Alternative fruit fly control and market access for capsicums and tomatoes

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Department of Employment, Economic Development & Innovation

Project Number: VG06028

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This report is published by Horticulture Australia Ltd to pass on information concerning horticultural research and development undertaken for the vegetables industry.

The research contained in this report was funded by Horticulture Australia Ltd with the financial support of Bowen District Growers Association and the vegetables industry.

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ISBN 0 7341 2766 9

Published and distributed by:
Horticulture Australia Ltd
Level 7
179 Elizabeth Street
Sydney NSW 2000
Telephone: (02) 8295 2300
Fax: (02) 8295 2399

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FINAL REPORT

HAL Project VG06028

(31 August 2011)

Alternative fruit fly control and market access for capsicums and tomatoes

A system approach for tomato and capsicum production in Bowen

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Agri-Science Queensland

Department of Employment, Economic Development and Innovation

HAL project number VG06028

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Funding sources: This project has been funded by HAL using the vegetable industry levy, voluntary contributions from industry and matched funds from the Australian Government. Bowen Tomato growers provided voluntary contribution funding through Bowen District Growers Assoc. State government funding for the project has been provided through Agri-Science Queensland a service of the Department of Employment, Economic Development and Innovation.

Date: 30 August 2011

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Media summary

The Queensland vegetable industry is worth around $1.1 billion annually, and the capsicum and tomato industries are worth approximately $130 and $270 million respectively. A significant proportion of Queensland's capsicum (60%) and tomato (50%) production is based in the Bowen region. The main harvest period is from May until November. The major markets for Queensland fresh tomatoes and capsicums are Sydney, Melbourne, Brisbane, Adelaide and New Zealand.

Queensland fruit fly and its sibling species, lesser Queensland fruit fly are recorded as infesting both capsicums and tomatoes. They are considered as major quarantine pests and preharvest and/or postharvest treatments are required to meet the market access requirements of both domestic and international trading partners.

This research project focused on developing a systems approach to meet market access requirements in tomato and capsicum production in the Bowen region. The research undertaken quantitatively evaluated the effectiveness of pre-harvest production systems and postharvest inspection in reducing the risk of fruit fly infestation in tomatoes and capsicums produced for interstate markets and the New Zealand export market. In addition, an extensive region-wide trapping program and a preliminary wild fruit survey were conducted to determine fruit fly seasonal patterns and host range in relation to the cropping seasons.

To assess the level of fruit fly infestation on commercial farms at total of 29,381 capsicums and 20,828 tomatoes were collected from across the region. No fruit flies were recorded in tomato and only one infested capsicum was recorded.

Fruit fly trapping over four consecutive seasons (from August 2006 to January 2010) clearly showed a "low fruit fly period" from March to August. These trapping results further demonstrate that tomatoes and capsicum grown during this period are at minimal risk of fruit fly infestation.

The project demonstrated that field control and inspection in the pack-house can provide a high level of security that could be used in future market access negotiations.

Technical Summary

Queensland fruit fly (*Bactrocera tryoni*) and its sibling species, lesser Queensland fruit fly (*B. neohumeralis*) are recorded as infesting both capsicums and tomatoes. They are considered as major quarantine pests and preharvest and/or postharvest treatments are required to meet the market access requirements of both domestic and international trading partners.

The insecticides dimethoate and fenthion are used in preharvest and/or postharvest quarantine treatments to meet both domestic and export market access requirements. Both insecticides are currently being reviewed by the Australian Pesticides and Veterinary Medical Authority (APVMA) and it is likely that certain uses in capsicums and tomatoes will no longer be allowed when the reviews are finalised. This will have a very serious implication for the $400 million capsicum and tomato industries in Queensland which currently have a heavy reliance on the postharvest use of both chemicals..

This project is focused on developing a systems approach to meet market access requirements in tomato and capsicum produced in the Bowen region. The research undertaken quantitatively evaluated the effectiveness of pre-harvest production systems and postharvest mitigation measures in reducing the risk of fruit fly infestation in tomatoes and capsicums produced for interstate and New Zealand export markets. In addition, an extensive district-wide trapping program and a preliminary wild fruit survey were conducted to determine fruit fly seasonal patterns and host range in relation to the cropping seasons.

A total of 17,626 field-harvested and 11,755 pack-house tomatoes were sampled from ten farms and the DEEDI research station over three cropping seasons (2006 to 2009). The fruit were incubated and examined for fruit fly infestation. No fruit fly infestation was recorded over the three seasons in either the field or the pack-house samples. Statistical analysis showed that upper infestation levels were extremely low (between 0.025 and 0.062 %) at the 95% confidence level.

A total of 13,722 field-harvested and 7,106 pack-house capsicums were sampled from 12 farms and the DEEDI research station over three cropping seasons. No infested fruit were recorded until November in either field or pack-house samples. Only one infested capsicum was recorded, from a field sample collected in November 2007. However the pack house sample originating from the same block had no infestation. Statistical analysis showed that upper infestation levels were very low (0.036 %) with a 95% confidence level.

Region wide monitoring of fruit fly activity was undertaken for 40 months (Aug 2006 to Dec 2009). Around 70 cue-lure traps were placed across the district, covering tomato and capsicum farms, riverbanks and natural vegetation. This extensive trapping has provided, for the first time, detailed knowledge of fruit fly populations and species distribution for the Bowen region.

The trap catches reflected a seasonal pattern in fruit fly activity, with low numbers during the autumn and winter months, rising slightly in spring and peaking in summer. This seasonal pattern was similar over the four seasons.

Fruit fly numbers were higher in the traps located on riverbanks and vegetation adjacent to fruit trees, while the numbers were low in the traps on capsicum and tomato farms in more

open terrain. In addition the rate of increase in fruit fly numbers in spring and summer was higher in traps located on riverbanks and vegetation which would indicate that insecticide use on commercial farms does impact on fruit fly populations.

The results of this project clearly demonstrate that field cover sprays and pack-house mitigation measures (washing, sorting and grading to remove defective and damaged fruit) can provide a high level of security that could be used in future market access negotiations.

Introduction

The Queensland vegetable industry is worth around $1.1 billion annually, and the capsicum and tomato industries are worth approximately $130 and $270 million respectively. A significant proportion of Queensland's capsicum (60%) and tomato (50%) production is based in the Bowen-Burdekin region (Mullins and Subramaniam 2010) . The fruits are harvested during the cooler months from May until November. The major markets for Queensland fresh tomatoes and capsicums are Sydney, Melbourne, Brisbane and Adelaide. A small proportion is exported to New Zealand during winter months.

Queensland fruit fly (*Bactrocera tryoni*) and its sibling species lesser Queensland fruit fly (*B. neohumeralis*) are pests of fruits and fresh vegetables such as capsicums and tomatoes. Their importance as major quarantine pests necessitates preharvest and/or postharvest quarantine treatments to meet both domestic and export market protocols. The insecticide dimethoate is used widely in both preharvest and postharvest treatments to ensure that produce is free from fruit flies to meet domestic and export market access requirements.

Of particular concern to the vegetable industry is the fact that the long-term availability of dimethoate and fenthion, which is used as a quarantine treatment, is very uncertain. Products containing dimethoate were reviewed at a national level because of toxicological, occupational health and safety, and residue concerns.

The Australian Pesticides and Veterinary Medicines Authority (APVMA) has recently completed the review and suspended the use of dimethoate on a number of fruit and vegetable crops. This new restrictions will not permit dimethoate to be used for preharvest and postharvest treatments in fresh tomatoes and postharvest treatments in capsicum (APVMA 2011).

Fenthion review is continuing and it is likely that certain uses of fenthion will no longer be allowed when the review is completed. The loss of dimethoate for preharvest and/or postharvest treatments will have a very serious impact on the capsicum and tomato industries in Queensland if suitable alternative methods to meet quarantine market access requirements for fruit fly are not found.

The International Plant Protection Convention (IPPC) has defined system approaches as the integration of different pest management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of phytosanitary protection (ISPM Publication 14, 2002).

One of the alternatives to dimethoate treatment is to develop a systems approach to meet market access requirements where a number of independent procedures (e.g. ascertaining fruit fly prevalence, the influence of seasonal conditions, field control measures and pack-house quality control practices) can contribute to minimising the risk of fruit fly infestation.

The scope of this project is to find an alternative approach to the use of dimethoate or fenthion for fruit fly control while maintaining domestic market access, as well as to determine the potential for a future systems approach in tomato and capsicum production areas in the Bowen district. In addition, the information and data generated from the project are expected to provide additional support to maintain the export market to New Zealand.

This study focused on Queensland's major tomato production region at Bowen and capsicum production area around Bowen and Gumlu. The following components were planned in the tomato and capsicum production system to generate sufficient data and information as the basis for a market access protocol,

- Evaluate the effectiveness of pre-harvest insecticides sprays (used in the crops for other purposes) and field management practices adopted in commercial farms.

- Evaluate the effectiveness of post-harvest mitigation measures used in commercial pack-houses (not including insecticidal treatments) in reducing the risk of fruit fly infestation in tomatoes and capsicums packed for interstate or export markets.

- Undertake a district wide trapping program for fruit flies to determine fruit fly seasonal activity patterns in relation to the cropping seasons.

- Collect all information possible in relation to fruit infestation levels, presence of native hosts, and effects of current commercial practice which includes pesticide sprays, harvest maturity and crop hygiene to incorporate into a systems approach for meeting quarantine security requirements.

1. District-wide fruit fly monitoring

1.1 Introduction

Queensland fruit flies (QFF) *Bactrocera tryoni* and *B. neohumeralis*, are usually monitored using Lynfield traps with cue-lure as the attractant and maldison as a killing agent. Accurate methods for fruit fly population assessment are a prerequisite for effective decision making in area-wide control programs aimed at pest suppression, as well as to establish fruit fly free or low population periods with a view to incorporating such information into systems approaches to meet market access requirements.

This component of the project is aimed at quantifying fruit fly populations, gain insights into spatial as well as temporal variation in fruit fly activity and distribution of fruit fly species in the commercial production areas of Bowen and Gumlu, Queensland.

1.2 Materials & Methods - Trapping

District-wide fruit fly monitoring involved continuous trapping across the district for the 40-month period from August 2006 to January 2010. This trapping program was focused to cover the vegetable and mango production seasons in the Bowen and Gumlu regions. Fruit fly populations were monitored using cue-lure baited Bugs for Bugs (modified Lynfield) traps (commercially available from Bugs for Bugs) and the wicks were changed every 12 weeks (Fig. 1.1). The trap contents were emptied fortnightly and the collected fruit flies were taken to the Bowen laboratory for counting and species identification.

Bowen trapping - Around 50 cue-lure traps were placed across the Bowen farming region, covering tomato and capsicum farms, riverbanks, natural vegetation and urban areas. Around twenty-seven of these traps were installed in close proximity to the tomato and capsicum farms (grouped as ‘farm traps’) which were subject to influence by commercial practices during the production season. Fifteen traps were installed along the Don River, Euri creek and watercourses –considered as ‘river traps’ (Fig. 1.2). Another seven traps were installed within or adjacent to mango orchards (Mango traps), and the remaining two traps were placed at locations in the town of Bowen (‘town traps’).

The details of the locations, GPS coordinates and the surrounding vegetation were recorded for all traps and are summarised in Table 1.1. Daily minimum and maximum temperatures and rainfall data were collected for the trapping period from an automatic weather station established at Bowen Research Station (BRS).

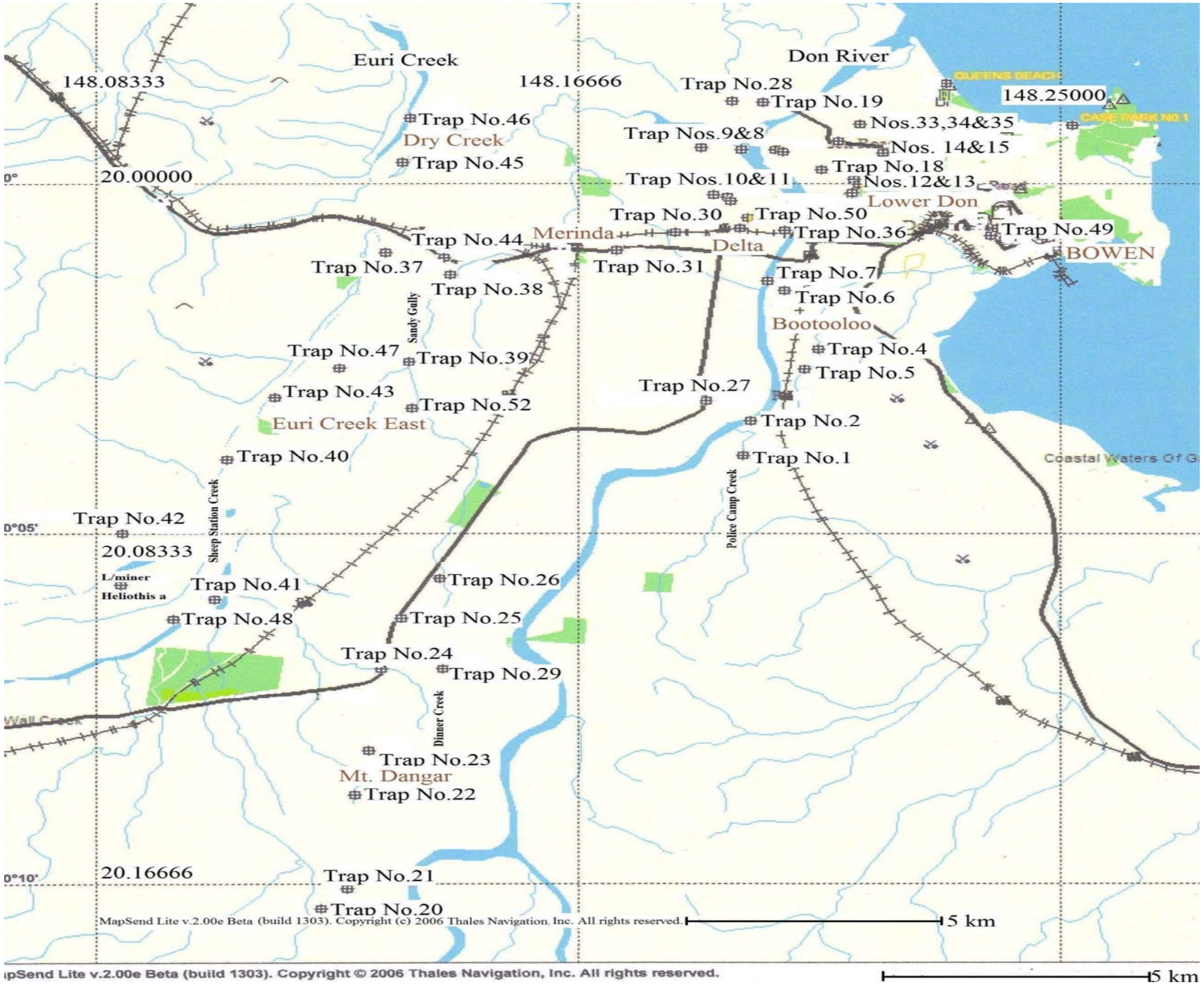
Gumlu trapping - Another 20 traps were installed around the capsicum farms, mango orchards and in creek vegetation in the Gumlu region. Seven traps were installed in close proximity to the capsicum farms (farm traps), and another seven traps were installed within or adjacent to mango orchards (Mango traps). Six traps were installed along the creek, watercourses and natural dense vegetation – considered as ‘river traps’.

The details of the locations, GPS coordinates and the surrounding vegetation were recorded for all traps and are summarised in Table 1.2

Figure 1.1. Cue-lure trap used for fruit fly monitoring

Figure 1. 2 Fruit fly trap installed in a river bank location

Figure 1.3 Cue-lure trap locations in Bowen



Locality	No. Traps
Lower Don	12
Bootooloo	7
Bowen Township	1
Delta	8
Mt. Dangar	8
Dry Creek	2
Euri Creek East	11

Crop	No. Traps	≈ No. Farms
Tomato	23	13
Capsicum	17	9
Beans & S/corn	3	3
Native	1	-
Mango +	3	-
Mixed	1	-
Township	1	-

Table 1.1 Descriptions of the cue-lure trap locations in Bowen (2006 – 2010)

Trap No.	GPS coordinates		Trap* Classification	Trap tree	Description of surrounding vegetation	
	Lat. (S)	Long. (E)			Commercial crops	Natural vegetation
BP 01	20.03896	148.11682	River trap	Leucaena		Ziziphus, Nauclea, Cordia, Leucaena, Eucalypt, Melaleuca .
BP 02	20.05668	148.19658	River trap	Mango	Grass land	Mango, Ziziphus, Carbeen, Eucalypt, Melaleuca .
BP 03	20.03399	148.12417	Farm trap	Terminalia	Capsicum, Pumpkin	Acacia
BP 04	20.02398	148.12309	Farm trap	Ziziphus	Capsicum	Ziziphus, Acacia
BP 05	20.04439	148.20586	Farm trap	Acacia	Pumpkin Capsicum	Acacia, Clerodendrum
BP 06	20.01319	148.12083	Farm trap	Mango	Capsicum	Mango , Callistemon & Palm
BP 07	20.01239	148.12006	River trap	Mulberry		Mango, Mulberry, Guava, Ziziphus, Carbeen, Melia, Acacia
BP 08	19.59309	148.11414	River trap	Leucaena		Mango, Leucaena, Melaleuca, Ziziphus, Ficus
BP 09	19.99162	148.18831	Mango trap	Mango	Mango	Mango orchard & horse paddock
BP 10	20.00265	148.19041	Farm trap	Mango	Tomato	Mango windbreak
BP 11	20.00436	148.19313	River trap	Leucaena		Swamp - Melaleuca, Leucaena, Acacia, Melia, Eucalypt, Alphitonia, Nauclea, Cordia
BP 12	20.00235	148.21394	Farm trap	Mulberry	Capsicum	Guava, Mango, Chilli, Papaw, Custard Apple, Citrus, Rosella

Trap No.	GPS coordinates		Trap* Classification	Trap tree	Description of surrounding vegetation	
	Lat. (S)	Long. (E)			Commercial crops	Natural vegetation
BP 13	19.99895	148.21437	Farm trap	Terminalia	Capsicum	Citrus, Tamarind, Macadamia, Mango
BP 14	19.99670	148.21835	Farm trap	Sapote	Capsicum	Mango, Sapote, Guava, Lychee, Citrus, Papaw, Banana, Mulberry
BP 15	19.99271	148.21878	Farm trap	Acacia	Capsicum	Acacias
BP 16	20.00139	148.12245	River trap	Ziziphus		Carbeen, Zizphus, Cassia
BP 17	20.00269	148.20822	Mango trap	Mango		Mango
BP18	19.99720	148.20872	Mango trap	Alphitonia	Capsicum	Carbeen, Acacia, Leucaena, Ziziphus; Mango Orchards
BP 19	19.98067	148.19875	Farm trap	Farm trap	Capsicum	Mango
BP 20	20.17272	148.12222	Farm trap	Planchonia		Eucalypt, Acacia, Casuarina, Alphitonia, Planchonia
BP 21	20.16781	148.12692	Farm trap	Gum	Tomato	Eucalypt, Acacia, Casuarina
BP 22	20.14556	148.12828	Farm trap	Ziziphus	Pumpkin	Eucalypt, Ziziphus, Capparis
BP 23	20.13487	148.13077	Farm trap	Capparis sp.	Capsicum	Acacia, Grevillea, Casuarina, Capparis
BP 24	20.11477	148.13306	River trap	Planchonia		Eucalypt, Ziziphus, Planchonia –
BP 25	20.10365	148.13643	Mango trap	Mango	Tomato, Pumpkin	Mango orchard
BP 26	20.09401	148.14252	Farm trap	Acacia	Tomato	Eucalypt, Acacia, Casuarina, Ziziphus, Carbeen

