in monitoring populations and as a mating disruption process in helping to manage eggfruit caterpillar populations in eggplant crops.

1.2 Objectives of the project.

a) To identify the compounds that make up the eggfruit caterpillar pheromone produced by female moths in attracting male moths for mating. Previous studies in Australia and New Zealand have shown variations in levels of some compounds that make up the pheromone.

b) Evaluate the effectiveness of the artificial lures baited with this pheromone based on the different ratios of these compounds to find a ratio that effectively attracts male moths.

c) Evaluate this artificial pheromone as a mating disruption and as a monitoring tool that could be used in a management program to maximise control options against this pest.

d) Undertake some studies on the biology of the eggfruit caterpillar.

2.0 PHEROMONE DEVELOPMENT

2.1.1 Materials and Methods.

Weekly collections of eggfruit from unsprayed fields of eggplants were returned to the laboratory and cut into quarters. This allowed inspection of the flesh and to collect larvae if they were present. These larvae were removed and held separately in plastic tubes 5.5 cm tall x 4.5 cm wide with a wedge of eggfruit flesh as the food source. A sheet of filter paper, Whatman® number 1, was inserted into the tube to absorb any excess moisture and the food material was changed daily. The lid to these tubes was placed on top without sealing so as to avoid a build up of moisture. The larvae were inspected daily to note signs of pupation. This was recognised by webbing of a cocoon by the larvae. One to two-day old pupa were removed from these tubes and sexed under a microscope. The female pupae were then posted to CSIRO in Canberra.

Development of the pheromone was undertaken by CSIRO. This was developed in two stages. First the pheromone emitted by the newly emerged moths had to be collected and secondly, the identification of the compounds that make up the pheromone had to be made. Identification of the compounds was undertaken using a gas chromatograph-mass spectrometer.

Triangular traps (delta type), 16 cm long with side and base measurements of 9.5 cm made out of wax coated cardboard were used to contain the lures. Both ends of the traps were open. Different ratios of the compounds, 5 : 1 5 : 2 5 : 3 4 : 1 1 : 1, that make up the pheromone were formulated and impregnated into 6mm diameter, sterilised rubber tubing which was cut into 2cm lengths called "baits". The dose rates were 0.025g/metre, 0.375g/metre, 0.5g/metre and 1g/metre. These baits were suspended from the inside middle apex of the trap by wire. The traps were positioned in the field at approximately 1 metre high and this corresponded with the top section of the eggplant crops. To collect the moths when they entered the traps, the base of the trap was smeared with a sticky substance that would render them to the base for counting. These traps were randomly positioned throughout a block of eggplant and the number of moths collected recorded.

2.1.2 Results and Discussion.

The compounds (E) - 11 - hexadecen - 1 - yl acetate and (E) - 11 - hexedecen - 1 - ol were identified in the extracts from the pheromone gland of female *Sceliodes cordalis.* This was similar to that found in New Zealand except that the level of alcohols present were far less than those found in that study. Also there were slight variations in some of the peaks of the different compounds.

From the early development work evaluating the different ratios, the 5:2 collected more moths than the 5:1 ratio, the 1:1 ratio didn't attract many male moths and the 4:1 ratio collect most moths.

3.0 PHEROMONE EVALUATION.

3.1 Pheromone Concentration.

3.1.1 Materials and Methods.

Triangular traps (delta type), 16 cm long with side and base measurements of 9.5 cm made out of wax coated cardboard were used to contain the baits. Both ends of the traps were open. The baits, 2 cm long and made from rubber impregnated with 0.375g/metre or 1.0g/metre pheromone, were suspended from the inside middle apex of the trap by wire. The traps were positioned in the field at approximately 1 metre high and this corresponded with the top section of the eggplant crops. To collect the moths when they entered the traps, the base of the trap was smeared with a sticky substance that would render them to the base for counting.

Virgin females less than one day old were caged in plastic tubes 5 cm long x 2.7 cm wide that had been perforated so as not to restrict air flow. A cotton wick immersed in a sugar solution was attached as a food source. These tubes were suspended in the delta traps (described previously) except instead of the bait being placed in the middle apex of the trap these tubes were substituted. Females were replaced when they died.

Four traps with each of the two pheromone rates and four traps with virgin female moths were randomly set up throughout an unsprayed block of eggplant and counts made every 1 to 3 days over a 25 day period.

3.1.2 Results and Discussions.

In table 1, analyses of the data was made to compare the number of male moths attracted to the traps between two different rates of pheromone and virgin female moths.

Table 1. Mean number of moths/trap collected from virgin female traps and two different rates of pheromone traps.

Treatment	Mean number of moths collected.
No pheromone – Virgin females	0.250 ns
Pheromone concentration 0.375g/metre	0.500 ns
Pheromone concentration 1.0g/metre	2.500 ns
Prob.	0.085

ns = not significantly different.

There were no significant differences between the two pheromone rates or the virgin female moths in attracting male moths to the traps. The higher concentration of pheromone (1.0g/m) did attract an average of 10 times the number of male moths compared to the virgin female traps and 5 times that of the lower pheromone concentration.

As the producers of the pheromone lures cannot guarantee that the 1 metre impregnated rubber strands are uniformly dosed then it is possible that cutting the lures into 2cm lengths could lead to some variation in dosage rates on these pieces. This could account for some of the variability in the number of moths attracted to the pheromone traps. Number of moths collected in this experiment on the same pheromone dose varied from 5 to 0 moths per trap.

3.2 Pheromone versus virgin females.

3.2.1 Materials and Methods.

3.2.1.1 Experiment 1. Virgin females were set up in traps as described under section 3.1.1 and placed randomly throughout crops. These were checked daily for male moth catches.

3.2.1.2 Experiment 2. Virgin females were set up in traps as described under section 3.1.1 and checked daily, for male moth catches. Triangular traps as described in section 3.1.1 and impregnated with 0.375g /metre pheromone, were used as the comparisons. All of these traps were positioned in the crop at plant height and were randomly allocated a position within the crop. The pheromone traps were re-allocated a new position approximately every 25 days. Traps were placed 3m apart. Refer to plan for position of traps.

Plan.

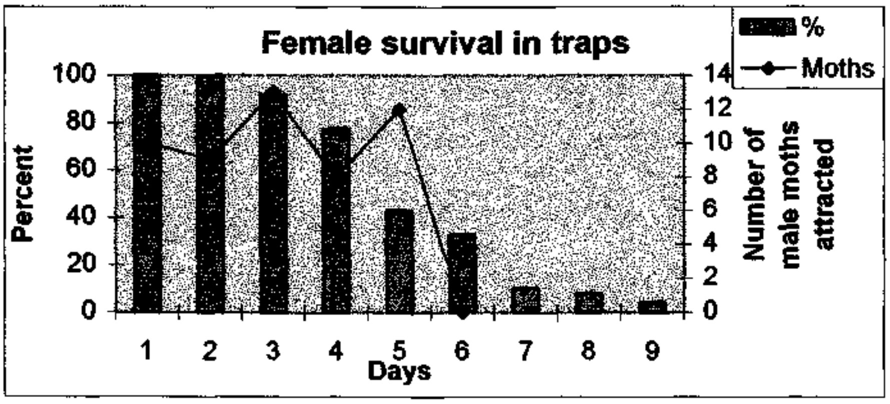
3m ⟶ 3m ⟶

Position 1		4		7
	Female C		Female A	
2		5		8
	Female B		Female D	
3		6		9

3.2.2 Results and Discussions.

3.2.2.1 Experiment 1. Figure 1 shows the percentage survival time (days) of the female moths when placed in these traps and the most attractive time for luring males.

Figure 1. Percent survival of female moths and their attractive period for males, when held in delta traps.



As can be seen from figure 1, over 91% survival occurred past the first three days and tapered from 77.6% in day 4 to 32.7% in day 6. The survival after this time was only for a few individuals.

Male moth catches occurred within the first five days with the majority being trapped at day 3 and day 5. This data confirms that female moths up to an age of 5 days old are the most suitable to use when comparing virgin females to an artificial pheromone in attracting male moths.

3.2.2.2 Experiment 2. Table 2 shows the mean daily average number of male moths attracted to traps and the also the mean daily average number of moths attracted for the different positions within the grid.

Table 2. Mean daily average number of male moths attracted to traps.

Trap or Position number	Mean daily average number of moths collected	
	Trap	Position
1	0.592^{c}	0.383^{c}
2	0.313^{abc}	0.383^{c}
3	0.302^{abc}	0.437^{c}
4	0.440^{bc}	0.253^{abc}
5	0.265^{ab}	0.373^{c}
6	0.510^{bc}	0.257^{abc}
7	0.235^{ab}	0.337^{bc}
8	0.375^{bc}	0.230^{abc}
9	0.341^{bc}	0.317^{bc}
A	0.000^{a}	0.000^{a}
B	0.012^{a}	0.033^{ab}
C	0.000^{a}	0.000^{a}
D	0.000^{a}	0.000^{a}
Prob.	0.001	0.025

Numbers followed by the same letter are not significantly different. P = < 0.05

The results show that trap numbers 1, 4, 6, 8 and 9 collected significantly more male moths than the virgin female baited traps, A, B, C and D. Trap 1 also collected significantly more male moths than traps 5 and 7.