Trap No.	GPS coordinates		Trap* Classification	Trap tree	Description of surrounding vegetation	
	Lat. (S)	Long. (E)			Commercial crops	Natural vegetation
BP 27	20.05200	148.18846	Farm trap	Acacia	Tomato	Acacias
BP 28	19.98042	148.19341	Farm trap	Leucaena	Capsicum	Tamarind, Leucaena, Acacia, Ziziphus
BP29	20.15780	148.14297	River trap	Ziziphus	Tomato	Eucalypts, Acacia, Ziziphus
BP 30	20.01200	148.18364	River trap	Ficus		Acacia, Eucalypt, Melaleuca (swamp)
BP 31	20.01585	148.17345	Farm trap	Acacia	Capsicum	Acacia,
BP 32	19.99331	148.20201	Mango trap	Mango	Mango orchard	Mango, Ziziphus,
BP 33	19.98604	148.21573	Farm trap	Mango	Tomato	Grass,
BP 34	19.98828	148.22217	Mango trap	Mango	Mango	Zucchini
BP 35	19.99018	148.21155	Farm trap	Mango	Tomato	Mango, cucumber
BP 36	19.01151	148.20244	River trap	Ziziphus	Tomato	Leucaena, Ziziphus
BP 37	20.01647	149.13355	River trap	Gum tree		Eucalypts
BP 38	20.02233	148.14513	Farm trap	Cordia	Tomato	Melaleuca, Eucalypt, Palm, Ziziphus, Alphitonia,
BP 39	20.04273	148.13768	River trap	Acacia	Tomato	Acacia, Melaleuca, Eucalypt, Leucaena, Ziziphus
BP 40	20.06558	148.10515	River trap	Ziziphus		Acacia, Melaleuca, Eucalypt, Ziziphus

Trap No.	GPS coordinates		Trap* Classification	Trap tree	Description of surrounding vegetation	
	Lat. (S)	Long. (E)			Commercial crops	Natural vegetation
BP 41	20.09898	148.10368	River trap	Celastraceae	Mango	Eucalypt, Ziziphus, Mango & citrus
BP 42	20.08310	148.08800	Farm trap	Alphitonia	Tomato	Acacia, Eucalypt
BP 43	20.05275	148.11461	Farm trap	Cassia	Tomato	Callistemon, Melaleuca, Palms &Cypress
BP 44	20.01793	148.14346	Farm trap	Acacia	Tomato	Acacia, Eucalypt, Capparis
BP 45	19.99501	148.13634	Farm trap	Mango	Sweet Corn, Beans	Eucalypt, Melaleuca, Mango
BP 46	19.98485	148.13907	Farm trap	Mango	Tomato	Mango
BP 47	20.04404	148.12537	Farm trap	Acacia	Tomato	Eucalypt, Acacia, Palms, Ficus, Pheltophora
BP 48	20.10391	148.09666	Mango trap	Fig	Mango	Eucalypt, Ziziphus
BP 49	20.01274	148.23810	Town trap	Brazilian Cherry	Suburban garden	Callistemon; Bauhinia, Frangipani
BP 50	20.00979	148.19649	Farm trap	Mango	Mango & small crops	Mango orchard
BP 51	19.98526	148.22821	Town trap	Mango	Home garden	Cashew, Moringa, Mango
BP 52	20.05582	148.13861	River trap	Ziziphus	Capsicum	Ziziphus, Leucaena

* River trap = traps installed in or close to river bank/ creek/ watercourse/ swamp often combined with dense vegetation
* Farm trap = placed around the farm boundaries and away from dense vegetation; Mango trap = placed in close proximity to mango orchard.
* Town trap = installed in Bowen town and adjacent to suburban garden or fruit trees.

1.3 Results & Discussion

Trap Results

The mean trap catches across the Bowen region for the three and a half year period are shown in Figure 1. 4a, and the Gumlu trap catches for three year period are shown in Figure 1.4b. Cue-lure trap catches reflected a typical seasonal pattern in fruit fly activity, with low numbers during autumn and winter months, moderate numbers in spring and high numbers in summer.

Fruit fly numbers were very low during autumn and winter months for 2007, 2008 and 2009. From March to August average trap catches along the river (0.5 - 6.0 flies/ trap/ day) and on the farms (0 - 0.3 flies/ trap/ day) were low.

The increase in fruit fly numbers starts in August, with numbers peaking in December to mid-January; this seasonal pattern was similar over the four seasons. In Bowen, high fruit fly numbers (average of 28 flies/ trap/ day) were caught in the traps that were located in riverbank and creek vegetation while the numbers were very low (average of 4 flies/ trap/ week) in the traps around capsicum and tomato farms.

In Gumlu, traps placed on mango trees or adjacent to mango orchards caught an average of 8 flies/ trap/ day while traps on native trees or adjacent to capsicum crops caught an average of 0.8 flies per trap per day.

In all traps, Queensland fruit fly (*Bactrocera tryoni*) and lesser Queensland fruit fly (*B. neohumeralis*) were the predominant species, accounted over 92% of the catches. Smaller proportions of non-pest species (*B. bryoniae, B. chorista* and *Dacus aequalis*) were recorded.

The vegetable production season starts in March and continues until November, with the first-half of the fruit harvest season coinciding with the low fruit fly period. The December/ January fruit fly peak coincides with end of the vegetable season and the cessation of field sprays on most vegetable farms. Therefore, this peak of activity for fruit fly is not a concern for the vegetable industry, as the production season ends in November.

The trap catches varied with trap locations and vegetation type. Fly numbers were higher in the traps located on riverbanks and vegetation adjacent to fruit trees, while the numbers were low in the traps on farms with open terrain. The Bowen trap catches were analysed according to "trap category": farm, river, mango and town traps as to show the differences with trap locations and the data are presented in Figures 1.5a to 1.6d and in Table 1.2.

Figure 1.4a Seasonal activity of Queensland fruit flies in the Bowen region, from Aug 2006 to Dec 2009

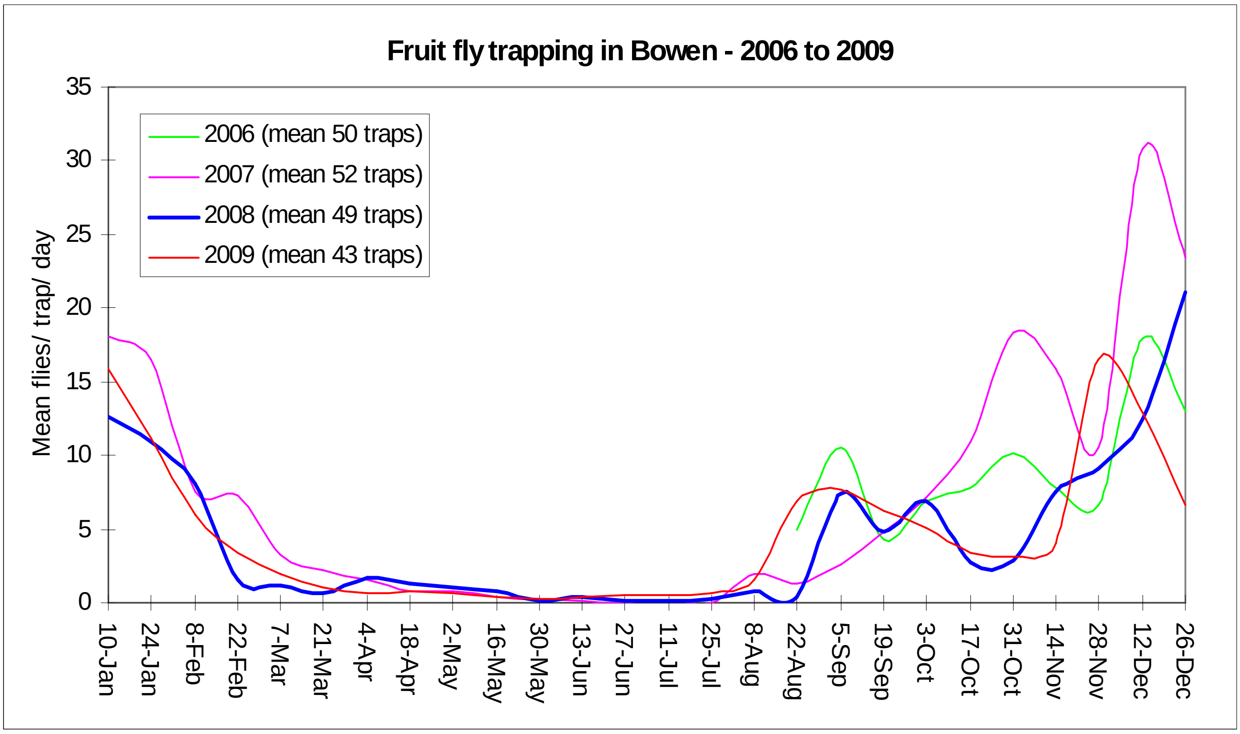
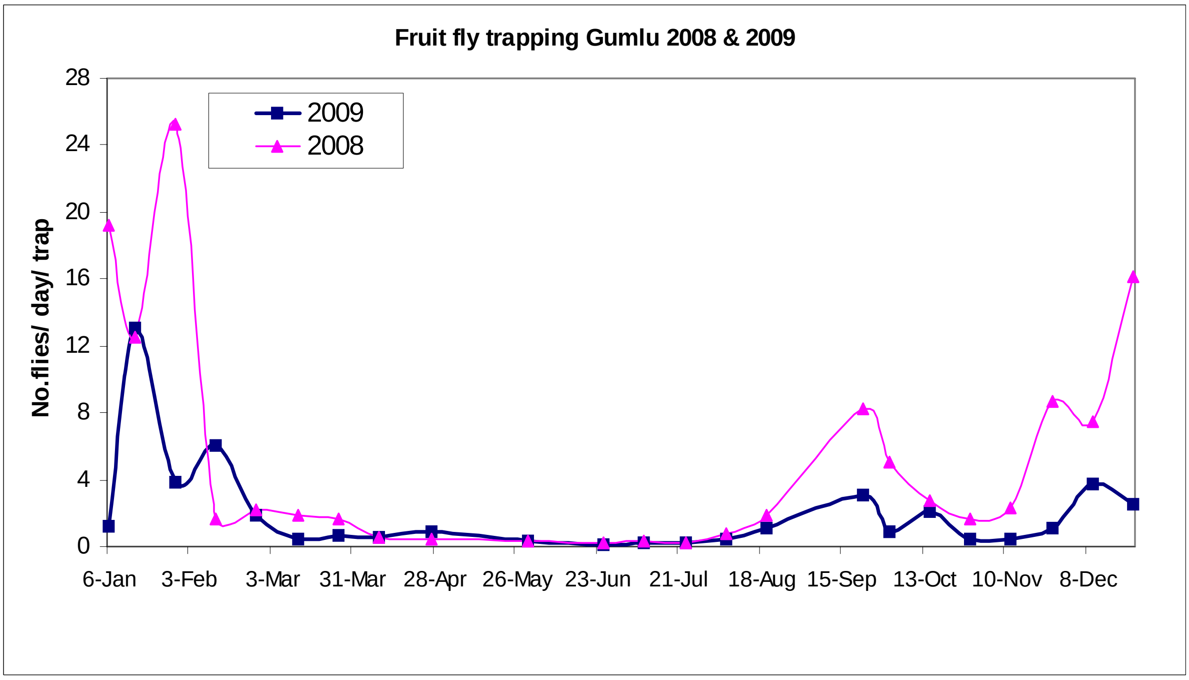


Figure 1.4b Seasonal activity of Queensland fruit flies in Gumlu, from Jan 2008 to Dec 2009



1.31 Fruit fly populations in relation to trap locations

The combined caches of all traps over the twelve month period and the mean annual catch per trap indicated that the area along the river and unsprayed or neglected mango orchards harboured the largest fly populations. This probably is due to the availability of food, dense vegetation and hosts for breeding throughout the year.

In 2007 and 2008, a total of 127,678 and 80, 080 flies respectively were collected and identified in all traps in Bowen. The fruit fly number varied with trap locations: the highest annual mean trap catch was along the river (4,324), followed by the mango orchards (3,283) and then the farms (1,499) (Table 1.2).

Table 1. 2 Annual fruit fly catches in relation to trap locations in Bowen – 2007 and 2008

Year	**Trap locations**	**Total traps**	**Total flies trapped** (all traps)	**Annual catches per trap**	**QFF * species %**	**Non-pest # species %**
	Trapping period: Jan to Dec 2007					
2007	Farm traps	28	41, 993	1, 499	98.72	1.28
	Mango traps	7	22, 981	3, 283	98.69	1.31
	River traps	14.5	62, 704	4, 324	97.55	2.45
	Trapping period: Jan to Dec 2008					
2008	Farm traps	27	31, 108	1, 152	97.60	2.40
	Mango traps	6	14, 146	2, 357	96.00	4.00
	River traps	13	34, 807	2, 677	92.60	7.40
	Trapping period: Jan to Dec 2009					
2009	Farm traps	27	22,319	827	97.10	2.90
	Mango traps	6	16,698	2,783	96.59	3.41
	River traps	14	35,597	2,738	93.02	6.98

* QFF = Queensland fruit flies includes *Bactrocera tryoni and B. neohumeralis*
# Non-pest species includes *B. bryoniae, B. chorista, B. alyxiae, Dacus aequalis, D. newmani, D. axanus*

During the winter months, trap catches along the river and in unsprayed mango orchards and the town of Bowen showed a similar pattern to those in sprayed farms. From May to mid-August fly numbers in the farm and mango traps were very low (0.2 flies/ trap / day) often with zero catches, while small numbers (around 1.5 flies/ trap/ day) were recorded in the town and river traps (Figs. 1.5a, 1.5b and 1.6b).

All mango and river traps showed a rapid increase in numbers from early September, with average catches reaching 12 flies in the traps, while the farm traps showed a slow increase until end of October (average of 3.5 flies/ trap/ day) (Fig 1.6 b and c).

The comparison of trap catches with the fruit infestation data (Chapter 2) showed that trap catches alone did not provide a clear indication of infestation levels in commercial tomato and capsicum crops. The trap catches during November were moderately high around the tomato farms (around 4-6 flies/ trap/ day), but no infestation was found in the sampled fruit. This probably was due to the regular insecticide cover sprays that are applied for controlling other pests in the crop.

In summer, fruit fly numbers remained high in most locations until end of January, after which they decreased rapidly (Figs 1.5a and b). This is also most likely related with end-of mango season and resumption of field sprays for the new season vegetable crops. In the river and mango areas, the fly populations were at higher level, which was correlated with the widespread availability of feral mango trees for breeding.

The annual catches were low in most of the traps that were located around the tomato and capsicum farms. The major factors that were affecting the fruit fly populations around the farms were regular application of pesticides, intensive farming practices and open habitat around farms.

In addition, the decreasing pesticide sprays in vegetable farms towards the later part of the season and maturity of wild mangoes would appear to be the major factors contributing to the peak summer population.

This trapping program demonstrated that the trap catches in the area varied greatly depending on the location of the trap. Traps placed along the river-side or adjacent to natural vegetation frequently caught higher number of flies compared to the traps around the farms during the same period.

Figure 1.5a Mean catches of QFF from the traps installed in farms, mango orchards, river and town locations in Bowen - 2007.

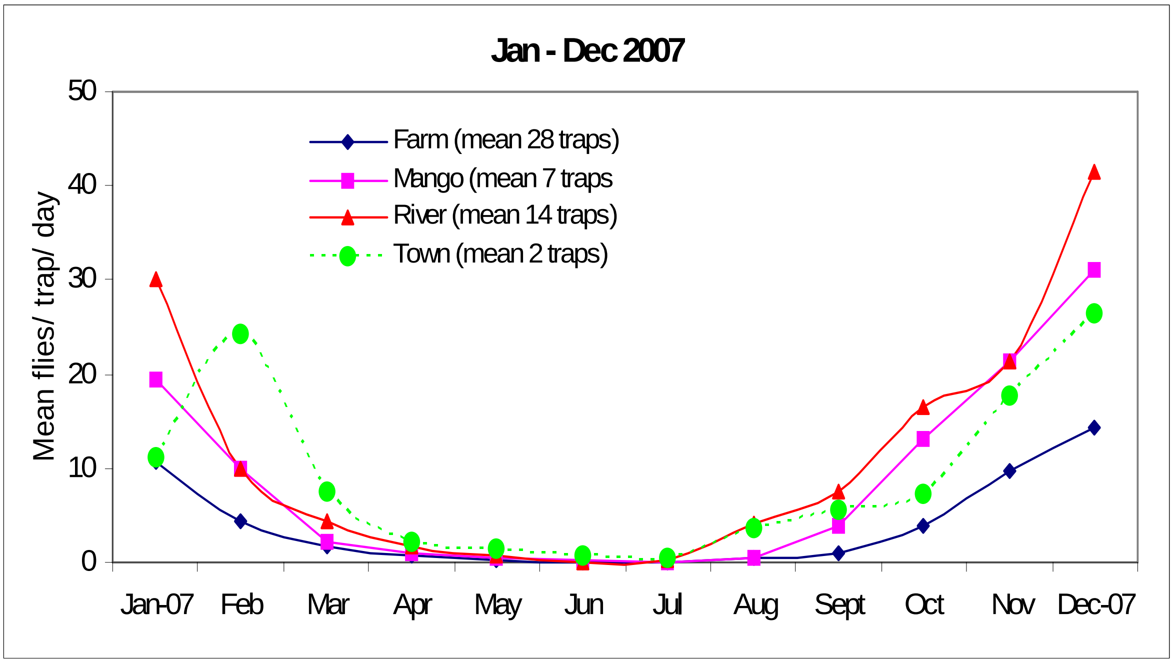


Figure 1.5b Mean catches of QFF from the traps installed in farms, mango orchards, river and town locations in Bowen - 2008.