This shows that traps with 0.375g/m pheromone can mask the attractiveness of virgin female moths. Why 4 traps did not have the same significant difference could be due to moth activity or maybe again the unevenness of the dosage impregnated into the rubber.

Trap positions 1, 2, 3 and 5 collected significantly more male moths that all the virgin female trap positions and trap positions 7 and 9 collected significantly more male moths than the virgin female baited trap positions A, C and D.

Except for position 5 the other trap positions were along edges of this grid.

The comparison of the female traps surrounded by pheromone traps in this grid pattern with those in an open block of eggplant in collecting male moths is shown in table 3.

Table 3. Daily average number of moths per trap collected at virgin female traps placed inside an artificial pheromone trapping grid and virgin female traps outside of an artificial pheromone trapping grid.

	Days after set up								
	1	2	3	4	5	6	7	8	9
Inside	.25	0	0	0	0	0			
Out side	0.32	0.29	0.42	0.26	0.39	0	0	0	0

Analyses of the data show a significance difference in that there were more males collected outside the area compared to inside the grid area during the same period.

3.3 Effectiveness of mating disruption dispensers (MD).

3.3.1 Materials and Methods.

Triangular traps as described in section 3.1.1, each loaded with 0.025g/metre of pheromone (bait) were compared to delta traps with 10 cm long rubbers loaded with 0.5g/metre of pheromone (dispensers) used for mating disruption (MD). Lures or baits are used in trap catches whereas mating dispensers are used in disruption processes. The object was to determine if male moths could be prevented from locating a synthetic pheromone baited trap when surrounded by MD dispensers.

In blocks of eggplant, a delta trap containing a pheromone "bait" was surrounded by 8 pheromone "dispensers" (MD traps) placed 1 metre from the pheromone bait trap. These traps were arranged at approximately 7- minute intervals on the circumference around this bait trap. Five sets of these traps were set up at a minimum of 50 metres apart. At the same time five individual traps (bait) were set up within approximately 20 metres from each of these groups.

These traps were monitored for a 5 week period and then replaced with new pheromone baits, dispensers and traps for a further 5 weeks.

3.3.2 Results and Discussion.

In table 4 the difference between the baits and dispensers is shown for two 5 week periods. The analyses were performed on each of these periods as well as the total of the two periods.

Table 4. Mean number of male moths per trap collected over two 5 week periods.

	Week (1 to 5 first period)					Week (1 to 5 second period)					
Trap type	1	2	3	4	5	6	7	8	9	10	Total for periods x 2
MD	.00	.025	.175	.200^{b}	.28	.20	.23	.47	.82	.175	2.58^{b}
Bait	.00	.000	.000	.000^{a}	.00	.20	.00	.20	.40	.000	0.80^{a}
Solo bait	.00	.000	.000	.000^{a}	.40	.20	.60	.80	.80	.400	3.20^{b}
Prob.	NS	NS	NS	.019	NS	NS	NS	NS	NS	NS	0.027

Numbers followed by the same letter are no significantly different. P = < 0.05.

The results show a significant difference between the traps during the 4th. week of the first period and again for the total of the two periods. The dispensers (MD) and the solo bait traps collected significantly more moths than the 'bait' traps surrounded by the dispenser traps. This indicates that the mating disruption dispensers could mask the 'bait' traps.

To show the consistency of the traps over time, analyses of the data was made on splitting it into two sections, weeks 1 to 5 for the first period and weeks 6 to 10 for the second period. The analyses of this data gave no significant difference between the moth catches during the same week periods (1 to 5) after the initial setting up of traps.

4.0 MONITORING.

4.1 Field Populations.

4.1.1 Materials and Methods.

4.1.1.1 Fruit collections. Fruit were regularly collected from crops of unsprayed eggplants. The fruit was returned to the laboratory and cut open from the top of the fruit to the bottom. Each half was then cut in half in the same manner. Damage to the flesh was noted and larvae collected.

4.1.1.2 Moth collections. Collections of moths from pheromone traps over the years has been grouped to show the seasonal pattern of eggfruit caterpillar activity.

4.1.2 Results and Discussions.

4.1.2.1 Fruit collections. In table 5 the results from cutting fruit open over the years 1997 to 1998 is shown. The figures show the number of fruit cut open, the number damaged and the number of larvae found.

Table 5 Amount of damage to eggplant fruit over the years 1997 to 1999 and the number of larvae detected.

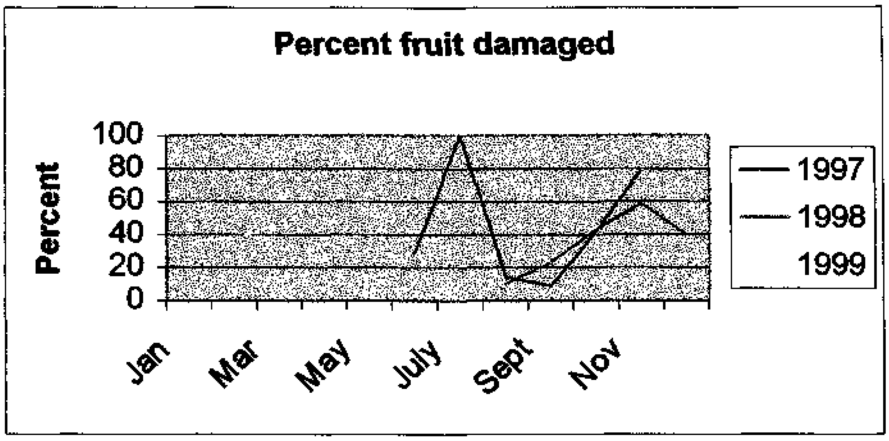
	June – November	**August – December**	**January – March**
	1997	**1998**	**1999**
# fruit cut	2024	2410	2778
Damaged fruit	887*	916	1068
# larvae	887	239	414
% fruit damage	43*	10 – 58	35 – 45
% with larvae	14 – 100	0 – 45	9 – 24

* = Damage based on the number of larvae collected.

The results show that in these unsprayed blocks of eggplant the damage in each of the three years has been averaging approximately 38% though at certain times throughout the year it can be much higher than this figure. Generally only one larvae is found in each fruit and this has been used to calculate the percent damage in the year 1997.

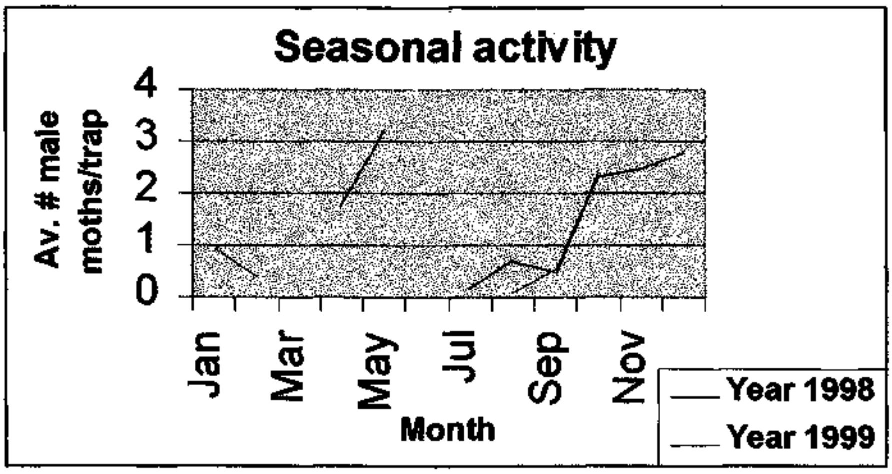
In figure 2, the percent of damaged fruit over the three periods, July to November 1997, August to December 1998 and January to April 1999 is shown. From this figure it can be seen that the highest damage peaks occur during July 1997, decreasing during September and October and again increasing during November. The pattern during the 1998 sampling period appears to mirror that of 1997. The complete seasonal pattern for the whole year is not possible as the main cropping period for this crop is from May/June to November. The sampling period during in the early part of 1999 was from a crop planted out of season which would suggest if cropping was undertaken at this time of the year then it could experience reasonable damage.

Figure 2. Percent of fruit damaged from collections over three years.



4.1.2.2 Moth collections. The collections of moths from traps have been used to indicate times of moth activity throughout the years. The figure may not give a true account of moth activity as counts have been from different lure strengths and averaged for the years. In 1997 there are no records as this was the period when the pheromones were being developed. In figure 3 the seasonal activity of male moths generated from this data is shown.

Figure 3. Seasonal pattern of male eggfruit caterpillar activity.



Although there are a number of gaps within the data due to the non-continuous planting of eggplant crops hence no traps, a guide can be taken through the 1998 data that show population trends.