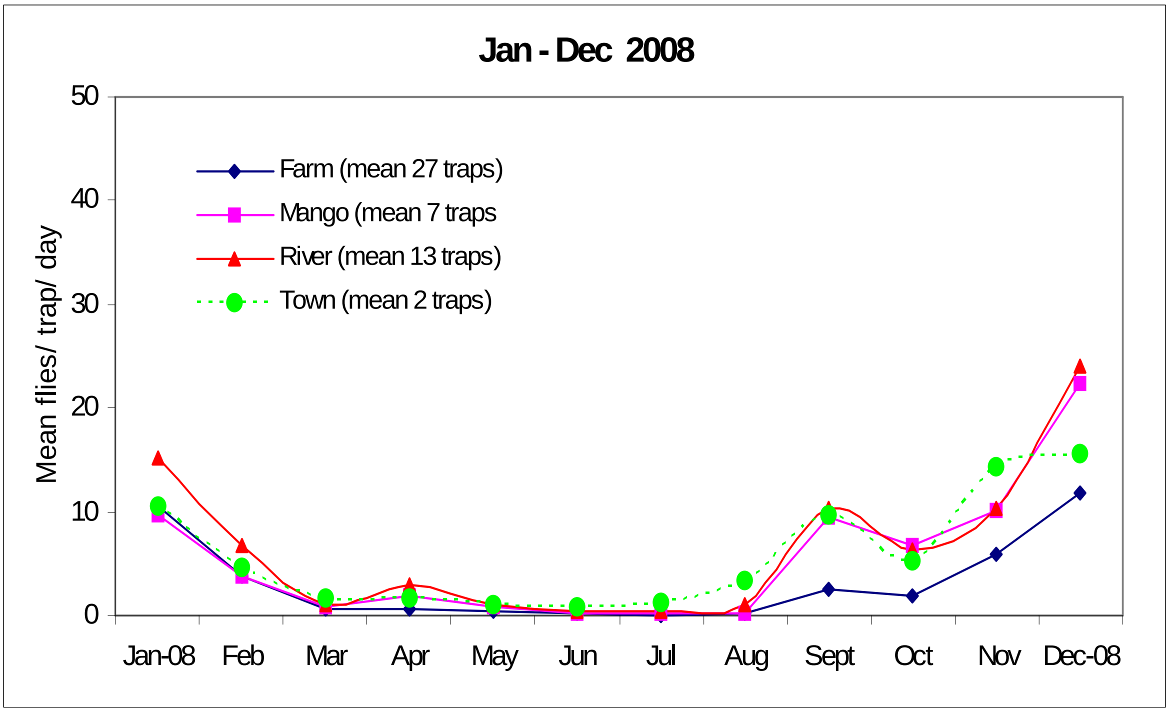


Figure 1.6a QFF activity during autumn (Mar – May) season in 2007 and 2008

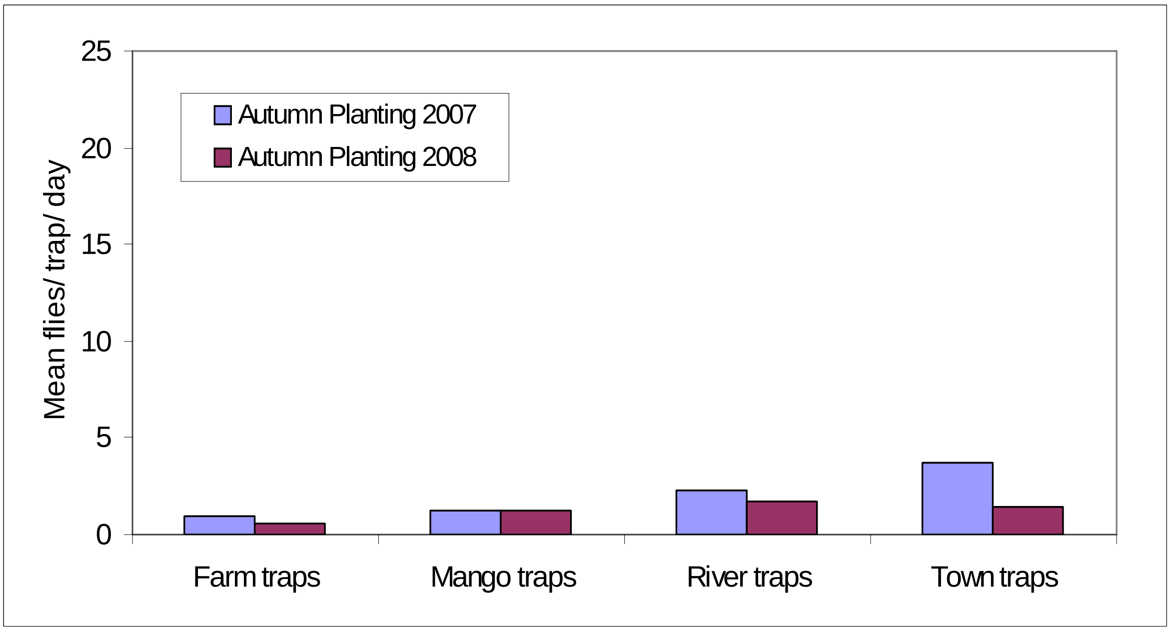


Figure 1.6b QFF activity during winter harvest (Jun – Aug) period in 2007 and 2008

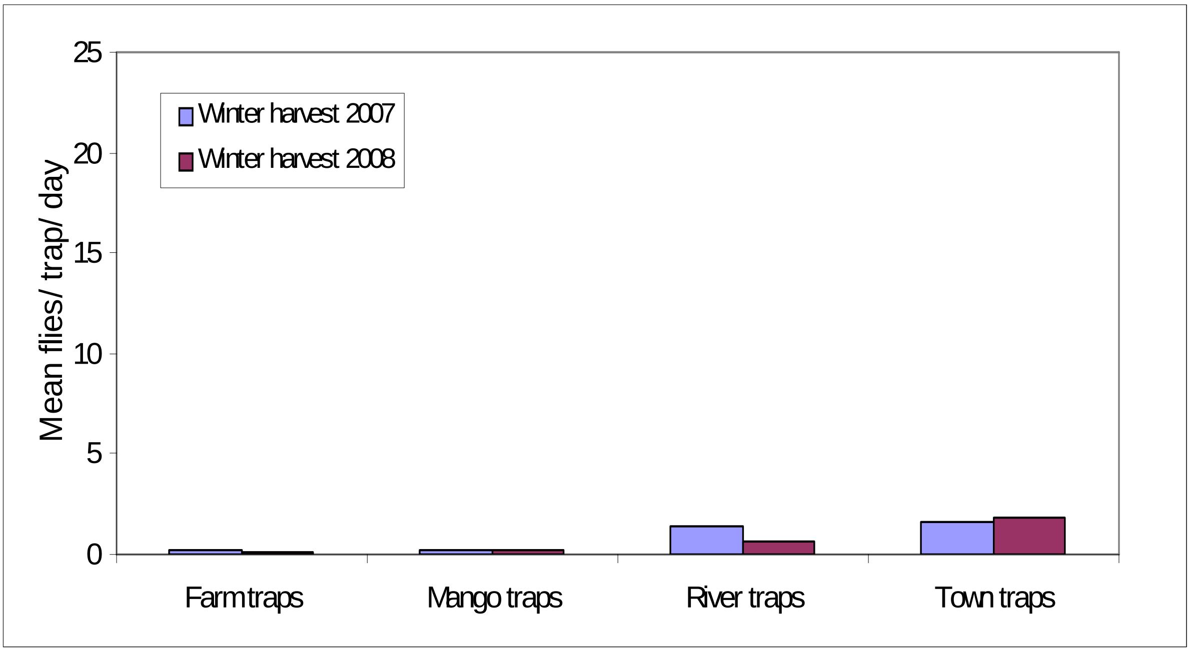


Figure 1.6c QFF activity during spring harvest (Sep – Nov) period in 2006 - 2008

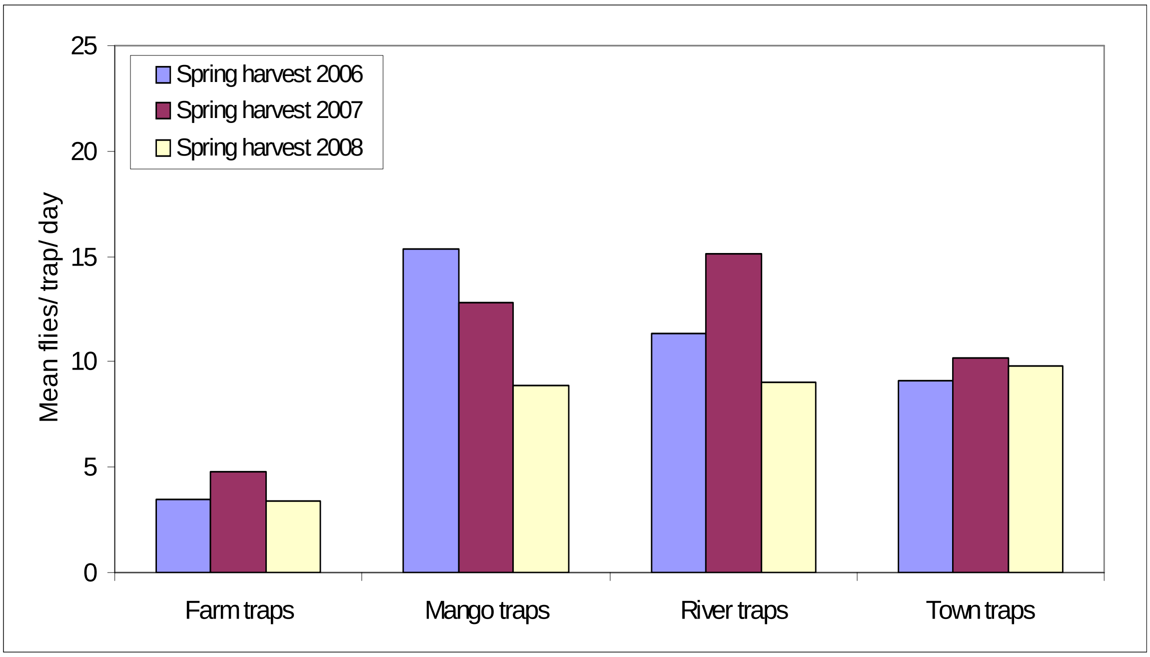
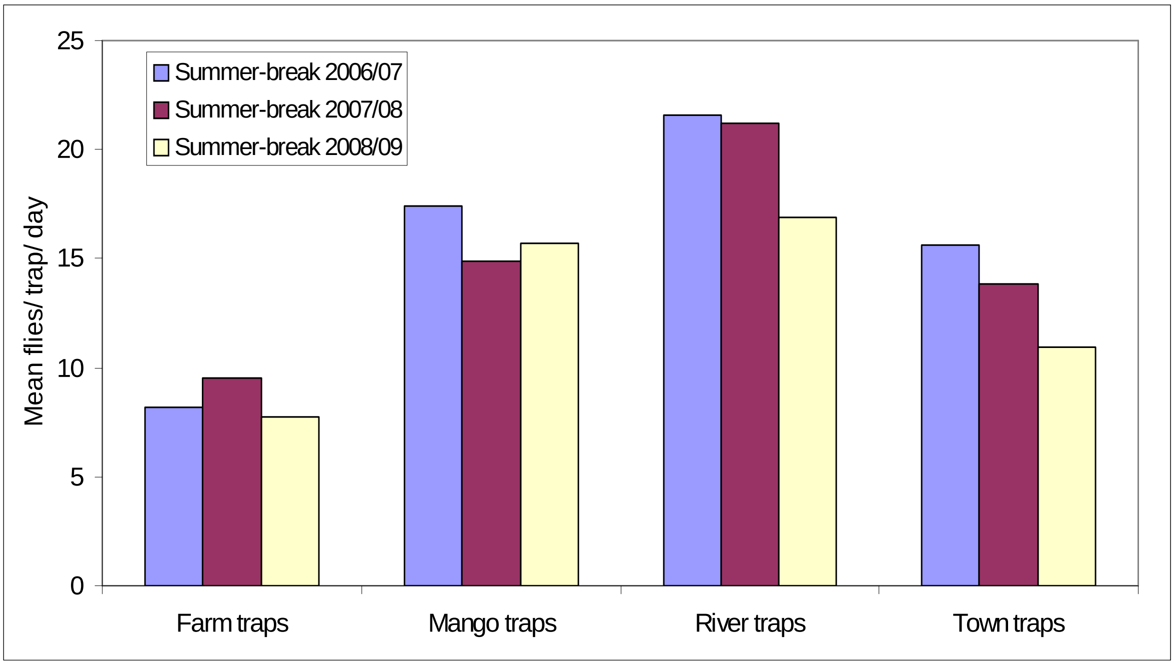


Figure 1.6d QFF activity during summer-break (Dec – Feb) period in 2006 - 2008



1.32 Species distribution

Queensland fruit fly (*B. tryoni*) and lesser Queensland fruit fly (*B. neohumeralis*) were the predominant species caught in all traps. The proportion of each species varied between years. In 2007 *B. tryoni* and *B. neohumeralis* catches accounted for 71.8 and 26%; and in 2008 the proportion was changed to 82.5 and 12.8%, respectively (Fig 1.7a & 1.7b).

A non-pest species, *B. bryoniae*, was recorded in a small proportion (1.7%) in 2007 and the annual catches increased to 3.9% in 2008. *B. bryoniae* is widely distributed in northern and eastern parts of Australia with a narrow host range. Wild cucumber (*Diplocyclos palmatus*) was reported as its major host (Drew 1989). This species has not been recorded from the wild fruit survey conducted in Bowen (see Chapter 4).

Other species, *Bactrocera. chorista, B. alyxiae, B. jarvisi, Dacus aequalis, D newmani, D. axanus*, were present in very small numbers (0.1 to 0.7%).

The distribution of fruit fly species in farm, river, orchard and town traps showed that the same species were caught in approximately similar proportions. This pattern was consistent across the three seasons in the district.

Figure 1.7a Distribution of fruit fly species in cue-lure traps in Bowen, Jan – Dec 2007

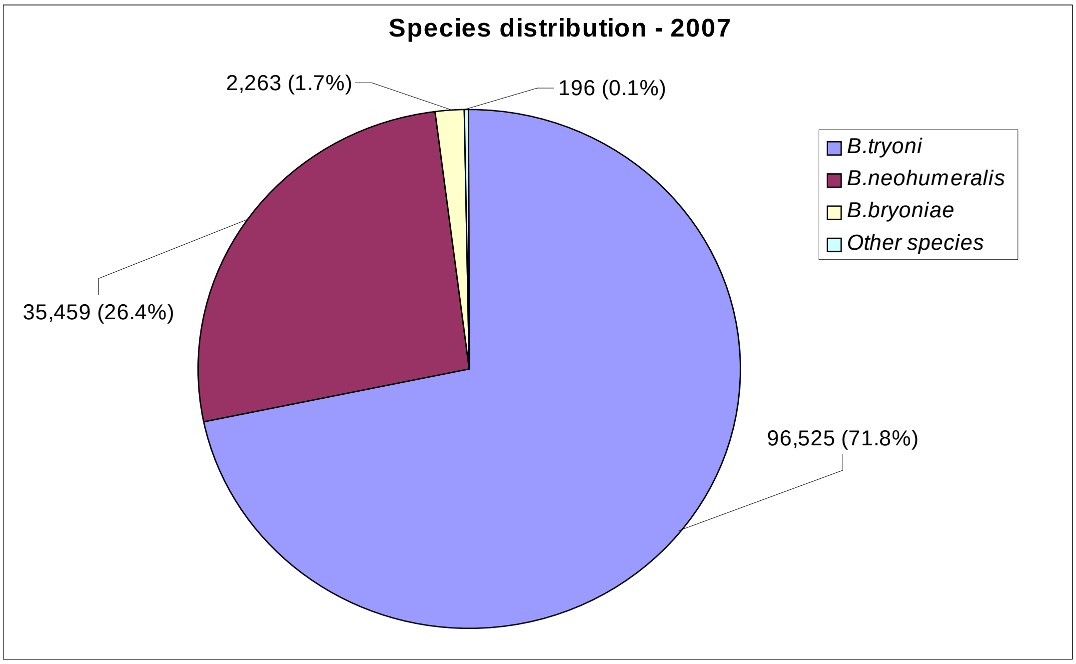
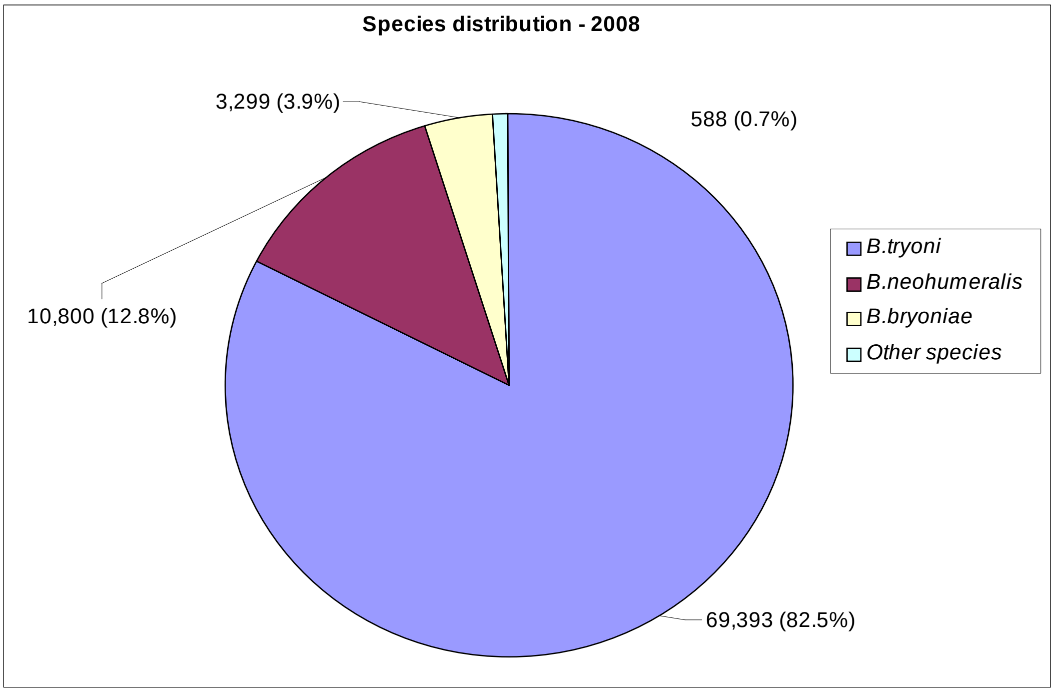


Figure 1.7b Distribution of fruit fly species in cue-lure traps in Bowen, Jan- Dec 2008



Other species = *Bactrocera. chorista, B. alyxiae, B. jarvisi, Dacus aequalis, D newmani, D. axanus.*

1.33 Temperature data for Bowen – 2007 and 2008

Daily maximum and minimum temperatures and monthly rainfall data were collected for 2007, 2008 and 2009 from the weather station at BRS. The mean fortnightly temperatures together with QFF trap catches for 2007 and 2008 are given in Figure 1.8a and 1.8b.

In 2007, the mean minimum temperatures during June/ July fluctuated between 10 and 16 ºC, and then gradually increased to 18ºC in September. In 2008 the winter was slightly warmer, the mean minimum for June/ July ranged between 14 to 19 ºC, and that probably was the reason for a small peak in trap catches in late-August.

River trap catches often showed small increases in numbers in mid-August or September, which coincided with increasing temperatures. The limited availability of wild hosts during this time would have limited the population increase. Even though other commercial hosts such as tomatoes and capsicums were available in large numbers, there was strong evidence that both crops were not supporting QFF breeding (Subramaniam *et al*. 2011). This was mainly due to the regular insecticide cover sprays and adoption of crop hygiene practices (e.g. timely destruction of crops residues, deep ploughing and weed control).

Higher minimum (25ºC) and maximum (32ºC) temperatures and abundance of mango fruits probably were the major reasons for the peak populations from late November to January. The early season mango varieties such as Kensington Pride and R2E2 mature in November and the season continues with late-varieties Keith and Kent until late-January.