In combining the data from the fruit damage and the moth activity and allowing approximately 4 weeks development time for each eggfruit caterpillar generation the following should have occurred. As the insect population increased around the May/June period the increase in fruit damage occurs around the June/July period. This relationship does show up when looking at figure 3 and figure 2 for the year1998. In the July/August period the flight activity was low and this corresponds with low damage in the August/September period. Again in the August/September period flight activity was low though rising and this corresponds to increasing fruit damage during September/October. As the moth numbers increased in the traps during September to December this related to a major increase in damage for the same period. Incomplete data for 1999 does not allow confirmation of the data for 1998.

4.2 Trap Populations.

4.2.1 Materials and Methods.

Triangular traps (delta type), 16 cm long with side and base measurements of 9.5 cm made out of wax coated cardboard were used to contain the baits. Both ends of the traps were open. The baits, 2 cm long and made from rubber impregnated with 0.025g/metre of pheromone, were suspended from the inside middle apex of the trap by wire. The traps were positioned in the field at approximately 1 metre high and this corresponded with the top section of the eggplant crops. To collect the moths when they entered the traps, the base of the trap was smeared with a sticky substance that would render them to the base for counting.

4.2.1.1 Experiment 1. Delta traps were set up in a fruiting block, 60m x 10 rows of eggplant, in a grid pattern as detailed in plan 1 during April 1998. Traps were placed equal distance along rows 1 and 10 with the middle traps between rows 5 and 6. Traps were re-positioned approximately every 7 days and replaced with new lures on the 1st. May 1998.

PLAN 1

position 1	to	position 6
position 7	to	position 12
position 13	to	position 18

← 60 m →

4.2.1.2 Experiment 2. Delta traps were set up in a fruiting block, 60m x 10 rows of eggplant in a grid pattern as detailed in plan 2 during May 1998. Traps were placed equal distance along the outside rows. Traps were re-positioned on the 11th, 18th and 26 May 1998.

4.2.1.3 Experiment 3. Delta traps were set up in a fruiting block, 60m x 10 rows of eggplant in a grid pattern as detailed in plan 2 during July 1998. Traps were placed equal distance along the outside rows. Traps were re-positioned on the 16th July and 17th August 1998.

PLAN 2

position 1	to	position 6
position 7	to	position 12

← 60 m →

4.2.1.4 Experiment 4. Delta traps were set up in a fruiting block, 60m x 10 rows of eggplant in a grid pattern as detailed in plan 3 during October 1998. Traps were placed equal distance along the outside rows with one trap placed between the middle rows at each end of the block.

PLAN 3

position 1	to	position 6
position 7		position 8
position 9	to	position 14

← 60 m →

4.2.1.5 Experiment 5. Delta traps were set up in a fruiting block, 60m x 10 rows of eggplant in a grid pattern as detailed in plan 2 during November 1998. Traps were placed equal distance along the outside rows.

4.2.1.6 Experiment 6. Delta traps were set up in a fruiting block, 60m x 10 rows of eggplant in a grid pattern as detailed in plan 2 during November 1998. Traps were placed equal distance along the outside rows.

4.2.2 Results and Discussion

4.2.2.1 Experiment 1. The results from experiment 1 are shown in tables 6 and 7. The analyses for comparing trap differences is based on daily average number of moths collected.

Table 6. Mean daily average number of moths collected from each of 18 traps during April 1998.

Trap or position number.	**Daily average number of moths collected between 7/4/98 and 30/4/98.**	
	Trap	Position
1	0.000^{a}	0.188
2	0.000^{a}	0.438
3	0.143^{ab}	0.400
4	0.000^{a}	0.000
5	0.071^{ab}	0.125
6	0.036^{ab}	0.263
7	0.321^{bc}	0.100
8	0.321^{bc}	0.075
9	0.036^{ab}	0.250
10	0.571^{c}	0.087
11	0.107^{ab}	0.122
12	0.286^{abc}	0.025
13	0.000^{a}	1.075
14	0.071^{ab}	0.263
15	0.250^{ab}	0.025
16	0.000^{a}	0.063
17	0.000^{a}	0.000
18	0.000^{a}	0.125
Prob.	0.002	0.635

Numbers followed by the same letter are no significantly different. $P = <0.05$

There was no significant difference between moth catches in anyone position of the grid. There were significant differences between traps in collecting moths. Traps 10, 7 and 8 caught significantly more moths than traps 1, 2, 4, 13, 16 and 17. Trap 10 also caught significantly more moths than traps 9, 6, 5, 14, 11, 3 and 15. This could be due to the variation in dosing 1 metre lengths of rubber used to contain the pheromone.

Table 7. Mean daily average number of moths collected from each of 18 traps during May 1998.

Trap or position number.	**Daily average number of moths collected between 1/5/98 and 6/5/98.**	
	Trap	Position
1	0.000^{a}	0.000
2	0.100^{a}	0.500
3	0.300^{a}	2.500
4	0.100^{a}	0.500
5	0.100^{a}	1.000
6	0.100^{a}	1.000
7	0.000^{a}	3.000
8	1.100^{b}	6.000
9	0.000^{a}	0.500
10	0.100^{a}	6.000
11	0.000^{a}	1.000
12	0.100^{a}	2.500
13	0.000^{a}	0.000
14	0.200^{a}	1.500
15	0.100^{a}	3.000
16	0.000^{a}	0.000
17	0.000^{a}	0.000
18	0.000^{a}	0.000
Prob.	<.001	0.253

Numbers followed by the same letter are no significantly different. $P = <0.05$

Again there were no significant differences in moth catches in anyone position of the grid. The only significant difference in trap catches was with trap 8 that collected more moths than any of the other traps.

4.2.2.2 Experiment 2.

Table 8. Mean daily average number of moths collected from each of 12 traps during May 1998.

Trap or position number.	**Daily average number of moths collected between 8/5/98 and 27/5/98.**	
	Trap	Position
1	0.042[a]	0.443
2	0.333[a]	0.592
3	0.028[a]	0.042
4	0.167[a]	0.125
5	0.277[a]	0.025
6	0.312[a]	0.143
7	0.146[a]	0.125
8	0.048[a]	0.318
9	0.042[a]	0.068
10	1.597[b]	0.042
11	0.194[a]	0.318
12	0.194[a]	0.650
Prob.	< .001	0.283

Numbers followed by the same letter are no significantly different. P = <0.05

As with the previous experiments there were no significant differences between moth catches for anyone position in the grid. Trap 10 caught significantly more moths than all the other traps.

4.2.2.3 Experiment 3.

Table 9. Mean daily average number of moths collected from each of 12 traps during July to October 1998.

Trap or position number.	**Daily average number of moths collected between 13/7/98 and 14/10/98.**	
	Trap	Position
1	0.040	0.094
2	0.020	0.022
3	0.010	0.023
4	0.057	0.040
5	0.204	0.006
6	0.161	0.006
7	0.129	0.081
8	0.236	0.006
9	0.029	0.046
10	0.060	0.079
11	0.020	0.113
12	0.103	0.040
Prob.	0.096	0.581

Numbers followed by the same letter are no significantly different. P = <0.05

There were no significant differences in moth catches between traps or in trap position.

4.2.2.4 Experiment 4.

Table 10. Mean daily average number of moths collected from each of 12 traps during October and November 1998.

Trap or position number.	**Daily average number of moths collected between 19/10/98 and 23/11/98.**	
	Trap	Position
1	0.000^{a}	0.077^{ab}
2	0.076^{ab}	0.077^{ab}
3	0.077^{ab}	0.622^{d}
4	0.414^{cd}	0.372^{bcd}
5	0.077^{ab}	0.378^{bcd}
6	0.378^{bcd}	0.102^{abc}
7	0.228^{abc}	0.025^{a}
8	0.256^{abc}	0.228^{abc}
9	0.102^{abc}	0.202^{abc}
10	0.025^{a}	0.262^{abc}
11	0.262^{abc}	0.000^{a}
12	0.202^{abc}	0.076^{ab}
13	0.622^{d}	0.414^{cd}
14	0.372^{bcd}	0.256^{abc}
Prob.	0.005	0.005

Numbers followed by the same letter are no significantly different. P = <0.05

Trap in position 3 collected significantly more moths than traps in all of the other positions except traps in positions 4, 5 and 13. Traps in positions 4, 5 and 13 collected significantly more moths than traps in positions 7 and 11 and trap in position 13 also collected significantly more moths than traps in positions 1, 2 and 12.

Traps 4 and 13 collected significantly more moths that traps 1, 2, 3, 5 and 10 while trap 13 also collected significantly more moths than traps 7, 8, 9, 11 and 12. Traps 6 and 14 collected significantly more moths than traps 1 and 10.

4.2.2.5 Experiment 5.

Table 11. Mean daily average number of moths collected from each of 12 traps during November 1998 and January 1999.