Figure 1.8a Mean maximum and minimum temperatures recorded at Bowen Research Station, with daily trap catches - Jan to Dec 2007

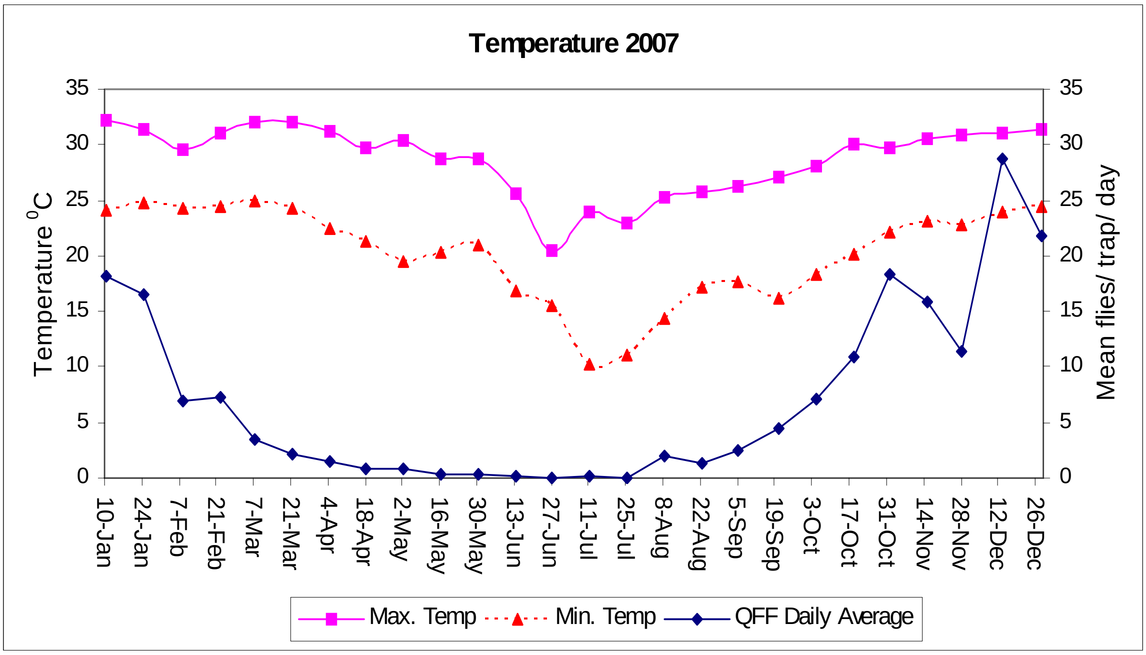
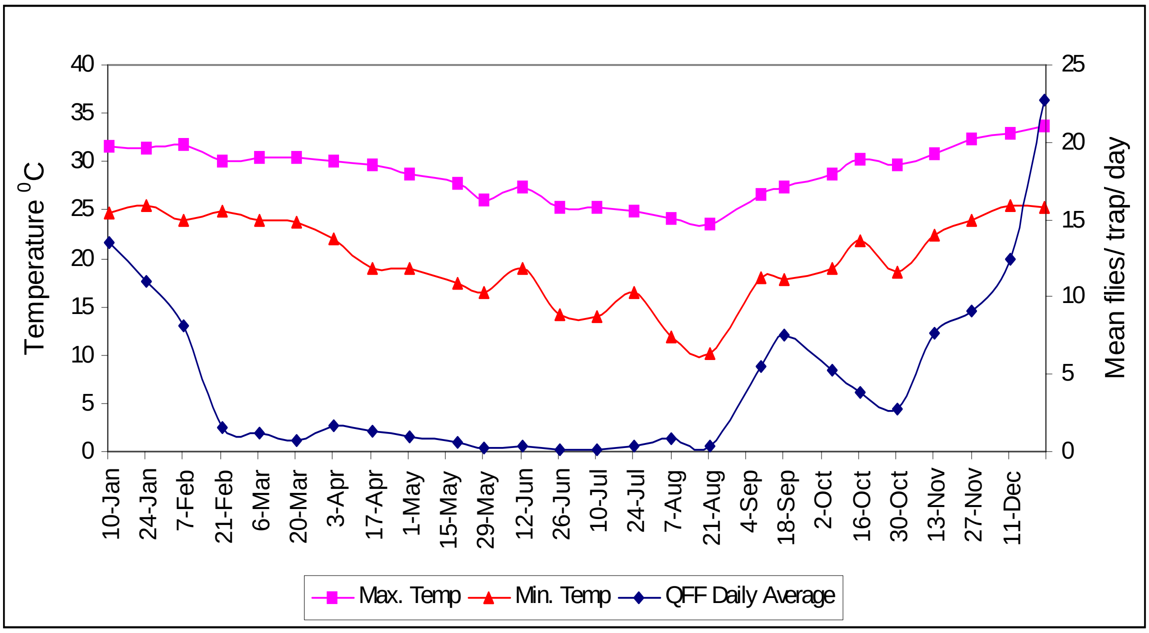


Figure 1.8b Mean maximum and minimum temperatures recorded at Bowen Research Station, with daily trap catches - Jan to Dec 2008



1.4 Conclusion

Very low activity from April to August, an increase in numbers from early September and peak populations during December to February were features common to the all trap locations in the district. Although trap catches were very low during the winter months, they were rarely zero in river and town traps indicating that small populations were over wintering across the natural or undisturbed habitats and in the urban environment.

The increasing temperatures, availability of suitable hosts (e.g. mango) and cessation of pesticide sprays across the farms were the possible reasons for populations peaking during December and January.

Low fruit fly population in the field means low quarantine risk for the host crops grown during that period. This extensive trapping data, in combination with other supporting information, could be used for establishing a seasonal window (as a component of a systems approach) for the Bowen and Gumlu regions.

2. Evaluation of preharvest treatment and pack-house mitigation measures as fruit fly quarantine procedures in tomato production

A systems approach for tomato production in Bowen

2.1 Summary

This study was focused on commercial tomato production systems in the Bowen region, where fruit were harvested from June to November. A fruit sampling program was designed to evaluate the effectiveness of preharvest (field) cover sprays and postharvest mitigation measures in pack-houses but not including postharvest dips. The cover sprays were carried out according to commercial practice by participating growers or contract spray operators.

A total of 17,626 field-harvested and 11,755 pack-house fruit were sampled from ten tomato farms and research station trials. The fruit were incubated and then examined for fruit fly infestation over three cropping seasons (2006, 2007 and 2008).

No fruit fly infestation was recorded over the three seasons in either the field or the pack-house samples. The pack-house and field samples were harvested from the same block on the same day, so it is safe to assume that the samples came from the same population and experienced the same fruit fly pressure. Therefore infestation levels have been calculated for the field and pack-house samples combined. Statistical analysis showed that upper infestation levels were extremely low (between 0.025 and 0.062 %) at the 95% confidence level (Table 1).

Table 1. Summary of fruit fly infestation levels: - combined results across tomato farms for 2006, 2007 and 2008 seasons.

Preharvest fruit fly treatments	Year	No. Fruit Sampled		Total No. Fruit Sampled	No. Fruit Infested	Upper % Infestation (95% confidence)
		Field	Packhouse			
With trichlorfon field sprays	2006	949	960	1,909	0	0.1569
	2007	3583	2506	6,089	0	0.0492
				7,998	**0**	
Without dimethoate or trichlorfon sprays	2006	2659	2172	4,831	0	0.0620
	2007	7184	4587	11,771	0	0.0254
	2008	3251	1530	4,781	0	0.0627
				21, 383	**0**	

Spray records were collected from sampled tomato farms in the 2006, 2007 and 2008 seasons. This exercise was to match insecticide use-patterns with fruit fly infestation levels for each sampling block on a particular farm. The crop blocks were sprayed at 7 to 10 day intervals between March and August and then at 5 to 7 day intervals until November. Two broad-spectrum insecticides (methomyl, bifenthrin) were used frequently across the farms, mainly targeting helicoverpa spp., silverleaf whitefly (SLW) and mites.

District-wide monitoring of fruit fly activity was undertaken from August 2006 to December 2009. Around 50 cue-lure traps were placed across the district, covering tomato and capsicum farms, riverbanks and natural vegetation. The trap catches reflected a seasonal pattern in fruit fly activity, with low numbers during the autumn and winter months, rising slightly in spring and increasing further in summer. There was a rapid increase in fruit fly numbers in traps between September and January; this seasonal pattern was similar over the four seasons. However, the rate of increase in fruit fly numbers in spring and summer appeared to be substantially moderated by insecticide use on the sampled farms.

2.2 Introduction

Queensland fruit fly (*Bactrocera tryoni*) and its sibling species, lesser Queensland fruit fly (*B. neohumeralis*), are quarantine pests of fruits and fresh vegetables such as capsicums and tomatoes. The insecticide dimethoate is used widely in both preharvest and postharvest treatments to ensure that produce is free from fruit flies to meet domestic and export market access requirements.

Around 50% of the Queensland’s tomato production is based in the Bowen region. The fruit are harvested during the cooler months from May until November. The major markets for Queensland fresh tomatoes are Sydney, Melbourne, Brisbane and Adelaide. A small proportion is exported to New Zealand during the winter months.

Dimethoate and fenthion have been reviewed at a national level and dimethoate will no longer be allowed for post harvest use in tomatoes and capsicums. The loss of dimethoate for preharvest and/or postharvest treatments will have a very serious impact on the capsicum and tomato industries in Queensland if suitable alternative methods to meet quarantine market access requirements for fruit fly are not found.

The International Plant Protection Convention (IPPC) has defined system approaches as the integration of different pest management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of phytosanitary protection (ISPM, 2002).

One of the alternatives to dimethoate treatment is to develop a systems approach to meet market access requirements, where a number of independent procedures (e.g. ascertaining fruit fly prevalence, the influence of seasonal conditions, field control measures and pack-house quality control practices) can contribute to minimising the risk of fruit fly infestation.

Project aims and scope

The scope of the project is to find alternatives to the use of dimethoate or fenthion for fruit fly control while maintaining domestic market access. The research undertaken evaluated the effectiveness of preharvest insecticide sprays (used in the crops for other purposes) and postharvest mitigation measures in reducing the risk of fruit fly infestation in tomato produced for interstate markets.

2.3 Materials & Methods - Evaluation

This study focused on Bowen tomato production region in Queensland. These activities were extended to three cropping seasons to determine the impact of seasonal effects and different levels of fruit fly pressure on fruit infestation.

Details of tomato production and management practices

Information on tomato production and cultivation practices was collated by interviewing growers, consultants and a local agronomist. In addition, the project leader had gathered the information through his regular farm visits and while working with the Bowen tomato industry over the past 10 years. The details are summarised in Table 2.

Table 2. Summary of the industry standard practices for tomato production

Growing and Management Practices	Descriptions
Number of farms	14 field grown and 1 glasshouse
Cultivated area & volume	Estimated at 1500 ha and 90,000 tons
Type of tomato	Gourmet on trellis (85%), Roma on trellis (10%) and Round on ground (5%)
Common varieties	Pinnacle, Lava, Ember, Manilla, Guardian
Major interstate and export markets	NSW, Victoria, SA, WA & Tasmania. Export to New Zealand
Growing season	February to November
Harvest season	From mid-May through November
Plant population	Between 11,000 and 16,000 plants/ ha
Cultivation practices	Transplanting into polythene mulched bed, trickle irrigation, and fertigation, pruning and trellising
Weed control	Pre- and post-emergence herbicides, and inter-row sprays
Major insect pests	Silverleaf whitefly, heliothis, mites, aphids, potato moth
Pest management	Routine and monitoring-based insecticide sprays at 5 to 14 day intervals. Ground-rig application with 300 to 800 L spray volume. (insecticide sprays are given in Appendix 1)
Major fungal diseases	Target spot, bacterial spots, powdery mildew, fusarium wilt
Disease control	Fungicide applications at 5 to 14 days intervals.
Market access treatments	Most farms flood spray with dimethoate postharvest (ICA-02). Three farms used trichlorfon preharvest spray for NZ export.
Fruit harvests	Sequential picking at breaker to half-coloured fruit at 4 to 7 day intervals.
Pack-house operations	Washing (iodine or chlorine), manual sorting, colour grading, controlled ripening, dimethoate flood spray, sorting, packing and inspection, cooling and transport.

Insecticide cover sprays

The objective of this exercise was to match insecticide use patterns with fruit fly infestation levels for each sampling block of a particular farm.

Insecticide cover sprays were applied to the trial blocks by participating growers. The sprays were selected based on the type of pest and pressure levels or the recommendation provided by crop consultants. The spray records were maintained by the collaborating growers or crop consultants.

Spray records were collected from tomato growers who participated in fruit sampling during the 2006, 2007 and 2008 seasons. For each sampling block, the insecticide sprays that were applied 4 to 5 weeks prior to the fruit sampling were extracted from the spray records. In addition, the spray intervals and spray volume were documented.

Dimethoate or trichlorfon are the preharvest spray options for interstate (eg ICA 26) or New Zealand market protocols. Three tomato farms with accreditation to export to New Zealand markets that applied fruit fly specific preharvest sprays (trichlorfon) to the crop block were included in the sampling program but were recorded separately.

Fruit fly monitoring

This component was aimed at quantifying fruit fly activity periods in commercial production regions Bowen and Gumlu. As well as to establish low population periods with a view to incorporating such information into systems approaches to meet market access requirements.

District-wide fruit fly trapping was conducted for over four seasons (August 2006 to December 2009) in Bowen. Around 50 cue-lure baited Lynfield traps were placed across the district for the 40 month survey. This trapping has covered tomato and capsicum farms, riverbanks and native vegetation in the Bowen region. On all tomato farms, fruit fly trapping continued throughout the year from 2006 to 2009. A minimum of two traps per farm were placed within cultivated boundaries. Traps were cleared at fortnightly intervals and trap catches were counted and identified to species level.

Field harvest fruit sampling

A monthly fruit sampling program covering eight commercial tomato farms was conducted during the 2006, 2007 and 2008 seasons.

A systematic sampling procedure developed by one of the project biometricians (based on Jorgensen *et al.* 2003) was followed for field sampling. The tomato blocks were between 2 and 4 ha in size. The field samples (200 – 300 fruit/ crop block/ sample) were collected by the project staff immediately prior to commercial harvest. Fruit of commercial harvest size and red coloured fruit (but irrespective of blemishes) were selected across the entire block (Fig 1a).

In 2006, the first season fruit sampling was conducted from October to December from four farms. Two farms used no preharvest dimethoate or trichlorfon treatments. The other two farms used trichlorfon as preharvest fruit fly treatments as a requirement for New Zealand export.

In 2007, the second season fruit sampling program was conducted to cover the entire tomato harvest season to determine the levels of fruit infestation under different fruit fly pressures during the season. Six tomato farms and research station trial crops were sampled from June to December at 3-4 weeks intervals. Seven blocks on the farms had no preharvest dimethoate or trichlorfon sprays and three blocks received preharvest trichlorfon sprays. Only field samples were collected from research station crops but no pack-house sample.

In 2008, the third season fruit sampling program was conducted during the latter part of the season. This was to confirm the 2007 season results and to focus more on the high fruit fly activity period (September to December), as identified during the trapping program. Six tomato farms and research station crops were sampled from September to November. None of the farms used preharvest dimethoate or trichlorfon as cover sprays in the field.

Pack-house fruit sampling

In this component, the effectiveness of pack-house mitigation measures was evaluated as a means to intercept fruit fly infested fruit.

Harvested bins of fruit are tracked from harvest in the field through the pack-house process. In the packing line, the fruit were processed according to the order the harvested-bins were transported from the field. Hence, we ensured the pack-house samples were taken from the fruit batch originating from the same block and on the same day as the in-field harvest sample.

Pack-house samples were randomly collected by the pack-house supervisor or quality control staff after fruit (originating from the same field blocks) had been washed, sorted and colour graded through the normal commercial packing line but before the postharvest dimethoate treatments were applied. For each sampling date, a total of 200 to 250 fruit were sampled to represent coloured fruit for each block run (Fig. 1b).

Incubation and assessment of fruit samples

Both field and pack-house samples were transported to the Horticulture Research Station (HRS) immediately after collection. Fruit were sorted based on ripening stage (full coloured or half-coloured) and placed in ventilated plastic containers. The containers, each with approximately 8-12 fruit, were incubated at 26± 2^{o}C and 70-80% relative humidity to allow eggs and larvae to develop. After 7 to 10 days of incubation, each entire fruit was cut open and examined for fruit fly presence. Any larvae from an infested fruit or pupae found in the containers (including *Atherigona* sp.) were removed and counted, and reared through to adults for species confirmation.

Statistical analysis

The upper percentage infestation (with 95% confidence) for fruit fly in tomatoes were calculated by a project biometrician. All calculations were performed using CQT_Stats (Liquido etal, 1997). Upper infestation levels were based on the number of samples taken and the number of infested fruit found. The samples of 6,000 field and 6,000 pack fruit were targeted across tomato farms as to allow detection of infestation levels of 0.05% with 95% confidence at each of harvest and pack.

Figure 1a. Tomato field harvest

Figure 1b. Tomato pack-house sorting process

2.4 Results and Discussion

2.41 Fruit fly infestation levels in field and pack-house fruit samples

The sampling program was designed to determine fruit fly infestation levels on each tomato farm during the commercial harvest period (field sample) and after fruit from the same block had passed through the commercial packing line (pack-house sample).

The farms for sampling were selected on the basis of their Interstate Certification Assurance (ICA) and export accreditation arrangement that included either no fruit fly sprays or trichlorfon or dimethoate preharvest sprays in the field. All the farms had regular insecticide programs to control other insect pests such as helicoverpa spp., silverleaf whitefly, aphids and mites (Table 7, 8 and 9).

Fruit sampling 2006

A total of 6,740 tomatoes were sampled across the four farms at 2-3 week intervals from October to December 2006. **No fruit fly infestation** was found in 2,659 field fruit or in the 2,172 pack-house sample from the farms not using trichlorfon preharvest. Similarly, no fruit fly infestation was found in the 949 field fruit or in the 960 pack-house sample from the farms applying trichlorfon sprays preharvest (Table 3).

Since the field and pack-house samples were harvested from the same blocks at the same time in any given sample, it is reasonably assumed both samples have been drawn from the same population, have been subjected to the same growth conditions and the same fruit fly pressure. It is also assumed that the infestation level of the pack-house fruit is no greater than that of the fruit in the field. Hence the two samples for each treatment have been combined to give a better estimate of the maximum infestation level in the total fruit. Using a similar argument (given that no infestation was found in any of the samples at any pick on either farm), all samples from both farms in each trichlorfon use category have been combined to give an overall estimate for the district of infestation levels.

Statistically, after combining results across the two farms for each treatment and across field and pack-house samples, the 2006 sampling shows that the upper % infestation (at 95% confidence) was:

- No trichlorfon preharvest or dimethoate postharvest: 0.0620% (a total of 4,831 fruit)
- Trichlorfon preharvest spray, no dimethoate postharvest: 0.1569% (a total of 1,909 fruit).

Table 3. Fruit fly infestation levels in tomatoes in the Bowen region, 2006 season

(no postharvest dimethoate – with and without dimethoate or trichlorfon sprays in the field)

Farm ID	Sampling period	Sample Type	Number of samples	No. of fruit sampled	No. of infested fruit	Larvae / fruit	Upper % infestation (95% confidence)
Without dimethoate or trichlorfon preharvest sprays							
Farm-1	Oct & Nov	Field	2	470	0	0	
		Pack	2	414	0	0	
				884	**0**	**0**	**0.3389**
Farm-2	Sep to Nov	Field	3	710	0	0	
		Pack	3	608	0	0	
				1318	**0**	**0**	**0.2273**
Farm-3	Sep to Dec	Field	6	1479	0	0	
		Pack	5	1150	0	0	
				2629	**0**	**0**	**0.1139**
Farm-1+ Farm-2 + Farm-3	***GRAND TOTAL***		**21**	**4831**	**0**	**0**	**0.0620**
With trichlorfon preharvest sprays							
Farm-1	*Sep*	Field	1	256	0	0	
		Pack	1	232	0	0	
				488	**0**	**0**	**0.6139**
Farm-4A	Sep, Oct, & Nov	Field	3	693	0	0	
		Pack	3	728	0	0	
				1421	**0**	**0**	**0.2108**
Farm-3+ Farm- 4A	***GRAND TOTAL***		**8**	**1909**	**0**	**0**	**0.1569**

Fruit sampling 2007

Three of the six farms plus research station used no preharvest dimethoate or trichlorfon sprays throughout the season. The other three farms (Farm 1, 4B and 5) used trichlorfon preharvest sprays during the winter window (1 May to 1 September) for NZ export, but no trichlorfon was used from October to December.

A total of **17,860** tomatoes were sampled across the seven farms at 3-4 week intervals. Results show **no fruit fly infestation** in 7,184 field fruit or in the 4,587 pack-house sample **without** preharvest fruit fly sprays of dimethoate or trichlorfon (Table 4). Similarly, **no fruit fly infestation** was found in the 3,583 field fruit or in the 2,506 pack-house sample with trichlorfon sprays applied for preharvest fruit fly control (Table 5).

Given that no infestation was found in any of the samples at any harvest on any farm, all samples from farms with or without trichlorfon sprays have been combined to give an overall estimate for the district infestation levels.

Statistically, after combining results across the farms for each treatment and across field and pack-house samples, the 2007 sampling shows that the upper % infestation (at 95% confidence) was:

- No trichlorfon preharvest or dimethoate postharvest: 0.0254% (a total of 11,771 fruit)
- Trichlorfon preharvest spray, no dimethoate postharvest: 0.0492% (a total of 6,089 fruit)

Table 4. Fruit fly infestation levels in tomatoes in the Bowen region, 2007 season
(No postharvest dimethoate – without dimethoate or trichlorfon sprays in the field)

Farm ID & Location	Sampling period	Sample Type	No. of samples	No. of fruit sampled	No. of infested fruit	Larvae / fruit	Upper % infestation (95% confidence)
Without dimethoate or trichlorfon preharvest sprays							
Farm-1	*Nov*	Field	1	294	0	0	
		Pack	1	214	0	0	
		Sub total		**508**	**0**	**0**	**0.5897**
Farm-2	Jun to Nov	Field	7	2145	0	0	
		Pack	6	1195	0	0	
		Sub total		**3340**	**0**	**0**	**0.0897**
Farm-3	Jun to Nov	Field	7	2046	0	0	
		Pack	7	1490	0	0	
		Sub total		**3536**	**0**	**0**	**0.0847**
Farm-4B	Oct & Nov	Field	2	615	0	0	
		Pack	1	204	0	0	
		Sub total		**819**	**0**	**0**	**0.3658**
Farm-5	Oct	Field	2	585	0	0	
		Pack	2	410	0	0	
		Sub total		**995**			**0.3011**
Farm-6	Jul to Nov	Field	5	1309	0	0	
		Pack	5	1074	0	0	
		Sub total		**2383**	**0**	**0**	**0.1257**
Research station trial	Oct	*Field*	1	190	0	0	1.5767
Farms 1+ 2+3+4B+5+6	***GRAND TOTAL***		**47**	**11,771**	**0**	**0**	**0.0254**

Table 5. Fruit fly infestation levels in tomatoes in the Bowen region, 2007 season
(No postharvest dimethoate – with trichlorfon sprays in the field)

Farm ID & Location	Sampling period	Sample Type	No. of samples	No. of fruit sampled	No. of infested fruit	Larvae / fruit	Upper % infestation (95% confidence)
With trichlorfon preharvest sprays							
Farm-1	*Jun to Oct*	Field	5	1442	0	0	
		Pack	5	942	0	0	
		Sub total		**2384**	**0**	**0**	**0.1257**
Farm-4B	Jul to Sep	Field	4	1206	0	0	
		Pack	4	735	0	0	
		Sub total		**1941**	**0**	**0**	**0.1543**
Farm-5	***Jul to Sep***	Field	**3**	**935**	**0**	**0**	
		Pack	**3**	**829**	**0**	**0**	
		Sub total		**1764**	**0**	**0**	**0.1698**
Farm-1+ 4B+5	***GRAND TOTAL***		**25**	**6,089**	**0**	**0**	**0.0492**

Fruit sampling 2008

The third season fruit sampling program was conducted to confirm the 2007 season results and focused on the main fruit fly activity period (September to December). Six/seven tomato farms, without preharvest dimethoate or trichlorfon treatments, were selected for the sampling.

A total of 4,781 tomatoes were sampled across the six farms and research station trials at 3-4 week intervals. Results show **no fruit fly infestation** was found in 3,251 field fruit or in the 1,530 pack-house sample.

Statistically, after combining results across the farms and across field and packhouse samples, the 2008 sampling shows that the upper % infestation (at 95% confidence) was 0.0627% (Table 6).

Table 6. Fruit fly infestation levels in tomatoes in the Bowen region, 2008 season
(No postharvest dimethoate – without dimethoate or trichlorfon sprays in the field)

Farm ID & Location	Sampling period	Sample Type	No. of samples	No. of fruit sampled	No. of infested fruit	Larvae / fruit	Upper % infestation (95% confidence)
Without dimethoate or trichlorfon preharvest sprays							
Farm-1	Nov	Field	1	277	0	0	**1.0815**
Farm-3	Sep to Nov	Field	3	762	0	0	
		Pack	3	647	0	0	
		Sub total		**1409**	**0**	**0**	**0.2126**
Farm-6	Oct	Field	1	218	0	0	
		Pack	1	250	0	0	
		Sub total		**468**	**0**	**0**	**0.6401**
Farm-7	Sep & Oct	Field	3	689	0	0	
		Pack	3	633	0	0	
		Sub total		**1322**	**0**	**0**	**0.2266**
Farm-8	Nov	Field	1	496	0	0	**0.6040**
Farm-9	Dec	Field	1	276	0	0	**1.0854**
Research trials	Jun & Oct	Field	4	533	**0**	**0**	**0.5620**
Farms 1+ 2+3+4B+5+6	***GRAND TOTAL***		**17**	**4,781**	**0**	**0**	**0.0627**

2.42 Insecticide cover sprays

A summary of the insecticide sprays applied on the sampling blocks across the nine tomato farms is listed in Tables 7, 8 and 9. These spray data for each block were matched with the fruit fly infestation of the relevant sampling block of the particular farm. The details of the insecticide sprays that were applied five weeks prior to field harvest for each block are given in Appendix 1.

The key results are summarised below:

- Insecticides belonging to various chemical groups (1A, 1B, 3A, 4A, 5, 6, 7C, 9B and 16) were sprayed to control a range of insect pests, but there was a consistent pattern in the use of some broad-spectrum insecticide across farms.

- Two broad-spectrum insecticides, **methomyl and bifenthrin,** were sprayed on a regular basis from fruiting to final harvest. This pattern was consistent across the nine tomato farms throughout the season.

- Two narrow-spectrum insecticides, **spinosad and abamectin,** were often used, but mainly for specific pests such as heliothis, thrips and mites.

- On a few occasions, other pyrethroid products such as beta-cyfluthrin and alpha-cypermethrin were used instead of bifenthrin.

- Two other whitefly specific insecticides, pyriproxyfen and pymetrozine, were used on most farms but often later in the season. It is expected that these two insecticides would have minimal impact on the fruit fly population.

- Organophosphate insecticides (methamidophos) were occasionally sprayed but only on three farms.

- On most farms, 7-10 day spray intervals were followed during the winter months and 5 -7 days during the spring months.

- On three farms, trichlorfon was applied at 7 to 10 day intervals only during the winter window (June to September) as a market access requirement for exporting fruit to New Zealand.

- All the farms (except Farm 4A in 2006) had no trichlorfon sprays during October / November. Even though fruit fly activity increased during October/November, no fruit fly infestation was recorded in the fruit samples collected from the tomato blocks that were not sprayed with trichlorfon.

- The cover sprays applied on the crop during October - November were more important because fruit fly activity gradually increased (see Fig. 3). Spray details for that period are given in Table 9.

Table 7. Number of insecticide sprays applied 4 to 5 weeks prior to fruit harvest in the tomato farms, Sep – Dec 2006

Farms	Farm 1			Farm 2			Farm 3						Farm 4			Total sprays
Blocks	B1	B2	B3	B1	B2	B3	B1	B2	B3	B4	B5	B6	B1	B2	B3	
Abamectin	0	0	0	0	1	2	0	1	1	4	3	1	2	1	1	17
Alpha-cypermethrin	0	0	0	0	0	0	0	2	1	1	1	1	0	0	0	6
Beta-cyfluthrin	0	3	3	0	0	0	4	3	1	2	2	1	0	0	0	19
Bifenthrin	2	2	3	4	3	3	0	1	2	4	4	2	3	2	3	38
Buprofezin	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2
Emamectin	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	4
Endosulfan	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2
Imidacloprid	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	3
Methamidophos	0	0	0	0	0	0	1	0	1	2	2	0	0	0	0	6
Methomyl	5	4	3	3	4	4	4	4	6	4	4	2	0	2	1	50
Petroleum oil	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2
Pymetrozine	0	0	0	2	1	0	0	0	1	3	3	2	2	0	0	14
Pyriproxyfen	1	3	3	1	2	1	1	0	0	0	0	0	2	0	0	14
Spinosad	3	0	1	2	4	3	0	0	2	0	0	0	4	2	1	22
Total insecticides/ block	**11**	**13**	**13**	**12**	**16**	**14**	**10**	**11**	**15**	**22**	**22**	**9**	**15**	**9**	**7**	

Table 8a. Number of insecticide sprays applied 4 to 5 weeks prior to fruit harvest in tomato (Farms 1, 2 and 3), Jun - Nov 2007

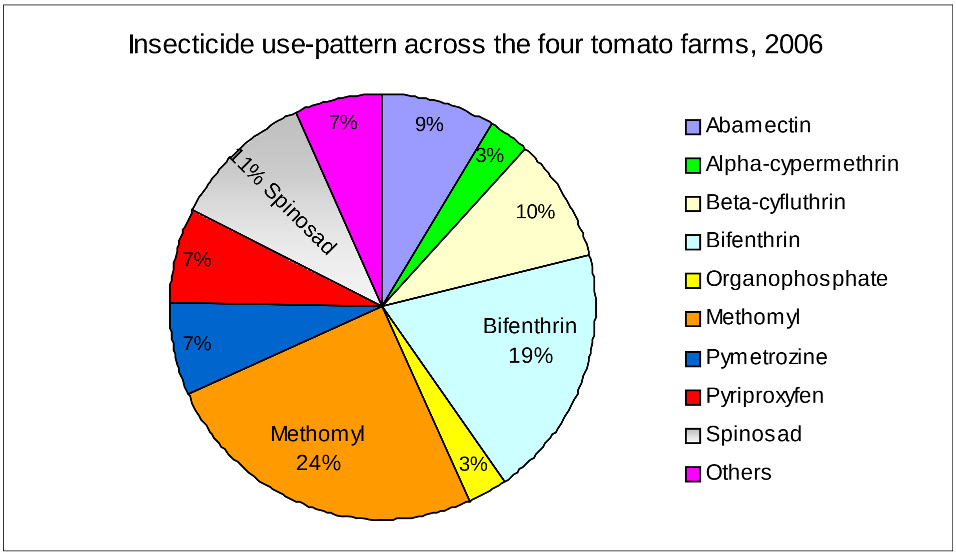
Farms	Farm 1					Farm 2							Farm 3							Total sprays
Blocks	B1	B2	B3	B4	B5	B1	B2	B3	B4	B5	B6	B7	B1	B2	B3	B4	B5	B6	B7	
Abamectin	0	0	0	0	0	1	0	1	1	1	2	1	0	0	0	0	0	1	0	**8**
Alpha-cypermethrin	0	0	0	0	1	0	0	0	0	0	0	0	0	2	1	2	1	1	1	**9**
Beta-cyfluthrin	1	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	2	**7**
Bifenthrin	2	3	3	5	3	1	2	2	2	2	2	2	1	1	1	1	3	3	3	**42**
Buprofezin	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**1**
Emamectin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Imidacloprid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	**2**
Methomyl	5	3	2	3	2	2	0	5	1	2	1	0	0	4	2	3	3	3	3	**44**
Organophosphate	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	3	**6**
Petroleum oil	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Pymetrozine	0	0	0	0	0	1	0	0	2	2	2	2	0	0	0	0	0	0	0	**9**
Pyriproxyfen	1	3	1	3	2	0	1	1	1	1	0	0	0	0	0	0	1	0	0	**15**
Spinosad	1	0	0	0	0	3	1	2	2	3	2	1	0	0	1	3	0	0	4	**23**
Total insecticides/ block	**10**	**10**	**6**	**11**	**8**	**10**	**4**	**12**	**10**	**12**	**9**	**6**	**2**	**7**	**5**	**9**	**9**	**10**	**17**	

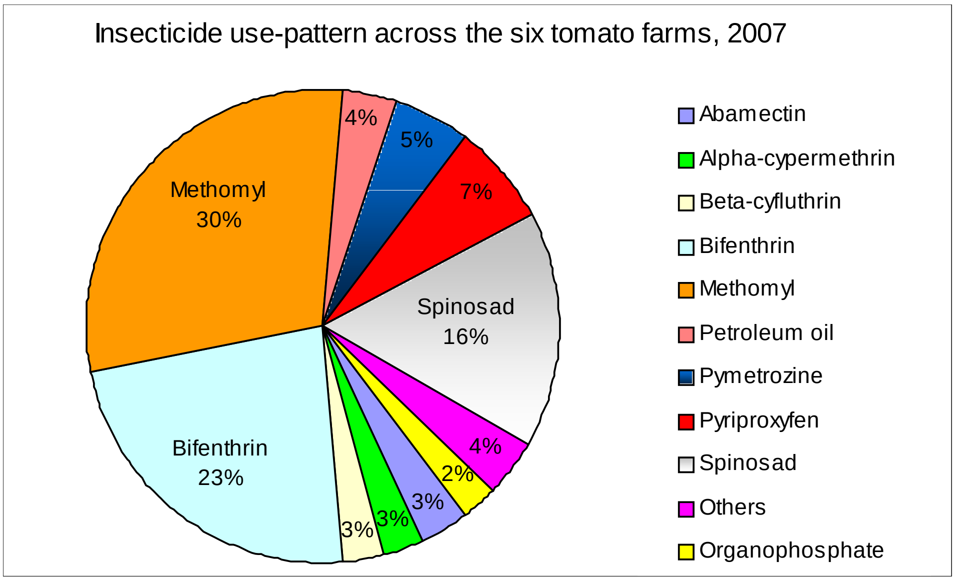
Table 8b. Number of insecticide sprays applied 4 to 5 weeks prior to fruit harvest in the tomato (Farms 4, 5 and 6), Jun - Nov 2007

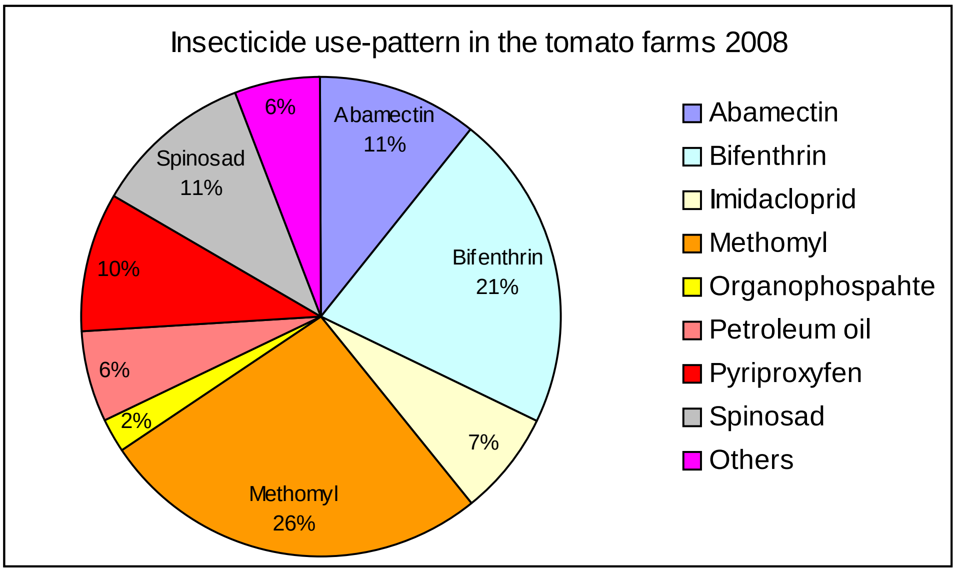
Farms	Farm 4						Farm 5					Farm 6					
Blocks	B1	B2	B3	B4	B5	B6	B1	B2	B3	B4	B5	B1	B2	B3	B4	B5	**Total sprays**
Abamectin	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	3
Alpha-cypermethrin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beta-cyfluthrin	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	2
Bifenthrin	2	2	2	4	4	2	1	2	0	3	2	1	1	2	3	4	35
Buprofezin	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2
Emamectin	1	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	4
Imidacloprid	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Methomyl	2	4	0	1	1	2	5	6	5	5	4	0	1	4	6	7	53
Organophosphate	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	2
Petroleum oil	3	0	2	2	3	1	0	0	0	0	0	0	0	0	0	0	11
Pymetrozine	1	0	2	0	2	1	0	0	0	0	0	0	0	0	1	1	8
Pyriproxyfen	1	1	1	3	1	1	0	0	0	0	0	0	0	0	0	0	8
Spinosad	3	3	3	3	2	2	0	0	1	1	1	2	0	3	3	3	30
Total insecticides/ block	**13**	**12**	**10**	**16**	**14**	**11**	**7**	**8**	**8**	**10**	**7**	**3**	**2**	**10**	**13**	**15**	

Table 9. Number of insecticide sprays applied 4 to 5 weeks prior to fruit harvest in tomato farms, Sep - Dec 2008

Farms	Farm 1	Farm 3			Farm 6	Farm 7			Farm 8	Farm 9	Total sprays
Blocks	B1	B1	B2	B3	B1	B1	B2	B3	B1	B1	
Sampling date	4-Oct	8-Sep	13-Oct	5-Nov	21-Oct	26-Sep	20-Oct	29-Oct	11-Nov	1-Dec	
Abamectin	1	0	2	1	0	1	0	0	2	2	9
Beta-cyfluthrin	0	0	0	0	0	0	1	1	0	0	2
Bifenthrin	2	2	1	1	2	1	3	3	1	2	18
Buprofezin	0	0	0	0	0	1	1	0	0	0	2
Imidacloprid	0	0	0	0	0	1	2	2	1	0	6
Methomyl	2	3	2	3	2	2	2	2	3	1	22
Organophosphate	0	1	0	0	0	0	0	0	0	1	2
Petroleum oil	0	1	0	1	0	1	1	1	0	0	5
Pymetrozine	0	0	1	0	0	0	0	0	0	0	1
Pyriproxyfen	2	0	1	1	1	0	1	1	1	0	8
Spinosad	1	0	0	1	3	2	1	0	1	0	9
Total insecticides/ block	**8**	**7**	**7**	**8**	**8**	**9**	**12**	**10**	**9**	**6**	


Insecticide use-pattern across the four tomato farms, 2006
9%
3%
10%
Bifenthrin
19%
3%
Methomyl
24%
7%
7%
11% Spinosad
7%
Abamectin
Alpha-cypermethrin
Beta-cyfluthrin
Bifenthrin
Organophosphate
Methomyl
Pymetrozine
Pyriproxyfen
Spinosad
Others


Insecticide use-pattern across the six tomato farms, 2007
4%
5%
7%
Spinosad
16%
4%
2%
3%
3%
3%
Bifenthrin
23%
Methomyl
30%
Abamectin
Alpha-cypermethrin
Beta-cyfluthrin
Bifenthrin
Methomyl
Petroleum oil
Pymetrozine
Pyriproxyfen
Spinosad
Others
Organophosphate

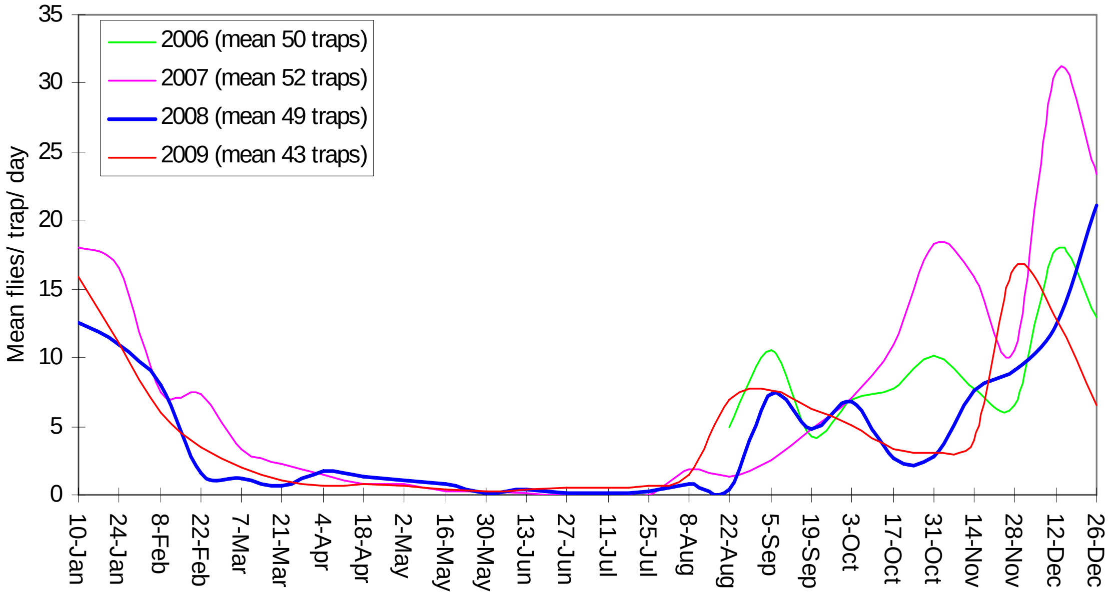

Insecticide use-pattern in the tomato farms 2008
Abamectin
11%
Bifenthrin
21%
7%
Methomyl
26%
2%
6%
10%
Spinosad
11%
6%
Abamectin
Bifenthrin
Imidacloprid
Methomyl
Organophospahte
Petroleum oil
Pyriproxyfen
Spinosad
Others

2.43 Fruit fly activity periods

District-wide trapping

The mean trap catches across the Bowen region for the three and a half year period are shown in Figure 2. Cue-lure trap catches reflected a seasonal pattern in fruit fly activity, with low numbers during autumn and winter months, moderate numbers in spring and high in summer.