Trap or position number.	**Daily average number of moths collected between 24/11/98 and 7/01/99.**	
	Trap	Position
1	0.130^{abc}	0.553^{de}
2	0.028^{ab}	0.372^{bcd}
3	0.118^{abc}	0.028^{ab}
4	0.097^{abc}	0.008^{a}
5	0.388^{cd}	0.153^{abc}
6	0.153^{abc}	0.130^{abc}
7	0.553^{de}	0.208^{abcd}
8	0.008^{a}	0.070^{abc}
9	0.208^{abcd}	0.097^{abc}
10	0.070^{abc}	0.772^{e}
11	0.372^{bcd}	0.118^{abc}
12	0.772^{e}	0.388^{cd}
Prob.	< .001	< .001

Numbers followed by the same letter are no significantly different. P = <0.05

Traps in positions 1 and 10 collected significantly more moths than traps in positions 3, 4, 5, 6, 8, 9 and 11 while the trap in position 10 also collected significantly more moths than traps in positions 2, 7 and 12. Traps in positions 2 and 12 collected significantly more moths than the trap in position 4 while the trap in position 12 also collected significantly more moths than the trap in position 3.

Traps 7 and 12 collected significantly more moths that traps 1, 2, 3, 4, 6, 8 and 10 while trap 12 also collected significantly more moths than traps 5, 9 and 11. Traps 5 and 11 collected significantly more moths than trap 8 while trap 5 also collected significantly more moths than trap 2.

4.2.2.6 Experiment 6.

Table 12. Mean daily average number of moths collected from each of 12 traps during November 1998 and January 1999.

Trap or position number.	**Daily average number of moths collected between 24/11/98 and 7/01/99.**	
	Trap	Position
1	0.030	0.050
2	0.050	0.066
3	0.014	0.027
4	0.073	0.000
5	0.000	0.093
6	0.027	0.000
7	0.000	0.099
8	0.099	0.000
9	0.000	0.030
10	0.000	0.099
11	0.093	0.014
12	0.066	0.073
Prob.	0.307	0.307

Numbers followed by the same letter are no significantly different. $P = <0.05$

There were no significant differences in moth catches between traps or trap positions.

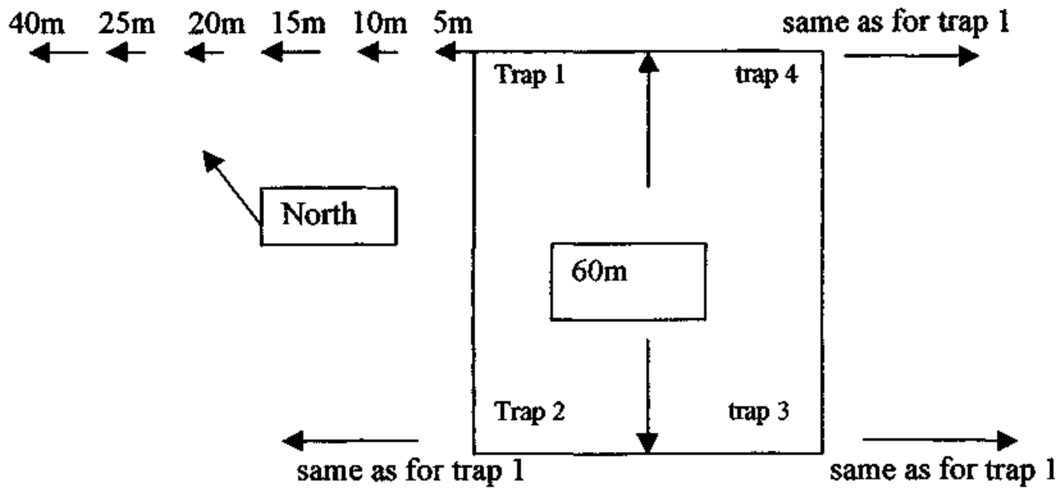
Generally there was no particular position of a trap that collected more moths throughout the different grid patterns. This could suggest that the flights of the moths were at random throughout these experiments and that the other trials looking at mating disruption and pheromone evaluation would not have been affected by the position of the trap in comparing results. The variation between traps could be due to the variation in the inability to evenly dose 1 metre lengths of rubber used to contain the pheromone.

4.3 Distance trial.

4.3.1 Materials and Methods.

Triangular traps, as described previously in section 3.1.1 and impregnated with 0.025g/m pheromone, were placed in the vicinity of each corner of a block of eggplant measuring 60 m x 12 row as shown in the plan. The traps were placed at approximately 1m above ground height and this was near the top of plant height. Traps were positioned at each of 5, 10, 15, 20, 25 and 40 metres set distances along the two edges of the crop for a period of time. Counts of moths were made daily and the traps moved a further 5 metres apart until the last move of 15 metres.

PLAN



Traps were placed at the north, trap 1; north-west, trap 2; south, trap 3 and east, trap 4 of a block of eggplant.

4.3.2 Results and Discussions.

In table 13 the results are given for the daily average number of moths collected at each of the four traps over the different distances from the crop.

Table 13. Daily average number of moths collected at different distances from a eggplant crop.

Distance from crop.	**Daily average number of moths collected.**			
	Trap 1.	Trap 2.	Trap 3.	Trap 4.
5 metres	0	0	0	0
	0	0.2	0	0.8
	0	0	0	1.0
10 metres	0	0	0	0
	0	0	0	2.0
15 metres	0	1.0	0.33	0.33
20 metres	0.5	0	0.5	0.5
25 metres	1.0	0	0	0
	2.0	1.0	6.0	0
40 metres	0	0	0	0

The results show that male moths could be collected up to a distance of 25 metres from a crop of eggplant. As the collection at this distance occurred at the same time at three points, it could be assumed that the moths were attracted and not on the wing flying with the breeze from one direction.

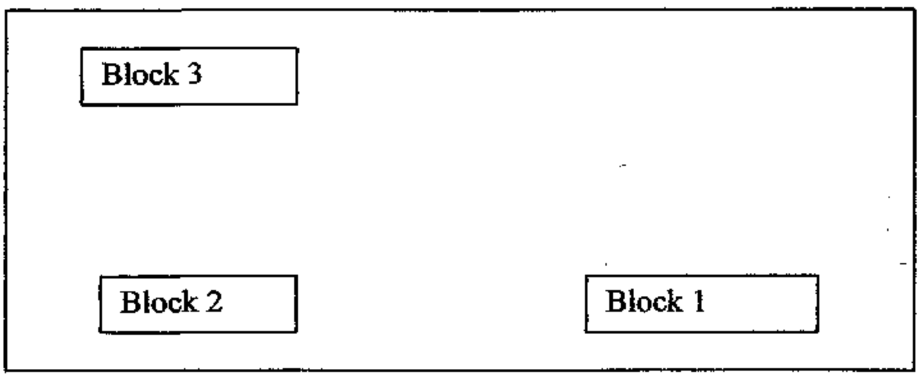
5. MATING DISRUPTION.

5.1 Materials and Methods.

Three blocks, each 60 metres long by 10 rows of fruiting eggplant, separated by a minimum of 50 metres from each other were allocated a grid pattern of 5, 10 or nil traps (refer to plan 1). Traps were placed in a grid pattern in blocks 1 and 3 as shown in the plans 2 and 3.

Triangular traps (delta type), 16 cm long with side and base measurements of 9.5 cm made out of wax coated cardboard were used to contain the baits. Both ends of the traps were open. The baits, 2 cm long and made from rubber impregnated with 0.025g/metre of pheromone, were suspended from the inside middle apex of the trap by wire. The traps were positioned in the field at approximately 1 metre high and this corresponded with the top section of the eggplant crops. To collect the moths when they entered the traps, the base of the trap was smeared with a sticky substance that would render them to the base for counting. Baits and traps were replaced after approximately 4 weeks.

Plan 1. Area showing the different blocks.



Plan 2. Block 1 showing traps on a 5 metre grid pattern.

trap 1	to	trap13
trap 14	to	trap 26
trap 27	to	trap 39
trap 40	to	trap 52

← 60 metres →

Plan 3. Block 3 showing traps on a 10 metre grid pattern.

trap 1	to	trap 7
trap 8	to	trap 14
trap 15	to	trap 21

← 60 metres →

5.2 Results and Discussions.

Analyses of the data comparing the differences in reducing fruit damage between traps placed on a 5 metre (block 1) and a 10 metre (block 3) grid and nil traps per block gave the following results. In block 1, the number of moths collected was not significantly different between the 52 traps within the block. In block 3 there was a significant difference between the traps during the first trapping period but not in the second, this is shown in table 14.

Table 14. Mean daily average number of moths collected over two trapping periods for 21 traps.