Fig. 2 Seasonal activity of QFF in the Bowen district, from Aug 2006 to Dec 2009



The trap catches varied with trap locations and vegetation type. Fly numbers were higher in the traps located on riverbanks and vegetation adjacent to fruit trees, while the numbers were low in the traps on farms with open terrain.

Fly numbers were very low during autumn and winter months for 2007, 2008 and 2009. From March to August average trap catches along the river (0.5 - 6.0 flies/ trap/ day) and on the farms (0 - 0.3 flies/ trap/ day) were low. The vegetable production season starts in March and continues until November, with the major part of the fruit harvest season coinciding with the low fruit fly period.

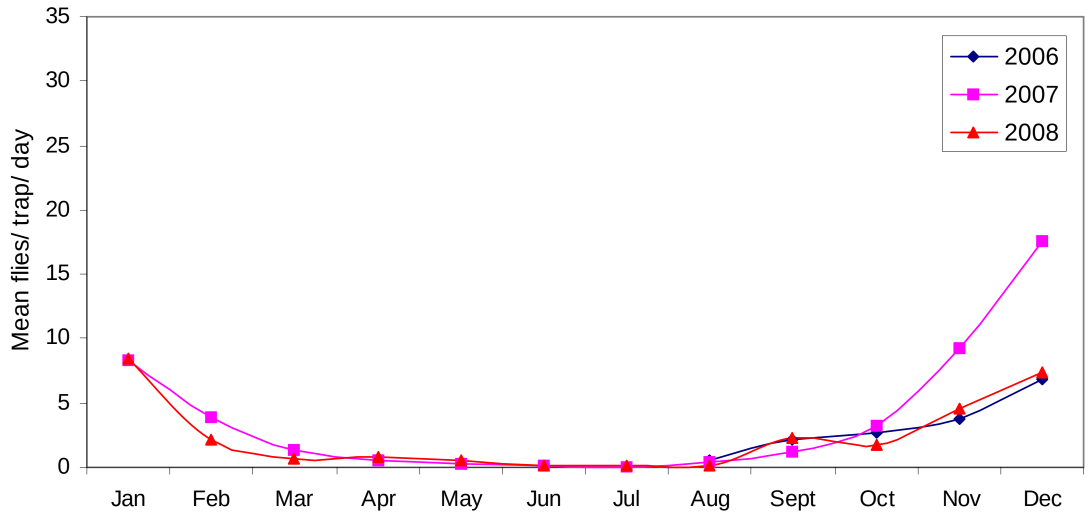
The increase in fruit fly numbers starts in August, with numbers peaking in November/ December to early January; this seasonal pattern was similar over the four seasons (Fig. 2). This coincides with end of the vegetable season and the cessation of field sprays on most vegetable farms. Therefore, this peak of activity for fruit fly is not a concern for the vegetable industry as the production season ends in November.

Queensland fruit fly and lesser Queensland fruit fly were the predominant species accounting for 70 and 25% of catches respectively. Smaller proportions of non-pest species (*B. bryoniae*, *B. chorista* and *Dacus aequalis*) were also recorded.

Tomato farm trapping

The trapping data showed that fruit fly activity from March to October was very low (average of 0 – 3 flies/ trap/ day) on all eight tomato farms, with almost no flies caught in many traps between late May and August (Fig. 3). The farm trap catches started to increase by early November and peaked in December. Although the average number of fruit flies trapped varied between farms, the seasonal activity pattern over the three seasons (2006, 2007 and 2008) was consistent (Fig. 3).

Fig. 3 Fruit fly catches for three seasons, aveараged from eight different tomato farms



Trapping data from tomato Farm-1 and Farm-3 indicated a lower level of fruit fly activity during November and December 2008 compared to the same period in 2007. An early season peak in January and February, very low numbers from March to October and an increase in populations in November were features common to the two tomato farms (Figs. 4 and 5). Farm-1 is located in open area and near a river, while Farm-3 was close to a creek and natural vegetation.

Fig. 4. Fruit fly trap catches in Tomato Farm-1 from Aug 2006 to Dec 2008

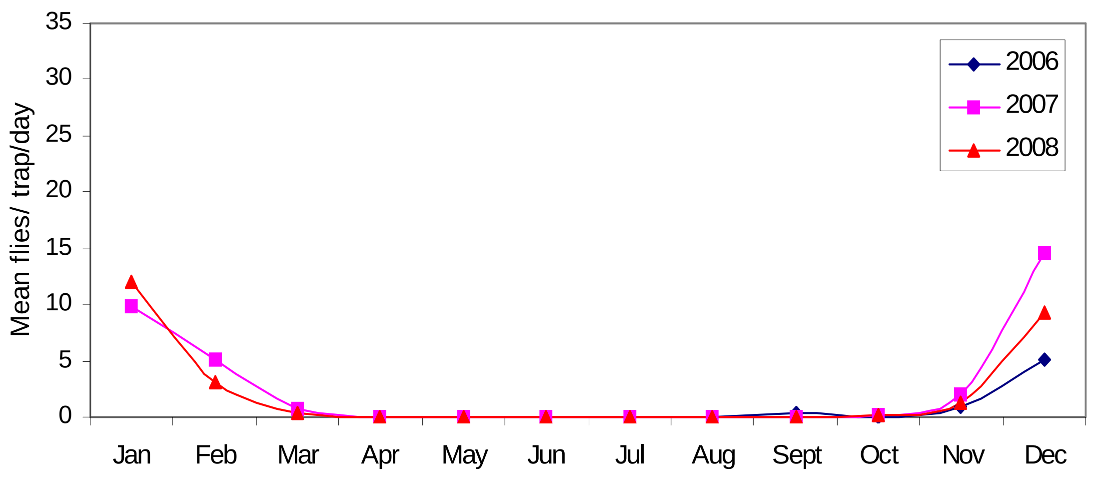
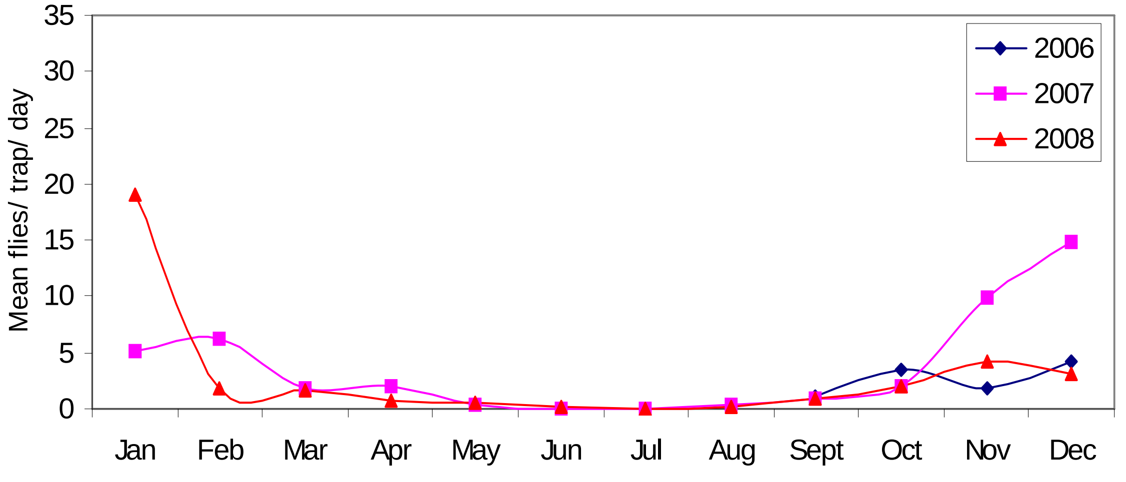


Fig. 5. Fruit fly trap catches in Tomato Farm-3, from Aug 2006 to Dec 2008

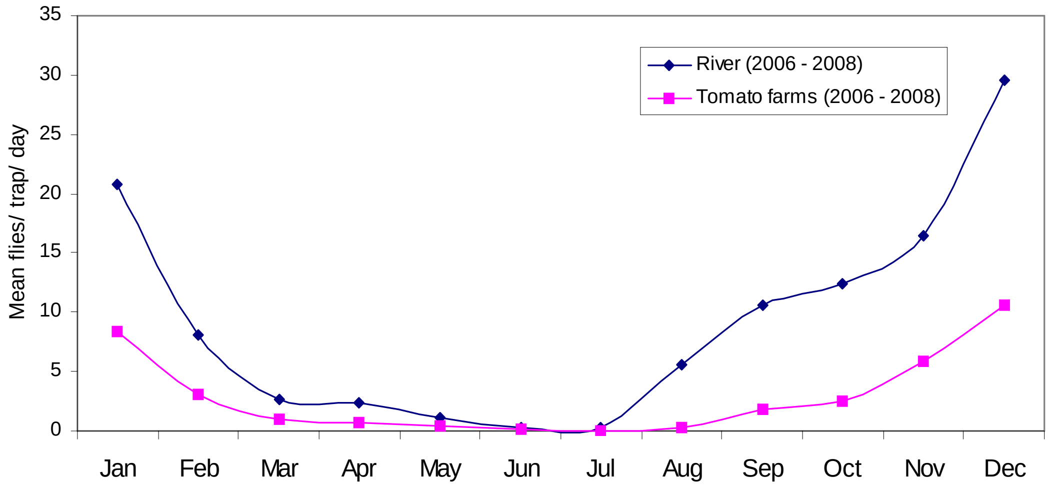


Trapping data over the three seasons indicated that fruit fly numbers varied greatly between tomato farms and river or natural vegetation locations. The cue-lure traps that were installed within or close to river or creek vegetation and fruiting trees (e.g. mango) caught more fruit flies than the traps placed around tomato blocks (Fig. 6).

From March to July trap catches along the river and in the farms were very low with mean catches of 0.1- 2.6 flies per trap per week. All river traps showed a very rapid increase in numbers from August to December while the tomato farm traps showed a slow increase until December (Fig. 6).

No relationship between trap catches and fruit infestation levels for any particular farm could be determined as no infested fruit were recorded. The trap catches during November were moderately high around the tomato farms (average of 6 flies per trap per day), but no infestation was found in the sampled fruit. This probably was due to the insecticide cover sprays that were applied at regular intervals for controlling other pests in the crop (Tables 7 to 9).

Fig. 6 Fruit fly catches in river and tomato farm traps, averaged over three seasons



2.5 Conclusions

- This study has demonstrated that tomatoes grown under commercial spray programs and harvested from June to November had negligible risk of fruit fly infestation. Such fruit could be considered for interstate markets with no dimethoate treatments in the pack-house. This has been proven through the extensive sampling program conducted in the Bowen region, where a large volume of samples (over 29,000 fruit) was assessed to give high levels of confidence.

- The current field sprays (Tables 7 to 9) used for other pests was sufficient to minimise fruit fly pressure during the harvest season in the Bowen region, and to prevent fruit fly infestation in the tomato fruit.

- As the fruit fly infestation levels were zero in the field samples, we were unable to determine the effectiveness of pack-house mitigation measures for any infested fruit originating from the same field blocks. However, the data collected for the pack-house samples over the three seasons provided additional evidence that the packed fruit were free from fruit fly infestation. This should provide further confidence in procedures for interstate and export markets.

- District fruit fly trapping over four consecutive seasons (from Aug 2006 to Dec 2009) clearly showed a "low fruit fly period" from March to August. These data provide further support to indicate that tomatoes grown during this period are at minimal risk of fruit fly infestation.

- Although trap catches increased around tomato farms and river banks during the October – November period, no fruit fly infestations were found in fruit samples (field or pack-house) collected during that period. This indicated that standard field control practices (insecticide cover sprays) practised by tomato growers were providing sufficient protection against fruit flies.

- It is highly likely that the risk reduction measures assessed would be acceptable to, and adoptable by, the tomato industry because the measures were based on existing commercial practice.

3. Evaluation of preharvest treatment and pack-house mitigation measures as fruit fly quarantine procedures in capsicum production

A systems approach for capsicum production Bowen and Gumlu regions

3.1 Summary

This study was focused on commercial capsicum production systems in the Bowen and Gumlu farming area where fruit is consistently harvested from May to November. A program was designed to evaluate the effectiveness of preharvest (field) cover sprays and postharvest mitigation measures in pack-houses but excluded postharvest flood sprays. The cover sprays were carried out according to commercial practice requirements by participating growers.

An extensive fruit sampling program was continued over a period of three years (2006, 2007 and 2008) in Bowen and Gumlu. A total of 13,722 field-harvested and 7,106 pack-house fruit were sampled covering 12 capsicum farms and the Bowen Research Station trials. The fruit were incubated and then examined for fruit fly infestation over the three cropping seasons.

The sampling results clearly indicated that the risk of fruit fly infestation was very minimal. **No** fruit fly infestations were recorded until November in either field or pack house samples. Only one infested capsicum was recorded from a field sample collected in November 2007, however the pack house sample originating from the same block had no infestation.

The pack-house and field samples were harvested from the same block on the same day, so it is safe to assume that the samples came from the same population and experienced the same fruit fly pressure. Therefore infestation levels have been calculated for the field and pack-house samples combined. Statistical analysis showed that upper infestation levels were very low (between 0.036 and 0.154 %) with a 95% confidence level (Table 3.1).

Spray records were collected from sampled capsicum farms. The crops had insecticide cover sprays consistently at 7–14 day intervals that provided sufficient protection against the fruit fly infestation. The two broad-spectrum insecticides, bifenthrin and methomyl, were commonly used across the 12 farms. These two insecticides have provided sufficient protection against the fruit fly in the field and is evident by the very low level infestation (upper % infestation 0.036) in capsicum fruit collected from farms that also alternated with methomyl and bifenthrin.

District-wide monitoring of fruit fly activity was undertaken from August 2006 to December 2009. The trap catches reflected a seasonal pattern in fruit fly activity, with low numbers during the autumn and winter months, rising slightly in spring and peaking in December. This seasonal pattern was similar over the four seasons. However, the rate of increase in fruit fly numbers in spring and summer appeared to be substantially moderated by insecticide use on the sampled capsicum farms.

Table 3.1 Summary of Fruit Fly Infestation Levels
(combined results across capsicum farms for 2006, 2007 & 2008)

Field Treatments	Harvest Season	Fruit Sampled	Total fruit Sampled	No. of Infested Fruits	No of larvae / fruit	Upper % Infestation (95% confidence)
Cover sprays* + trichlorfon or dimethoate	Winter	Field	1778	0	0	
		Pack	946	0	0	0.1100
	Spring	Field	2485	0	0	
		Pack	806	0	0	0.0910
Cover sprays* Only	Winter	Field	1170	0	0	
		Pack	770	0	0	0.1544
	Spring	Field	8289	1	11	
		Pack	4584	0	0	0.0368

* - insecticide sprays applied for controlling other pests

3.2 Introduction

Bowen and Gumlu are the major capsicum production regions in Queensland, with an estimated annual value of $91 million. The fruit are harvested during the cooler months from May until November. The major markets for Queensland fresh capsicums are Sydney, Melbourne, Brisbane and Adelaide. A small proportion is exported to New Zealand during the winter months.

Queensland fruit flies are quarantine pests of fruit and fresh vegetables such as capsicums and tomatoes. The insecticide dimethoate is used widely in both preharvest and postharvest treatments to ensure that produce is free from fruit flies to meet domestic and export market access requirements.

Dimethoate and fenthion are being reviewed at a national level and it is likely that certain uses of dimethoate will no longer be allowed when the review is completed. The loss of dimethoate for preharvest and/or postharvest treatments will have a very serious impact on the capsicum and tomato industries in Queensland if suitable alternative methods to meet quarantine market access requirements for fruit fly are not soon found.

The International Plant Protection Convention (IPPC) has defined system approaches as the integration of different pest management measures - at least two of which act independently, and which cumulatively achieve the appropriate level of phytosanitary protection (ISPM, 2002).

One of the alternatives to dimethoate treatment is to develop a systems approach to meet market access requirements where a number of independent procedures (e.g. ascertaining fruit fly prevalence, the influence of seasonal conditions, field control measures and pack-house quality control practices) can contribute to minimising the risk of fruit fly infestation.

Project aims and scope

The scope of the project is to find alternatives to the use of dimethoate or fenthion for fruit fly control while maintaining domestic market access. The research currently undertaken evaluated the effectiveness of preharvest insecticide sprays (used in the crops for other purposes) and postharvest mitigation measures in reducing the risk of fruit fly infestation in capsicum produced for interstate and export markets.

3.3 Materials & Methods

The study focused on the Bowen and Gumlu region capsicum producing region of Queensland. Activities were extended across four cropping seasons to determine the impact of seasonal effects and different levels of fruit fly pressure on fruit infestation.

Details of capsicum production and management practices

Information on capsicum production and cultivation practices was collated by interviewing growers, consultants, and a local agronomist. In addition, the project leader had gathered further information through his regular farm visits. The details are summarised in Table 2.

Table 3.2 Summary of the industry standard practices for capsicum production

Growing and Management Practices	Descriptions
Number of farms	10 in Bowen and 8 in Gumlu
Cultivated area & volume (estimated)	Bowen - 820 ha and 31,000 tons Gumlu – 350 ha and 13,000 tons
Common varieties	Warlock, Merlin, Vampire, Hercules
Major interstate and export markets	NSW, Victoria, SA & Tasmania. Export to New Zealand
Growing season	February to November
Harvest season	From May through November
Plant population	Between 33,000 and 44,000 plants/ ha
Cultivation practices	Transplanting into polythene mulched bed, trickle irrigation, and fertigation,
Weed control	Pre- and post-emergence herbicides, and inter-row sprays
Major insect pests	heliothis, thrips, mites and aphids
Pest management	Routine and monitoring-based insecticide sprays at 5 to 14 day intervals. Ground-rig application with 300 to 500 L spray volume. (insecticide sprays are given in Table 3)
Major fungal diseases	bacterial spots, powdery mildew
Disease control	Fungicide applications at 7 to 14 days intervals.
Market access treatments	Most farms flood spray with dimethoate postharvest (ICA-02). Some farms with trichlorfon preharvest spray for NZ export.
Fruit harvests	Picking as green or red fruit at 3 to 7 day intervals.
Pack-house operations	Washing (iodine or chlorine), manual sorting, colour grading, controlled ripening, dimethoate flood spray, sorting, packing and inspection, cooling and transport.

Insecticide cover sprays

The objective of this exercise was to match insecticide use patterns with fruit fly infestation levels for each sampling block of a particular farm.

Insecticide cover sprays were applied to the trial blocks by participating growers. The sprays were selected by assessing information based on the type of pest and pressure levels or the recommendation provided by crop consultants. The spray records were maintained by the collaborating growers or crop consultants.

Spray records were collected from capsicum growers who participated in fruit sampling during the 2006, 2007 and 2008 seasons. For each sampling block, the insecticide sprays that were applied four weeks prior to the fruit harvest were extracted from the spray records. In addition, the spray intervals and spray volume were documented.

Dimethoate or trichlorfon are the preharvest spray options for interstate (eg ICA 26) or New Zealand market protocols. Five capsicum farms with accreditation to export to New Zealand markets or ICA-26 for Victoria markets that applied fruit fly specific preharvest sprays (trichlorfon or dimethoate) to the crop blocks were included in the sampling program but were recorded separately.

Fruit fly monitoring

This component was aimed at quantifying fruit fly activity periods across commercial capsicum production regions of Bowen and Gumlu as well as to establish low population periods with a view to incorporating this information into systems approaches to meet market access requirements.

District-wide fruit fly trapping was conducted over four seasons (August 2006 to December 2009) in Bowen and Gumlu. Around 70 cue-lure baited Lynfield traps were placed across the district for the 40 month survey. This trapping has covered tomato and capsicum farms, riverbanks and native vegetation in the Bowen and Gumlu region. On all capsicum farms, fruit fly trapping continued throughout the year from 2006 to 2009. A minimum of two traps per farm were placed within cultivated boundaries. Traps were cleared at fortnightly intervals and trap catches were counted and identified to species level.

Field harvest fruit sampling

A monthly fruit sampling program covering eleven commercial capsicum farms was conducted during the 2006, 2007, and 2008 seasons.

A systematic sampling procedure developed by one of the project biometricians (based on Jorgensen *et al.* 2003) was followed for field sampling. The tomato blocks were between 2 and 4 ha in size. The field samples (200 – 300 fruit/ crop block/ sample) were collected by the project staff immediately prior to commercial harvest. Fruit of commercial harvest size and red coloured fruit (but irrespective of blemishes) were selected across the entire block.

The first season of fruit sampling was conducted during the period of October to November in 2006 from four farms. Two farms used no preharvest dimethoate or trichlorfon treatments.

The other two growers used trichlorfon or dimethoate for part of their farms as preharvest fruit fly treatments as a requirement for export to New Zealand.

In 2007, the second season fruit sampling program was conducted to cover the entire capsicum harvest season to determine the levels of fruit infestation under different fruit fly pressures during the season. Eleven capsicum farms and research station trial crops were sampled from June to December at 3-4 weeks intervals. Only field samples were collected from the Bowen Research Station crops but no pack-house capsicums were taken for sampling.

The third season fruit sampling program was conducted during the latter part of the 2008, season. This was to confirm the 2007 season results and to focus more on the higher fruit fly activity period (September to November), as identified during the trapping program. Five capsicum farms were sampled from September to November. One of the farms used preharvest trichlorfon as cover sprays in the field, and others used standard insecticide cover sprays.

Pack-house fruit sampling

In this component, the effectiveness of pack-house mitigation measures was evaluated as a means to intercept fruit fly infested fruit.

Harvested bins of fruit were tracked from harvest in the field through the pack-house process. In the packing line, the fruit were processed according to the order in which the harvested-bins were transported from the field. Hence, we ensured the pack-house samples were taken from the fruit batch originating from the same block and on the same day as the in-field harvest sample.

Pack-house samples were randomly collected by the pack-house supervisor or project staff after fruit (originating from the same field blocks) had been washed, sorted and colour graded through the normal commercial packing line, but before the postharvest dimethoate treatments were applied. For each sampling date, a total of 200 to 250 fruit were sampled to represent coloured fruit for each block run .

Figure 3.2 Pack-house operation, Bowen

Reject fruit sample

Reject fruit sampling was included in this study to quantify the fruit fly infestation in capsicum after termination of the cover sprays. For this purpose, the capsicum crops were sampled after growers completed the final harvest and two to four weeks after termination of the field sprays. This sampling was conducted during the spring-harvest period (Sept to Nov) because of increasing fruit fly pressure indentified in the cue-lure traps.

Incubation and assessment of fruit samples

Both field and pack-house samples were transported to the Bowen Research Station (BRS) immediately after collection. Fruit were sorted based on ripening stage (full coloured or half-coloured) and placed in ventilated plastic containers. The containers, each with approximately 7-8 fruit, were incubated at 26± 2°C and 70-80% relative humidity to allow eggs and larvae to develop. After 7 to 10 days of incubation, each entire fruit was cut open and examined for fruit fly presence. Any larvae from an infested fruit or pupae found in the containers (including *Atherigona* sp.) were removed, counted, and then reared through to adults for species confirmation.

Figure 3.2 Capsicum fruit incubation in a controlled temperature room

Statistical analysis

The upper percentage infestation (with 95% confidence) for fruit fly in tomatoes were calculated by a project biometrician. All calculations were performed using CQT_Stats (Liquido etal, 1997). Upper infestation levels were based on the number of samples taken and the number of infested fruit found. The samples of 6,000 field and 6,000 pack-house fruit were targeted across capsicum farms to allow for detection of infestation levels of 0.05% with 95% confidence at each of harvest and pack.

3.4 Results and Discussion

3.41 Fruit fly infestation levels in field and pack-house fruit samples

The sampling program was designed to determine fruit fly infestation levels on each capsicum farm during the commercial harvest period (field sample) and after fruit from the same block had passed through the commercial packing line (pack-house sample).

The farms for sampling were selected on the basis of their compliance with ICA and export accreditation arrangement that included either no fruit fly sprays or trichlorfon or dimethoate preharvest sprays in the field. All the farms had regular insecticide programs to control other insect pests such as heliothis, thrips, aphids and mites (Tables 3.6 and 3.7).

Fruit sampling 2006

A total of 3,787 capsicums were sampled across the four farms at 3-4 week intervals from October to November 2006. No fruit fly infestation was found in 3,076 field and pack-house samples from the farms not using trichlorfon or dimethoate preharvest sprays. Similarly, no fruit fly infestation was found in the 725 fruit sampled from the farms applying trichlorfon or dimethoate sprays preharvest (Table 3.3).

Since the field and pack-house samples were harvested from the same blocks at the same time in any given sample plot, it is reasonably assumed both samples have been drawn from the same population, have been subjected to the same growth conditions and the same fruit fly pressure. It is also assumed that the infestation level of the pack-house fruit is no greater than that of the fruit in the field. Hence the two samples for each treatment have been combined to give a better estimate of the maximum infestation level in the total fruit. Using a similar argument (given that no infestation was found in any of the samples at any pick on either farm), all samples from both farms in each trichlorfon use category have been combined to give an overall estimate for the district of infestation levels.

Statistically, after combining results across the two farms for each treatment and across field and pack-house samples, the 2006 sampling shows that the upper % infestation (at 95% confidence) was:

- No trichlorfon/ dimethoate preharvest or dimethoate postharvest: 0.097% (a total of 3,067 fruit)
- Trichlorfon / dimethoate preharvest spray, no dimethoate postharvest: 1.29% (a total of 725 fruit).

Fruit sampling 2007

Three of the eleven farms plus research station used no preharvest dimethoate or trichlorfon sprays throughout the season. The other four farms (Farm 1A, 1B, 4B and 6) used trichlorfon preharvest sprays during the winter window (1 May to 1 September) for New Zealand export, but no trichlorfon was used from October to December.

A total of **12,781** capsicums were sampled across the eleven farms from June to November. The samples were collected at 3-4 week intervals. During the winter harvest, the results show **no fruit fly infestation** in 1,940 field fruit and pack-house sampled **without** preharvest fruit fly sprays of dimethoate or trichlorfon. Similarly, **no fruit fly infestation** was found in the 2,724 field fruit and pack-house sample with trichlorfon and dimethoate sprays applied for preharvest fruit fly control (Table 3.4a).

During the spring harvest, only one infested field fruit was found in the 5,148 fruit assessed but no infestation was evident in the pack-house sample **without** preharvest fruit fly sprays of dimethoate or trichlorfon. No fruit fly infestation was found in the 2,334 field fruit and pack-house sample with trichlorfon and dimethoate sprays applied for preharvest fruit fly control (Table 3.4b).

It is assumed that the infestation level of the pack-house is no greater than that of the fruit in the field, hence the samples have been combined**.** The trap catches indicated that the fruit fly pressure was similar across the farms during September to November, hence all samples have been combined. Statistically, after combining results across the farms for each treatment and across field and pack-house samples, the 2007 sampling shows that the upper % infestation (at 95% confidence) was:

- No trichlorfon preharvest or dimethoate postharvest: 0.092% (a total of 5,148 fruit)
- Trichlorfon preharvest spray, no dimethoate postharvest: 0.128% (a total of 2334 fruit)

Fruit sampling 2008

The third season fruit sampling program was conducted to confirm the 2007 season results and focused on the main fruit fly activity period (September to November). Four capsicum farms and research station crops, without preharvest dimethoate or trichlorfon treatments, were selected for the sampling.

A total of 4,023 capsicums were sampled across the four farms and research station crops at 3-4 week intervals. Results show **no fruit fly infestation** was found in 2,741 field fruit or in the 1,282 pack-house samples.

Statistically, after combining results across the farms and pack-house samples, the 2008 sampling shows that the upper % infestation (at 95% confidence) was 0.0745% (Table 3.5).

Table 3.3. Fruit fly infestation levels in capsicums during spring season - Bowen 2006

Farms	Farm Block ID	Sampling / harvest month	Preharvest fruit fly sprays	Sample type	No. of fruit sampled	No. of infested fruit	Larvae/ fruit	Upper % infestation (95% confidence)
Preharvest field treatments: insecticide cover sprays only*								
Farm-1B	Pt-13	October	nil	Field	231	0	0	
				Pack	220	0	0	0.6642
	Pt-17	November	nil	Field	198	0	0	
				Pack	220	0	0	0.7167
Farm-2A	BLK-3	October (early)	nil	Field	216	0	0	
				Pack	192	0	0	0.7342
	Tur. B1	October (late)	nil	Field	256	0	0	
				Pack	200	0	0	0.6570
	Tur. B2	November	nil	Field	256	0	0	
				Pack	226	0	0	0.6215
Farm-3	W.L 1	November (mid)	nil	Field	164	0	0	
				Pack	228	0	0	0.7642
	W.L 2	November (late)	nil	Field	211	0	0	
				Pack	249	0	0	0.6512
					3067	0		0.0977
Preharvest treatments: insecticide cover sprays* + trichlorfon or dimethoate #								
Farm-1B	Pt-11	September	Trichlorfon	Field	280	0	0	
				Pack	232	0	0	0.5851
Farm-4A	NW B1	November	Dimethoate	Field	213	0	0	1.4064
					725	0	0	0.4132

* - insecticides sprays applied for controlling other pests on the crop and the details are listed in Tables 3.5A to 3.5D.

Table 3. 4A Fruit fly infestation levels in capsicum farms during winter season - Bowen/ Gumlu 2007

Farms	Farm Block ID	Sampling / harvest month	Preharvest fruit fly sprays	Sample type	No. of fruit sampled	No. of infested fruit	Larvae/ fruit	Upper % infestation (95% confidence)
Preharvest field treatments: insecticide cover sprays only								
Farm-1A	Ponds	August	nil	Field	300	0	0	
				Pack	214	0	0	0.5828
Farm-2B	Pt-1	July	nil	Field	197	0	0	
				Pack	137	0	0	0.8969
	Pt-2	August	nil	Field	229	0	0	1.3082
Farm-3	BLK-Home	July	nil	Field	236	0	0	
				Pack	216	0	0	0.6628
	BLK- Shed	August	nil	Field	208	0	0	
				Pack	203	0	0	0.7289
					1940	0		0.1544
Preharvest treatments: cover sprays + trichlorfon or dimethoate								
Farm-1A	BLK-10	June	Trichlorfon	Field	256	0	0	
				Pack	216	0	0	0.6347
Farm-1B	Pt-19	June	Trichlorfon	Field	256	0	0	
				Pack	222	0	0	0.6267
Farm-4B	BLK- 15	July	Trichlorfon	Field	227	0	0	
				Pack	132	0	0	0.8345
	BLK- 16	August	Trichlorfon	Field	260	0	0	
				Pack	168	0	0	0.6999
Farm-6	BLK-26	August	Trichlorfon	Field	222	0	0	
				Pack	208	0	0	0.6967
Farm-5	BLK A&B	July	Dimethoate	Field	287	0	0	1.0438
Farm-7	BLK-H	August	Dimethoate	Field	270	0	0	1.1095
					2724	0		0.1100

Table 3.4B. Fruit fly infestation levels in capsicum farms during spring season - Bowen/ Gumlu 2007

Farms	Farm Block ID	Sampling / harvest month	Preharvest fruit fly sprays	Sample type	No. of fruit sampled	No. of infested fruit	Larvae/ fruit	Upper % infestation (95% confidence)
Preharvest field treatments: insecticide cover sprays only								
Farm-1A	Pt 12	October	nil	Field	334	0	0	
				Pack	211	0	0	0.5497
	Pt 17	November (early)	nil	Field	249	0	0	
				Pack	206	0	0	0.6584
	Pt 19/20	November (late)	nil	Field	219	0	0	1.3679
Farm-2B	BLK- 15	October	nil	Field	240	0	0	
				Pack	200	0	0	0.6808
	BLK- 18	November	nil	Field	299	0	0	
				Pack	72	0	0	0.8075
Farm-3	BLK- WL	September	nil	Field	260	0	0	
				Pack	247	0	0	0.5909
	BLK- FT1	October	nil	Field	342	0	0	
				Pack	220	0	0	0.5330
	BLK- FT2	November	nil	Field	281	1	11	
				Pack	245	0	0	0.9017
Farm-4B	BLK- 6	September	nil	Field	297	0	0	1.0087
	BLK- Todd2	October	nil	Field	244	0	0	
				Pack	160	0	0	0.7415
Farm-6	BLK-32	November	nil	Field	284	0	0	
				Pack	206	0	0	0.6114
Farm-12	BLK-2	October	nil	Field	168	0	0	1.7832
	BLK-3	November	nil	Field	164	0	0	1.8266
					5148	1		0.0921

Table 3.4C Fruit fly infestation levels in capsicum farms during spring season - Bowen/ Gumlu 2007

Farms	Farm Block ID	Sampling / harvest month	Preharvest fruit fly sprays	Sample type	No. of fruit sampled	No. of infested fruit	Larvae/ fruit	Upper % infestation (95% confidence)
Preharvest treatments: cover sprays + trichlorfon or dimethoate								
Farm-1B	BLK-13	September	Trichlorfon	Field	247	0	0	
				Pack	214	0	0	0.6498
Farm-6	BLK- 26	September	Trichlorfon	Field	219	0	0	
				Pack	107	0	0	0.9189
	BLK- 29	October	Trichlorfon	Field	291	0	0	
				Pack	136	0	0	0.7016
Farm-9	Rex-Top	October	Trichlorfon	Field	450	0	0	0.6657
Farm-7	BLK B	September	Dimethoate	Field	206	0	0	1.4542
Farm-10	BLK-55	October	Dimethoate	Field	226	0	0	1.3255
	BLK-82	November	Dimethoate	Field	121	0	0	
				Pack	117	0	0	1.2587
					2334	0		0.1284

Table 3.5. Fruit fly infestation levels in capsicum during spring season - Bowen research station 2007

Research station crops	D7	September	nil	Field	114	0	0	2.6278
	D1	October	nil	Field	94	0	0	3.1869
	D9	October	nil	Field	325	0	0	0.9218
	E12	October	nil	Field	102	0	0	2.9370
					635	0		0.4718

Table 3.5 Fruit fly infestation levels in capsicum farms during spring season - Bowen/ Gumlu 2008

Farms	Farm Block ID	Sampling / harvest month	Preharvest fruit fly sprays	Sample type	No. of fruit sampled	No. of infested fruit	Larvae/ fruit	Upper % infestation (95% confidence)
Preharvest field treatments: insecticide cover sprays only								
Farm-1A	BLK- 8	October	nil	Field	282	0	0	
				Pack	212	0	0	0.6642
	BLK- 7	November	nil	Field	256	0	0	
				Pack	240	0	0	0.6040
Farm-3	BLK-FT1	October	nil	Field	214	0	0	
				Pack	242	0	0	0.6570
	BLK-Shed	November	nil	Field	258	0	0	
				Pack	252	0	0	0.5874
Farm-6	BLK- 5	September	nil	Field	220	0	0	
				Pack	198	0	0	0.7167
	BLK-6	October	nil	Field	257	0	0	
				Pack	138	0	0	0.7584
	BLK-7	November	nil	Field	136	0	0	2.2027
Farm-12	BLK-3	October	nil	Field	144	0	0	2.0803
Research station crops	B8	July		Field	601	0	0	0.4985
		August	nil	Field	373	0	0	0.8031
			Total		4023	0		0.0745
Farm-4B	BLK-19	October	Trichlorfon	Field	232	0	0	1.2913

3.42 Insecticide cover sprays

A summary of the insecticide sprays applied on the sampling blocks across the eleven capsicum farms is listed in Tables 3.6 to 3.8. The spray data for each block was matched with the fruit fly infestation of the relevant sampling block of the particular farm. The details of the insecticide sprays that were applied five weeks prior to field harvest for each block are given in Tables 3.6A - 3.6D.

The key results are summarised below:

- Insecticides belonging to various chemical groups (1A, 1B, 3A, 4A, 5, 6 and 6A) were sprayed to control a range of insect pests, but there was a consistent pattern in the use of some broad-spectrum insecticide across farms.

- Two broad-spectrum insecticides, **methomyl and bifenthrin,** were sprayed on a regular basis from fruiting to final harvest. This pattern was consistent across the eleven capsicum farms throughout the season.

- A narrow-spectrum insecticide, **spinosad** was often used but mainly for specific pests such as heliothis and thrips.

- On some occasions, abamectin was used for controlling mites but often during the spring season.

- Two other products – imidacloprid and emamectin – were occasionally used in few farms.

- Five farms had sprayed the organophosphate insecticide Methamidophos, but mostly one application during the fruiting period.

- On most farms, 7-10 day spray intervals were followed during the winter months and 5 -7 days during the spring months.

- On five farms, trichlorfon was applied at 7 to 10 day intervals only during the winter window (1 May to 1 September) as a market access requirement for exporting fruit to New Zealand.

- Most of the capsicum blocks had at least two sprays of broad-spectrum insecticide (often methomyl and bifenthrin) during October/ November.