	Trapping period	
Trap number	**4/8/99 to 10/9/99**	**10/9/99 to 29/10/99**
1	0.000^{a}	0.156
2	0.000^{a}	0.118
3	0.000^{a}	0.000
4	0.000^{a}	0.102
5	0.000^{a}	0.086
6	0.000^{a}	0.032
7	0.000^{a}	0.018
8	0.000^{a}	0.102
9	0.000^{a}	0.183
10	0.026^{ab}	0.181
11	0.104^{c}	0.045
12	0.000^{a}	0.114
13	0.000^{a}	0.081
14	0.028^{ab}	0.047
15	0.026^{ab}	0.170
16	0.000^{a}	0.181
17	0.000^{a}	0.063
18	0.026^{ab}	0.018
19	0.000^{a}	0.072
20	0.000^{a}	0.039
21	0.062^{bc}	0.036
Prob.	< .001	0.513

Numbers followed by the same letter are no significantly different. P = <0.05

During the first trapping period, trap number 11 and 21 collected significantly more moths than the other traps except trap number 21 and traps 10, 14, 15 and 18 respectively. This is again probably due to the inability to accurately impregnate an even dose into the 1 metre lengths of rubber which carry the pheromone. In the second lot of traps there were no significant differences between traps in collecting moths.

Figure 5. Average number of moths collected per trap /day with the percent fruit damaged in block 1.

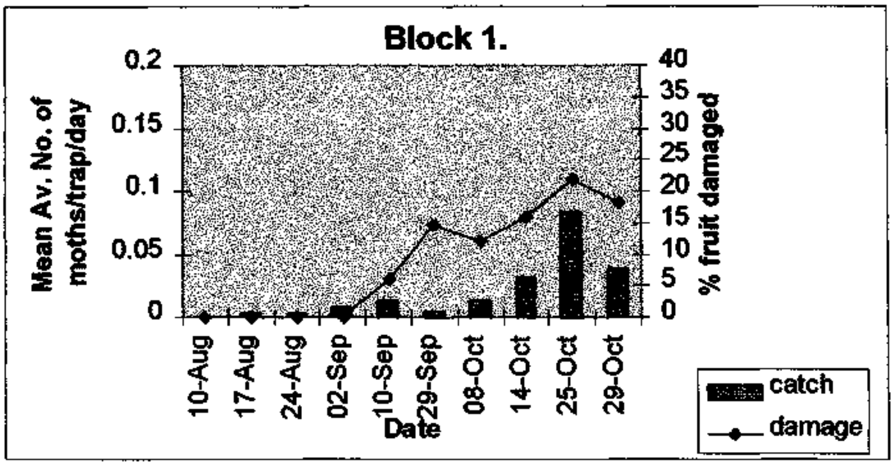
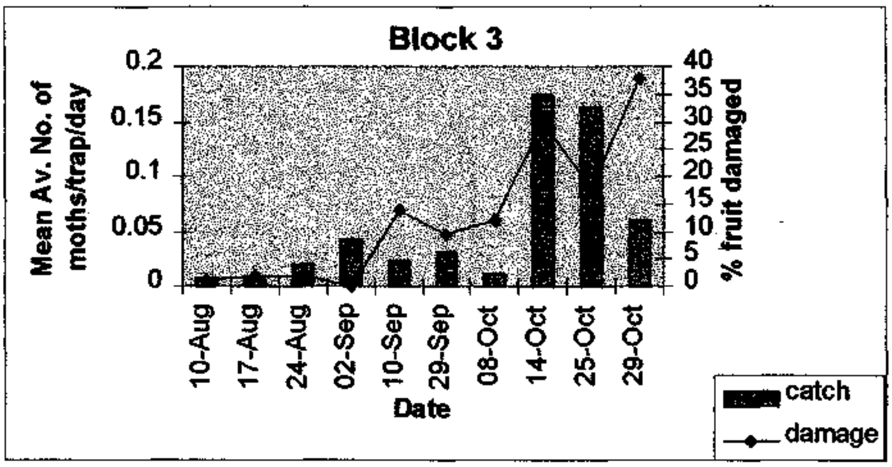


Figure 6. Average number of moths collected per trap /day with the percent fruit damaged in block 3



This data supports the results in the monitoring of populations where an increase in damage follows a rise in moth collections from traps.

Comparing the three blocks for fruit damage there was no significant difference between them but the percent of fruit damaged is increasing as the season continued.

Results comparing the different density of traps (moth collections) within the three blocks is shown in table 15 along with the percent of fruit damaged. There were significantly more moths collected from the 10 metre grid pattern compared to the 5 metre grid pattern. There was no significant difference between the amount of fruit damaged in the three blocks although the higher density of traps (block 1) had less damaged fruit than traps on the 10m grid and the nil trap blocks. Traps on the 10 metre grid also had less damage than the nil trapped block (block 2).

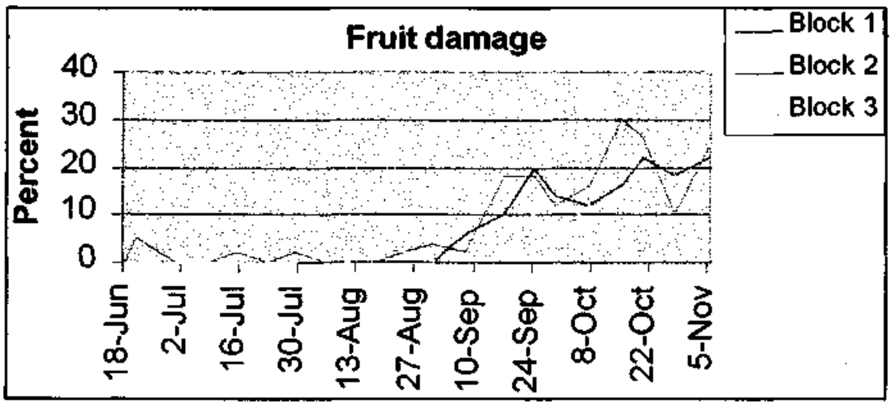
Table 15. Mean average number of moths collected per trap per day and percent of total fruit damaged.

	Block 1	Block 2	Block 3	Prob.
Mean average number of moths per trap per day.	0.00518[a]		0.02024[b]	0.044
Percent of total fruit damaged	14.72	17.72	16.99	

Numbers followed by the same letter are no significantly different. $P = <0.05$.

Figure 4 shows the trend in the amount of damaged fruit between the three blocks over the trapping period.

Figure 4. Percent fruit damaged from a 5 metre trapping grid (block 1), a 10 metre trapping grid (block 3) and a third block (block 2) with no traps.



The block with no pheromone traps present contained damage fruit from early in the sampling whereas in both the pheromone blocks fruit damage was not recorded until 6.5 weeks later. The number of fruit damaged in all blocks increased over time.

Looking at the trapped blocks, figures 5 and 6, it can be seen that as the number of moths collected increases, it corresponds with an increase in the percent fruit damage.

6, Biology

6.1 Egg and larva development.

6.1.1 Materials and Methods.

6.1.1.1 Egg development. Adult moths were held in circular cages measuring 20cm diameter x 30cm tall. A cotton wick was partly submersed in a saturated solution of sugar in water as a food source. Strips of paper were suspended from the top of these cages for the moths to lay eggs on. These strips were removed daily and the eggs on paper removed.

6.1.1.1.1 Experiment 1. Twenty-five eggs on paper were placed on moistened filter paper and held in a petri dish. One petri dish was placed in each chamber of a multi-temperature incubator with a range of temperatures from 40 ^{0}C to 10 $^\circ$ C. Larval emergence was recorded each day.

6.1.1.1.2 Experiment 2. Eighteen eggs were set up as described for experiment 1.

6.1.1.2 Larval development.

6.1.1.2.1 Fresh food diet. Newly emerged larvae were placed on eggfruit slices (approximately 2mm thick) which were positioned on top of moistened filter paper and held in petri dishes. Two larvae were placed in each petri dish. Daily records were kept and the food was changed every two days except in the higher temperatures when it was necessary to change the food daily due to mould development. Larvae were moved onto the fresh food at each change.

6.1.1.2.2 Artificial diet. An artificial diet was developed using dried eggfruit powder, yeast, wheat germ and preservatives mixed with agar. This was poured into 29.5ml plastic cups and two larvae placed on top of the cooled mixture. A perforated lid was placed on top to prevent escaping of the larvae. Enough food (approximately 15mls) was supplied for larvae to complete development without the need to add more diet.

6.1.2 Results and Discussions.

6.1.2.1 Egg development.

6.1.2.1.1 Experiment 1. From table 16 the survival of eggs to larvae emergence over the different temperatures is shown.

Table 16. Percent emergence of eggs over 10 controlled temperature regimes.

Temperature	Days to 100% emergence
39.94	Nil Emergence
36.65	3
33.21	3
29.97	3
27.34	4
24.7	5
22.06	6
19.38	9
16.66	16
13.56	Nil Emergence

To show the relationship between development and temperature a nonlinear regression analyses was performed on the data. The results are given in table 17 and figure 7 shows the relationship.

Table 17. Nonlinear regression analyses table on egg development.

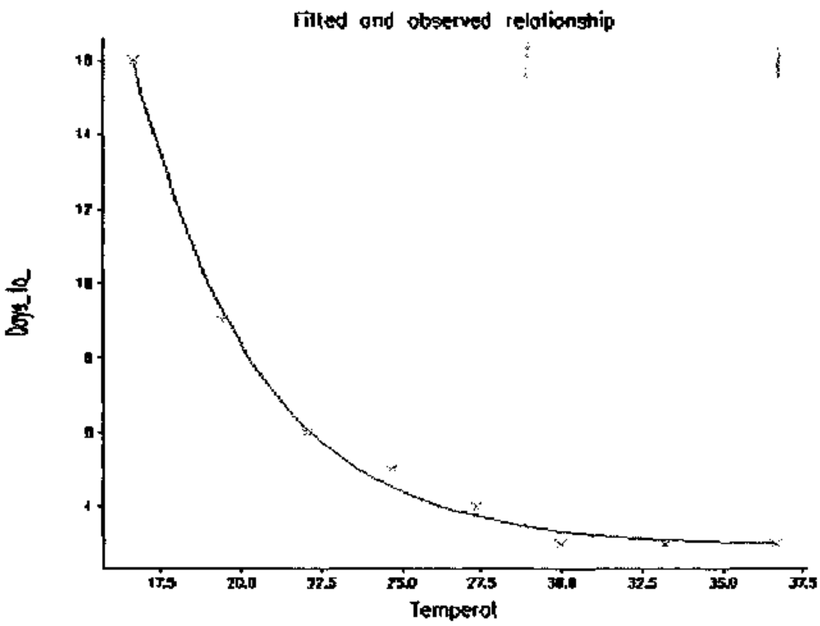
	Degrees of Freedom	Sums of Squares	Mean square	Variance Ratio	F
Regression	2	140.3389	70.1694	654.44	<0.001
Residual	5	0.5361	0.1072		
Total	7	140.8750	20.1250		

Response variate: Days_to_100% emergence.
Explanatory: Temperature.
Fitted Curve: A + B*R**X
Constraints: R < 1
Percentage variance accounted for 99.5
Standard error of observations is estimated to be 0.327

Estimates of parameters

	Estimate	S. E.
R	0.7684	0.0139
B	1042	314
A	2.955	0.209

Figure 7. Fitted and observed relationship between days to 100% emergence and temperature.



6.1.2.1.2 Experiment 2. From table 18 the survival of eggs to larvae emergence over the different temperatures is shown.

Table 18. Percent emergence of larvae over 10 controlled temperature regimes.

Temperature	Days to 100% emergence
40.19	Nil Emergence
36.96	3
33.6	3
30.38	3
27.88	4
24.96	5
22.24	6
19.5	9
16.66	16
13.56	Nil Emergence

To show the relationship between development and temperature a nonlinear regression analyses was performed on the data. The results are given in table 19 and figure 8 shows the relationship.

Table 19. Nonlinear regression analyses table on egg development.

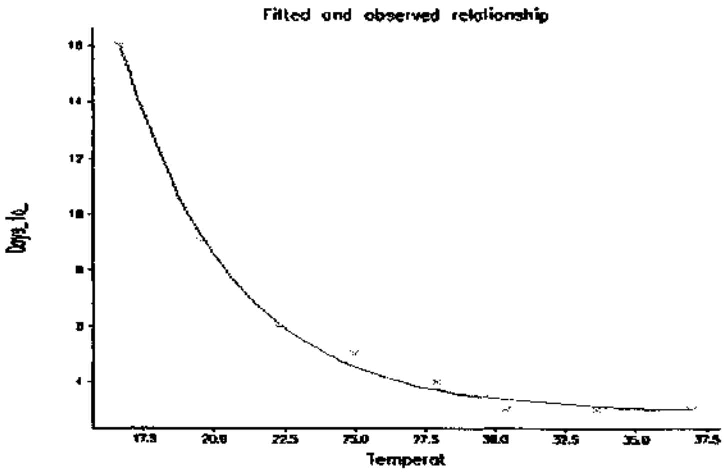
	Degrees of Freedom	Sums of Squares	Mean square	Variance Ratio	F
Regression	2	140.3428	70.1714	659.27	<0.001
Residual	5	0.5322	0.1064		
Total	7	140.8750	20.1250		

Response variate: Days_to 100% emergence.
Explanatory: Temperature.
Fitted Curve: A + B*R**X
Constraints: R < 1
Percentage variance accounted for 99.5.
Standard error of observations is estimated to be 0.326.

Estimates of parameters

	Estimate	S. E.
R	0.7760	0.0135
B	886	256
A	2.949	0.210

Figure 8. Fitted and observed relationship between days to 100% emergence and temperature.



The results for both of these experiments show that there is a strong relationship in egg development between days to emerge and temperature.

6.1.2.2 Larval development.

6.1.2.2.1 Fresh food diet. In table 20, the survival of larvae through 10 different temperatures is given. The first 10 days are tabled followed by multiples of 5 days until the 30th day. Between the 30th day and 60th day the interval has been increased to 10 days.

Table 20. Percent survival of larvae fed on fresh eggfruit through a range of temperatures.

Days	Temperature									
	12.5	15.7	19.1	22.2	25.1	28.2	31.1	34.2	37.5	40.6
1	90	80	90	85	95	85	76	67	57	27
2	90	80	85	85	95	77	65	62	50	7
3	90	75	85	85	95	69	61	57	46	3
4	75	65	70	65	65	54	59	53	46	0
5	65	55	55	50	65	54	56	53	37	
6	50	45	45	45	65	54	56	50	33	
7	35	40	45	45	60	54	50	40	27	
8	25	30	45	45	55	46	47	30	23	
9	25	30	45	45	55	42	41	17	23	
10	20	30	45	45	55	42	32	13	17	
15	10	25	35	35	35	27	9	3	17	
20	10	25	35	15	15	15	9	3	10	
25	10	25	35	10	10	8	9	0	0	
30	10	25	35	0	0	8	0			
40	5	10	20			0				
50	0	10	5							
60		0	0							

As can be seen from this table the survival of larvae on the fresh food diet can extend up to 50 days in the low temperature and they do not survive pass day 3 in the high temperature (40.6°C). At day 5 the survival is higher than 50% for all temperatures except at the two high temperatures and at day 10 the survival has dropped below 50% except at temperature 25°C. After day 15 the survival between the different temperatures is affected by adult emergence refer to table 21.

Table 21. Development time (days) for larvae to reach a pre-pupal, pupal and adult stage.

Temperature	Pre-pupa	Pupa	Adult
12.5	Nil	Nil	Nil
15.7	50	Nil	Nil
19.1	30	Nil	Nil
22.2	23.3	25	35
25.1	13.3	19	25
28.2	13.5	15.7	20
31.1	10.7	10.5	17
34.2	7.5	8.5	13
37.5	8.5	10.3	16
40.6	Nil	Nil	Nil

From table 21 it shows that no pre-pupa developed in the low temperature or high temperature and no pupa or adults developed in the next two low temperatures.

Analyses of the development time for each of these stages is given in tables 22, 23 and 24.

Table 22. Non linear regression analyses table for pre-pupa.

	Degrees of Freedom	Sums of Squares	Mean Square	Variance Ratio	F
Regression	2	1456.34	728.168	236.36	<0.001
Residual	5	15.40	3.081		
Total	7	1471.74	210.249		

Response variate: Days to reach pre-pupa.
Explanatory: Temperature.
Fitted curve: A + B*R**X
Constraints: R < 1
Percentage variance accounted for 98.5.
Standard error of observations is estimated to be 1.76.

Estimates of parameters.

	Estimate	SE
R	0.8438	0.0178
B	616	199
A	6.99	1.53

Figure 9. Fitted and observed relationship between days to pre-pupa and temperature.

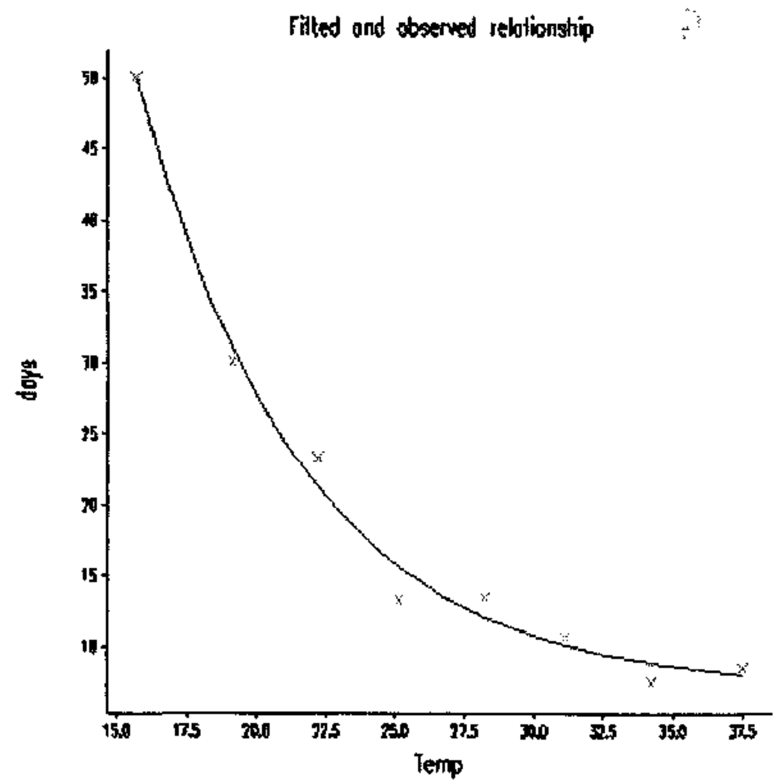


Table 23. Non linear regression analyses table for pupa.

	Degrees of Freedom	Sums of Squares	Mean Square	Variance Ratio	F
Regression	2	193.051	96.526	36.83	0.008
Residual	3	7.862	2.621		
Total	5	200.913	40.183		

Response variate: Days to reach pupa.
Explanatory: Temperature.
Fitted curve: A + B*R**X
Constraints: R < 1
Percentage variance accounted for 93.5.
Standard error of observations is estimated to be 1.62.

Estimates of parameters.

	Estimate	SE
R	0.8591	0.0544
B	530	688
A	7.06	3.03

Figure 10. Fitted and observed relationship between days to pupa and temperature.

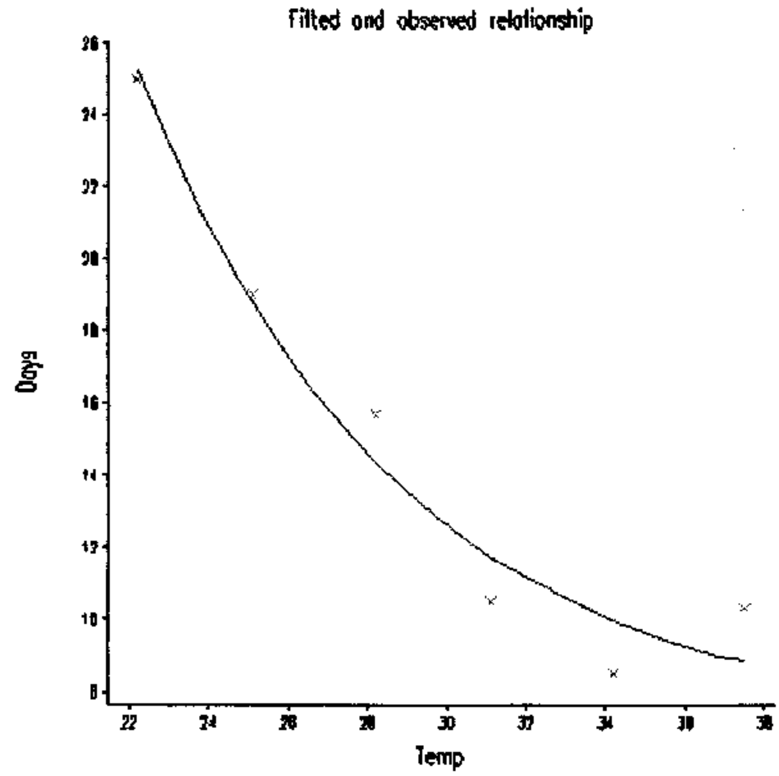


Table 24. Non linear regression analyses table for adults.

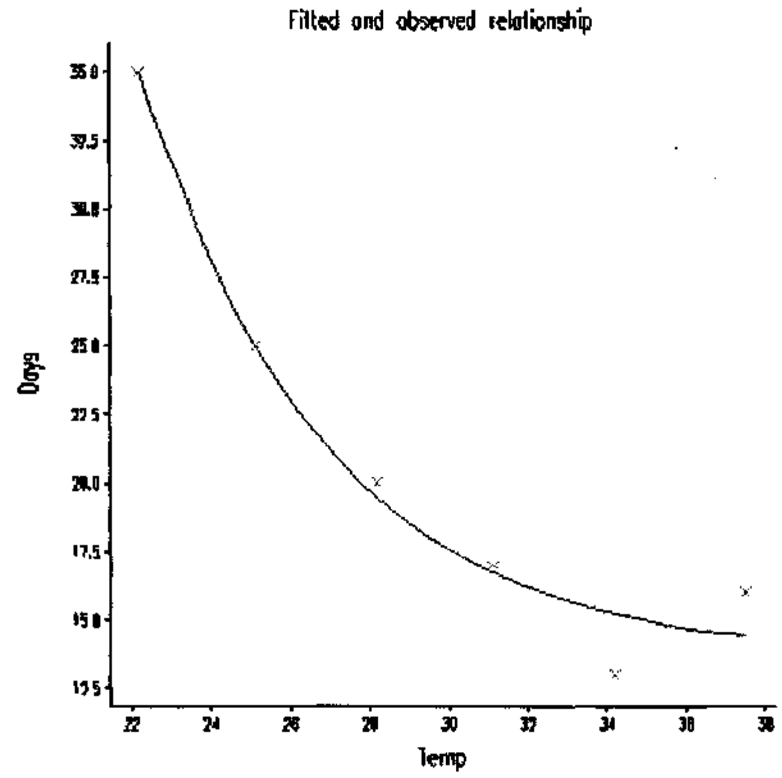
	Degrees of Freedom	Sums of Squares	Mean Square	Variance Ratio	F
Regression	2	310.182	155.091	59.51	0.004
Residual	3	7.818	2.606		
Total	5	318.000	63.600		

Response variate: Days to reach adult.
Explanatory: Temperature.
Fitted curve: A + B*R**X
Constraints: R < 1
Percentage variance accounted for 95.9.
Standard error of observations is estimated to be 1.61.

Estimates of parameters.

	Estimate	SE
R	0.8042	0.0475
B	2669	3437
A	13.68	1.81

Figure 11. Fitted and observed relationship between days to adult and temperature.



6.1.2.2.2 Artificial diet. In table 25, the survival of larvae through 10 different temperatures is given. The first 10 days are tabled followed by multiples of 5 days until the 30^{th} day. Between the 30^{th} day and 60^{th} day the interval has been increased to 10 days.

Table 25. Percent survival of larvae fed an artificial diet through a range of temperatures.

Days	**Temperature**									
	12.5	**15.7**	**19.1**	**22.2**	**25.1**	**28.2**	**31.1**	**34.2**	**37.5**	**40.6**
1	59	47	62	47	41	34	41	25	6	0
2	44	41	62	47	37	34	34	25	6	
3	44	41	56	41	34	28	34	25	5	
4	44	41	37	37	22	25	19	25	5	
5	44	37	34	37	22	25	19	25	5	
6	41	37	34	37	16	25	19	25	5	
7	38	37	34	32	16	16	16	25	3	
8	38	37	34	32	16	16	13	25	3	
9	31	34	22	25	16	16	13	25	3	
10	28	34	22	25	9	16	13	25	3	
15	22	19	12	13	9	13	13	19	3	
20	9	6	9	6	9	9	9	6	3	
25	0	0	3	3	6	3	3	0	3	
30			3	3	6	0	0		0	
40			0	3	6					
50				0	0					
60										

Comparing the two diets (fresh material and artificial diet) there was a higher survival rate on the fresh food during the first 5 days but after this period there is only a slight difference between the diets though less completed development on the artificial diet compared to the fresh food.

The following figures 12 to 21 show the percent survival of larvae for the fresh food and artificial diets at different temperatures.

Figure 12.

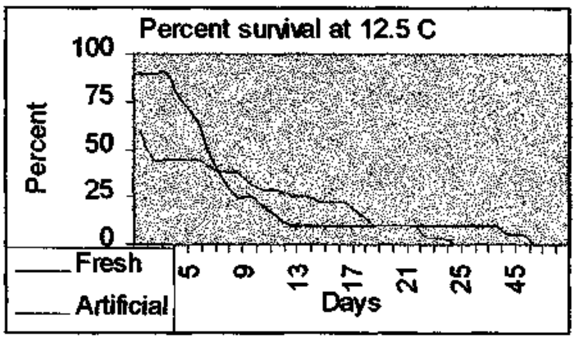


Figure 13.

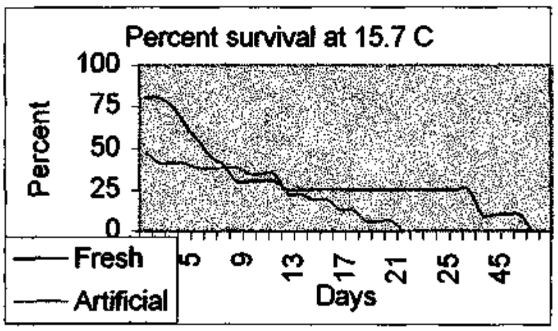


Figure 14.

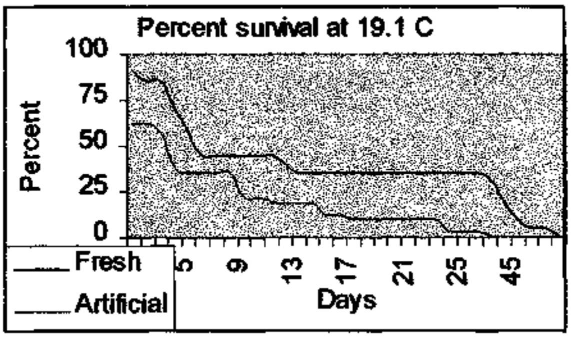


Figure 15.

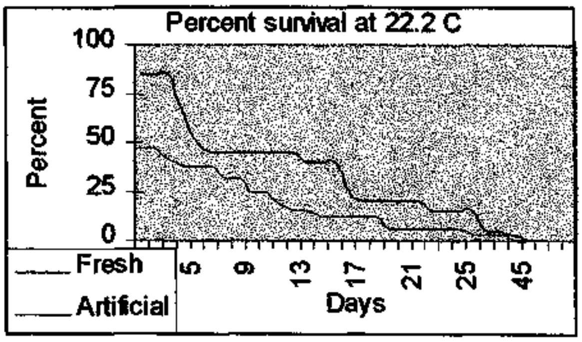


Figure 16.

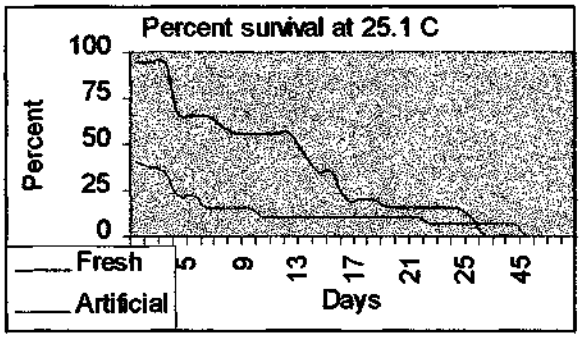


Figure 17.

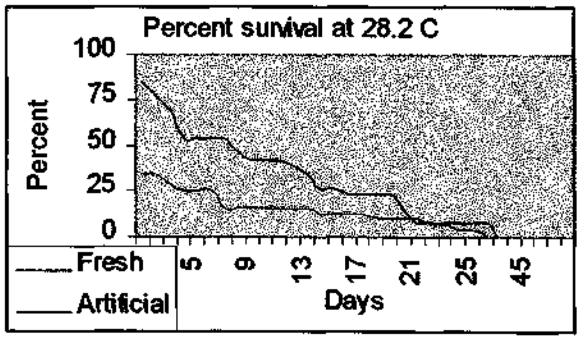


Figure 18.

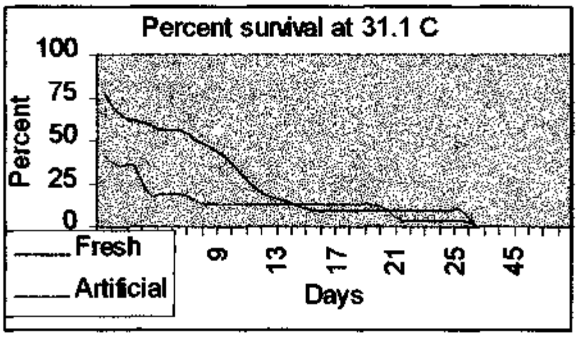


Figure 19.

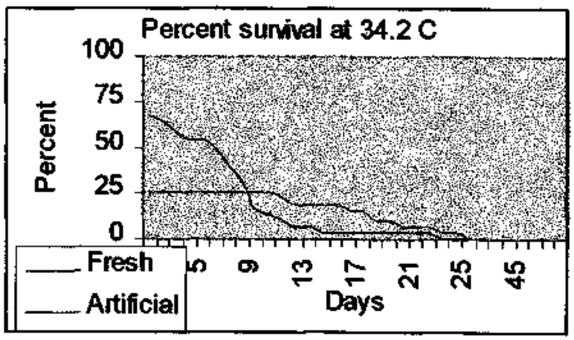


Figure 20.

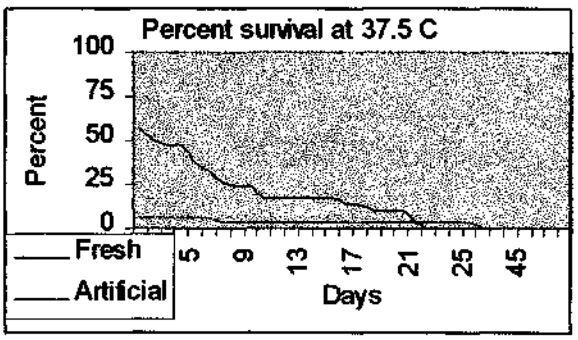
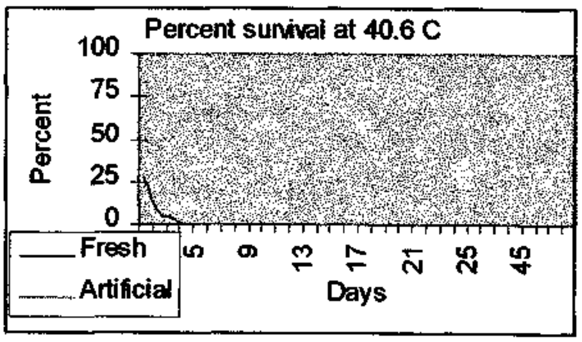


Figure 21.



The survival on the artificial diet was not as good as the fresh food diet. Although the survival was low, this was an early attempt at artificial diets with eggfruit caterpillar and with modifications it may be possible to improve this survival.

6.2 Parasite records.

6.2.1 Materials and Methods.

Collections of all larvae from the field that were held in the laboratory for other studies were always observed for parasite emergence.

6.2.2 Results and Discussions.

Following extensive sampling of fruit and collection of larvae from these fruit we have not found any parasites of this pest. In table 26 the sampling periods and results of holding larvae for parasite emergence is shown.

Table 26. Emergence of parasites from larvae collected in eggplant fruit over three years.

	June – November	**August – December**	**January – March**
	1997	**1998**	**1999**
# fruit cut	2024	2410	2778
# larvae	887	239	414
# parasites	0	0	0

6.3 New pests.

6.3.1 Materials and Methods.

Collections of all larvae from the field that were held in the laboratory and reared to adults, their identification was checked.

6.3.2 Results and Discussions.

A moth with similar but more intensive markings to that found on *Sceliodes cordalis* was observed from some of the studies. The adults of this new species (?) have slight variations in their antennae to that of *S. cordalis*. The difference in larval and pupal forms could not be distinguished from that of *S. cordalis*.

These specimens have been sent to specialists for identification but as this report is prepared a name has still not been provided for them.

7. DISCUSSION

This work has contributed to the knowledge on the eggfruit caterpillar *Scleoides cordalis* and more importantly established that a pheromone can be produced to help in developing a management strategy to control this insect pest. The developed pheromone, at the dosage levels and ratio of acetates and alcohols used in these studies, did not provide control when used alone as a mating disruption tool. It did cause a delay in fruit damage in trapped blocks compared to unprotected blocks so there is scope for improvement. This will require looking at changes in pheromone dosage rates and density of traps.

The success in being able to trap populations throughout the year has shown that the pheromone developed in these studies has proved successful and should be used as a monitoring and assessment tool by growers in managing populations. Being better informed on population activities will allow better timing of pesticides to target egg laying periods based on numbers being trapped. Some refinement will need to be made by growers to determine the best timing of pesticides to gain maximum benefit.

Future studies will need to look at the seasonal pattern of this insect and try to establish where they survive outside of the main cropping period. Also the flight period of the insect would be useful in determining egg laying periods ie dawn or dusk flights. The timing of pesticides in conjunction with flight records needs to be evaluated for maximum results. As no parasites were found in this study does not mean there are none and this will need to be confirmed by checking in other areas. All of these studies will aide in the refinement of using trapping as a monitoring tool to gain the best management strategies.

8. TECHNOLOGY TRANSFER

As this was a development phase of identifying if a suitable pheromone could be made there has been little technology transfer to date.

Eggplant growers have been made aware of the results from these experiments at grower meetings.

A second phase has been developed from this project and other projects to undertake the implementation of an IPM system in both eggplant and capsicum crops. The information obtained from this project will be of tremendous value in developing these systems.

The availability of this pheromone is being negotiated with CSIRO who can produce this pheromone.

It is envisaged that the vegetable industry and more specifically the eggfruit and capsicum sections of this industry will benefit the most through the adoption of an effective and optimum timing of pesticide applications based on moth catches.

9 ACKNOWLEDGEMENTS

The support of Dr. T. Bellas, CSIRO Canberra for developing and supplying the pheromone in the early studies as well as suggesting evaluation methods and Dr. R. Vickers, CSIRO Brisbane for supplying some of the is impregnated rubbers in mating disruption trials is particularly appreciated.

The support of the following people is also recognised; Mrs. L. Richter-Brown in collecting and maintaining laboratory cultures for pupal development in the early stages of the project; Mr. A. Horsefield, Mr. S. Boreel, M/s D. Galvin and Miss T. Betteridge in collecting samples from traps.

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