Table 3.6A. Summary of insecticide cover sprays applied on the capsicum crops in 2006 (spring harvest season)

Farms	Farm Block ID	Sampling / harvest month	Preharvest fruit fly sprays *	Carbamate	Pyrethroid	Organo-phosphate	Narrow spectrum products	Spray intervals (days)
		Season – Spring harvest from September to November 2006						
Farm-1B	Pt-11	September	Trichlorfon (x 2)	Nil	Bifenthrin (x 3)	nil	Abamectin (x 1) Spinosad (x 1)	5 - 7
	Pt-13	October	nil	Methomyl (x4)	Bifenthrin (x 4)	nil	Abamectin (x 1) Spinosad (x 1) Imidacloprid (x 1)	5 - 7
	Pt-17	November	nil	Methomyl (x2)	Bifenthrin (x 3)	nil	Abamectin (x 2) Spinosad (x 1) Imidacloprid (x 1)	7
Farm-2A	BLK-3	October (early)	nil	Methomyl (x3)	Bifenthrin (x 3)		Spinosad (x 1) Imidacloprid (x 1)	7
	Tur. B1	October (late)	nil	Methomyl (x2)	Bifenthrin (x 2)	Methamido-phos (x1)	Abamectin (x 1) Spinosad (x 1)	7
	Tur. B2	November	nil	Methomyl (x2)	Bifenthrin (x 2)		Abamectin (x 2) Spinosad (x 1)	6 -7
Farm-3	W.L 1	November (mid)	nil	Methomyl (x2)	Bifenthrin (x 2)	Methamido-phos (x1)	Abamectin (x 1) Spinosad (x 1)	7
	W.L 2	November (late)	nil	Methomyl (x2)	Bifenthrin (x 1)	Methamido-phos (x 2)	Spinosad (x 1)	7
Farm-4A	NW B1	November	Dimethoate (x2)	Methomyl (x3)	Bifenthrin (x2)	Methamido-phos (x2)	Spinosad (x 2) Abamectin (x 1)	5-7

Table 3. 6B Summary of insecticide cover sprays applied on the capsicum crops in 2007 (winter harvest season)

Farms	Farm Block ID	Sampling / harvest month	Preharvest fruit fly sprays *	Carbamate	Pyrethroid	Organo-phosphate	Narrow spectrum products	Spray intervals (days)
		Season – winter harvest Jun to August 2007						
Farm-1A	BLK-10	June	Trichlorfon (x2)	Nil	Bifenthrin (x 1)	nil	Spinosad (x 1)	7 - 10
	Ponds	August	Nil	Methomyl (x1)	Bifenthrin (x 2)	nil	Emamectin (x1)	7 - 10
Farm-1B	Pt19	July	Trichlorfon (x2)	Methomyl (x1)	Nil	nil	Spinosad (x 1)	9
Farm- 2B	Pt-1	July	nil	Methomyl (x1)	Bifenthrin (x 1)	Methamido-phos (x1)	Spinosad (x1)	7-10
	Pt-2	August	nil	Methomyl (x1)	Bifenthrin (x1)	Nil	Spinosad (x 1) Imidacloprid (x1)	7-10
Farm-3	Blk-home	July	nil	Methomyl (x2)	Bifenthrin (x 1)	Methamido-phos (x1)	Spinosad (x 1)	7-14
	Blk-shed	August	nil	Methomyl (x2)	Bifenthrin (x 2)	Methamido-phos (x2)	Spinosad (x 1)	7-10
Farm-4B	BLK-15	July	Trichlorfon (x2)	Methomyl (x2)	Bifenthrin (x 1)	Methamido-phos (x1)	Spinosad (x 1)	7 - 10
	BLK-16	August	Trichlorfon (x2)	Methomyl (x1)	Bifenthrin (x 1)	Methamido-phos (x1)	Spinosad (x 2)	7-10
Farm-5	Blk-A&B	July	Dimethoate (x1)	Methomyl (x1)	Bifenthrin (x 1)	nil	nil	28
Farm-6	Blk-26	August	Trichlorfon (x2)	Methomyl (x1)	nil	nil	nil	5-7
Farm-7	Blk H	August	Dimethoate (x1)	Methomyl (x2)	Bifenthrin (x 1)	Methamido-phos (x1)	nil	7-14

Table 3. 6C Summary of insecticide cover sprays applied on the capsicum crops in 2007 (spring harvest season)

Farms	Farm Block ID	Sampling / harvest month	Preharvest fruit fly sprays	Carbamate	Pyrethroid	Organo-phosphate	Narrow spectrum products	Spray intervals (days)
		Spring harvest season (Sep to Nov 2007)						
Farm-1A	Pt-12	October	nil	Methomyl (x2)	Bifenthrin (x 2)	nil	Spinosad (x 2)	6-8
	Pt-17	November (early)	nil	Methomyl (x2)	Bifenthrin (x 2)	nil	Spinosad (x 2)	5-10
	Pt-19/20	November (late)	nil	Methomyl (x2)	Bifenthrin (x 2)	nil	Spinosad (x 1)	7-10
Farm-1B	Blk-13	September	Trichlorfon (x3)	Methomyl (x1)	Bifenthrin (x 1)	nil	Spinosad (x 1)	9-10
Farm- 2B	Blk-15	October	nil	Methomyl (x2)	Bifenthrin (x 2)	Methamido-phos (x1)	Spinosad (x 1)	7
	Blk-18	November	nil	Methomyl (x2)	Bifenthrin (x 1)	nil	Spinosad (x 1) Abamectin	7-10
Farm-3	Blk- WL	September	nil	Methomyl (x2)	Bifenthrin (x 2)	Methamido-phos (x1)	Spinosad (x 1) Abamectin	7
	Blk- FT1	October	nil	Methomyl (x2)	Bifenthrin (x 2)		Abamectin	7
	Blk-FT-2	November	nil	Methomyl (x2)	Bifenthrin (x 1)			7-14
Farm-4B	BLK-6	September	nil	Methomyl (x2)	Bifenthrin (x 1)	Methamido-phos (x1)	Spinosad (x 2)	7
	Todd-2	October	nil	Methomyl (x2)	Bifenthrin (x 2)	Methamido-phos (x1)	Spinosad (x 2)	7

Table 3. 6C . Continued…

Farms	Farm Block ID	Sampling / harvest month	Preharvest fruit fly sprays *	Carbamate	Pyrethroid	Organo-phosphate	Narrow spectrum products	Spray intervals (days)
	Spring harvest season (Sep to Nov 2007)							
Farm-6	Blk-26, Pt5	September	Trichlorfon (x3)	nil	Bifenthrin (x 1)	nil	Spinosad (x 1) Petroleum oil (x3)	
	Blk-29	October	Trichlorfon (x2)	Methomyl (x1)	Bifenthrin (x1)	nil	Spinosad (x 1) Petroleum oil (x1)	
	Blk-32		nil	Methomyl (x1)	Bifenthrin (x 2)	nil	Spinosad (x 2) Imidacloprid (x1) Petroleum oil (x2)	
Farm-7	Blk B	September	Dimethoate (x1)	Methomyl (x2)	Bifenthrin (x 2)	Methamido-phos (x1)	nil	7
Farm-9	Rex Top	October	Trichlorfon (x2)	Methomyl (x2)	Bifenthrin (x 2)	nil	Spinosad (x 1)	7
Farm-10	Blk 55	October	Dimethoate (x2)	Methomyl (x1)	Bifenthrin (x 2)	nil	Spinosad (x 2)	
	Blk 82	November	Dimethoate (x2)	Methomyl (x2)	Bifenthrin (x 2)	nil	Spinosad (x 1)	
Farm-12	Blk 3	November	nil	Methomyl (x2)	nil	Methamido-phos (x2)	nil	7
Research station	D7	September	nil	nil	Bifenthrin (x1)	nil	Spinosad (x 1) Emamectin (x2)	7 - 14
	D1	October	nil	nil	Bifenthrin (x1)	Methamido-phos (x1)	Spinosad (x 2) Indoxacarb (x1)	7
	D9	October	nil	nil	Bifenthrin (x1)	Methamido-phos (x1)	Spinosad (x 1) Indoxacarb (x1) Emamectin (x1)	7
	E12	October	nil	nil	Bifenthrin (x1)	Methamido-phos (x1)	Emamectin (x2)	7

Table 3.6D Summary of insecticide cover sprays applied on the capsicum crops in 2008 (spring harvest season)

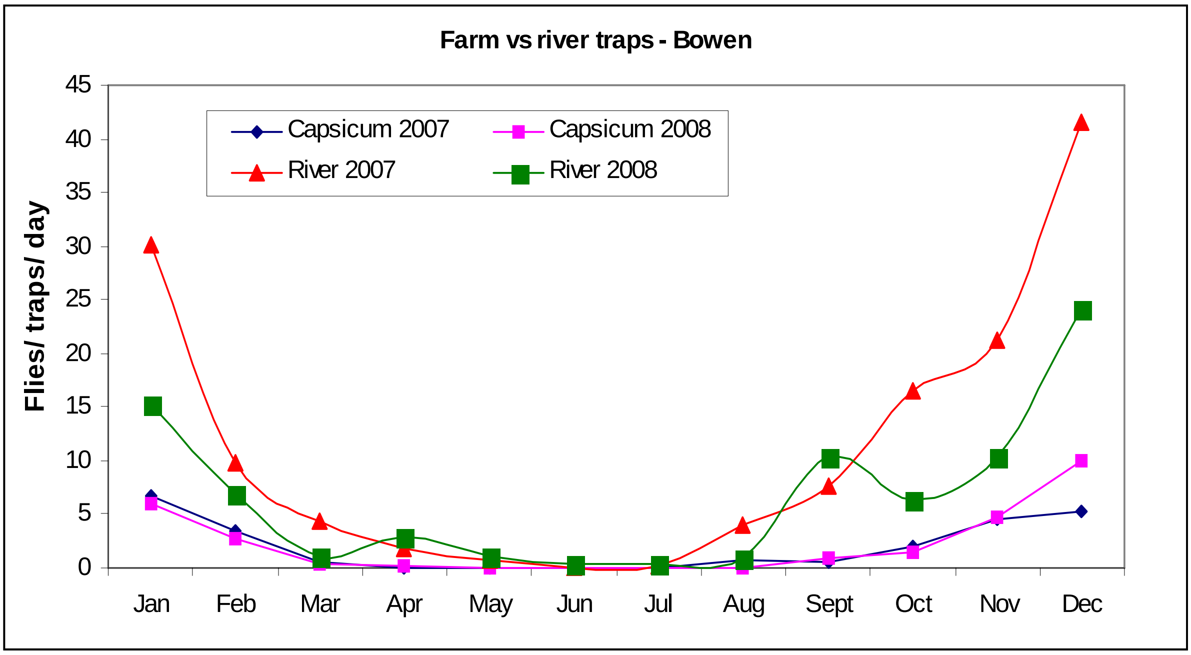
Farms	Farm Block ID	Sampling / harvest month	Preharvest fruit fly sprays	Carbamate	Pyrethroid	Organo-phosphate	Narrow spectrum products	Spray intervals (days)
	Spring harvest Season 2008 (Sep to Dec)							
Farm1A	BLK7	October	nil	nil	Bifenthrin (x1)	Methamido-phos (x1)	Spinosad (x 1) Petroleum oil (x2)	7-11
	BLK8	November	nil	nil	Bifenthrin (x1)	nil	Endosulfan (x1)	9-14
Farm-3	BLK -FT1	October	nil	Methomyl (x2)	Bifenthrin (x 1)	Methamido-phos (x1)	Spinosad (x 2)	7
	BLK-Shed	November	nil	Methomyl (x2)	Bifenthrin (x 2)	nil	Spinosad (x 2) Abamectin (x1)	7
Farm-4	BLK19	October	Trichlorfon (x2)	Methomyl (x3)	nil	Methamido-phos (x1)	Spinosad (x 1)	5-7
Farm-6	BLK-5	September	nil	Methomyl (x2)	Bifenthrin (x 1)	nil	Spinosad (x 2) Abamectin (x1)	7
	BLK-6	October	nil	Methomyl (x3)	Bifenthrin (x 1)	nil	Spinosad (x 1) Abamectin (x1)	7
	BLK-7	November	nil	Methomyl (x2)	Bifenthrin (x 2)	nil	Spinosad (x 2)	7
Farm-12	BLK-3	October	nil	Methomyl (x2)	nil	Methamido-phos (x2)	nil	7
Research station	B8	August	nil	nil	nil	nil	Spinosad (x 2) Imidacloprid (x1)	7-14

3.43 Fruit fly activity periods

Capsicum farm trapping

The trapping data showed that fruit fly activity from March to mid-October was very low (average of 0 – 0.7 flies/ trap/ day) on most capsicum farms, with almost no flies caught in many farm traps between late May and August. The farm trap catches started to increase by mid-October and peaked in December and January. Although the average number of fruit flies trapped varied between farms, the seasonal activity pattern over the two seasons (2007 and 2008) was consistent (Fig. 3.3).

Figure 3.3 Fruit fly catches in river and capsicum farm traps for 2007 and 2008, Bowen



Trapping data over the two seasons indicated that fruit fly numbers varied greatly between capsicum farms and river or natural vegetation locations. The cue-lure traps that were installed within or close to river or creek vegetation and fruiting trees (e.g. mango) caught more fruit flies than the traps placed around tomato blocks (Fig. 3.3).

From March to July trap catches along the river and in the farms were very low with mean catches of 0.1- 2.6 flies per trap per week. All river traps showed a very rapid increase in numbers from August to December while the capsicum farm traps showed a slow increase until November (Fig. 6).

No relationship between trap catches and fruit infestation levels for any particular farm could be determined as very low level of infested fruit were recorded across the farms. The trap catches during November were moderately high around the capsicum farms (average of 4.5 flies per trap per day), but only one infested fruit was found in the sampled 20,828 fruit. This probably was due to the insecticide cover sprays that were applied at regular intervals for controlling other pests in the crop.

3.5 Conclusions

- This study has demonstrated that capsicums grown under commercial spray programs and harvested from June to November had very low risk of fruit fly infestation. Such fruit could be considered for interstate markets with no dimethoate treatments in the pack-house. This has been proven through the extensive sampling program conducted in the Bowen and Gumlu regions, where a large volume of samples (over 20,000 fruit) was assessed to give continued high levels of confidence.

- The current field sprays (Tables 3.6A-D) used for other pests was sufficient to minimise fruit fly pressure during the harvest season in both districts and to prevent fruit fly infestation in the capsicum fruit.

- There is a small risk for capsicum harvested during November when the fruit may often be exposed to high temperature that causes sunburn, softness, cracks. This leads to greater attraction of flies into the crops and increases the chance for infestation. However this risk could be reduced in the pack-house through the mitigation measures such as washing, sorting and grading to eliminate the damaged and blemished fruits.

- The pack-house mitigation measures have provided additional support for minimising the risk of infestation in the packed fruit. The data collected for the pack-house samples (7,108 fruit) over the three seasons provided additional evidence that the packed fruit were **free from fruit fly** infestation. This should provide further confidence in current procedures for interstate and export markets.

- District fruit fly trapping over four consecutive seasons (from Aug 2006 to Dec 2009) clearly showed a “low fruit fly period” from March to August. This data provides further support to indicate that capsicum grown during this period are at minimal risk of fruit fly infestation.

- Although trap catches increased around capsicum farms and river banks during the Oct – Nov period, only one infested fruit was found in a field sample that was collected in late November. This indicated that standard field control practices (insecticide cover sprays) practised by capsicum growers were providing sufficient protection against fruit flies.

- It is highly likely that the risk reduction measures assessed would be acceptable to, and adoptable by, the capsicum industry because the measures were based on existing commercial practice.

4. Wild fruit survey and supplementary trapping in Bowen

4.1 Introduction

As an integral part of the system approach research project "Alternative fruit fly control and market access for capsicums and tomatoes" the 'Area Wide Trapping Program (AWTP)' has been completed in the Bowen region. This is the first in-depth survey of the endemic fruit fly populations in this district. This has provided valuable baseline data on fruit fly population levels, seasonal abundance and peak activity, impact of vegetation and environmental factors, species composition and distribution patterns (see Chapter 1)

A preliminary wild fruit survey, as an extension of this area wide trapping program, was initiated to provide supplementary data on fruit fly and host plant species composition, distribution patterns and seasonality.

The cue-lure trapping program was supplemented in 2008/09 by nine B. jarvisi (*Bj* lure) and ten methyl eugenol traps. On completion of the *B. jarvisi* trapping program (Neale *et al.* 2008) in March 2008, the nine specialised *Bj* lure traps in the Bowen region were maintained for a further 11 months until March 2009.

Fruit assessment was carried out subject to time/ resource availability, fruit seasonality, canopy accessibility, the degree of faunal predation and impact of environmental factors viz. weather. These factors at present have a major impact on the validity and usefulness of the data collected. Regular fortnightly collections were commenced in the 2007/08 fruiting season to facilitate the detection of potential trends in host plant use and status.

4.2 Materials and methods

Trapping Program:

Three types of traps were operated in the study area:

1. Cue-lure traps (Bugs for Bugs): August 2006 to March 2010 – as a part of AWTP;
2. Nine standard Lynfield traps baited with *Bj* lures and maldison: May 2008 – March 2009;
3. Ten Bugs for Bugs traps baited with 10ml methyl eugenol + 3ml maldison: November 2008 – March 2009.

Traps were widely distributed throughout the horticultural production areas of the Bowen region: Bootooloo, Delta, Lower Don, Inverdon, Merinda, Dry Creek, Euri Creek East and Mt Dangar, and covered a large range of landscape architectures. Cue-lure and *Bj* wicks were replaced quarterly and methyl eugenol wicks monthly. Traps were cleared fortnightly and trapped flies identified and counted at the Bowen Research Station.

Host Fruit Collection

Fruit was collected periodically during the 2006/07 season from domestic and wild fruiting trees throughout the Bowen region. Fruit collection was expanded in 2007/08 to include fruit from the ground to ascertain importance of the host as an infestation source for farm hygiene. Sampling in the 2007/08 season was conducted on a regular basis in conjunction with the fortnightly area wide trap clearance (see Chapter1).

A fruit sample consisted of one species of fruit from one location at one stage of maturity (ripe or green) and source (tree or ground). Data recorded included fruit species, common name, location (Trap No.), collection date, number and weight of fruit, maturity and source.

Individual samples were counted, weighed and placed on a 15mm bed of vermiculite in large 10L plastic incubation containers covered with gauze cloth. Incubation containers were held in a CT Room at 25-26°C and 70% RH for 3 to 4 weeks until adult eclosion had occurred. The vermiculite was sieved to recover pupae, adult flies and parasitoids. All flies and parasitoids were identified and counted.


Figure 4.1 Chinee apple tree with immature fruits


Figure 4.2 Guava fruit infested with fruit fly

4.3 Results

Trapping Program:

Analyses of the trapping results are confined to fruit fly species composition, distribution and seasonality.

The two economically significant species, QFF (*Bactrocera tryoni*) and lesser QFF (*Bactrocera neohumeralis*) were present in cue-lure traps together with eight minor species – *B. bryoniae, B. chorista, B. alyxiae, B. jarvisi, Dacus aequalis, D. axanus, D. newmani,* and *D. bellulus.*

The economically significant species present in *Bj* lure traps were *B. jarvisi* (96.4%), *B. tryoni* (0.9%) and *B. neohumeralis*. Non pest species included *D. aequalis* (2.7%), *D. secamoneae, D. absonifacies* and *B. aurea.* (Species without a percentage value were collected in very low numbers.)

Although most of these species display different levels of abundance and timing of their population peaks (Table 4.1), they can be classified into three broad types based on their population dynamics (Drew *et al.* 1984):

1. Relatively smooth changes in population sizes.
    a. Species present throughout the year;
    b. Rapid increase to peak levels in late spring and mid-summer;
    c. Levels decline during late summer and winter;
    d. Continuous breeding and/or movement; and
    e. Range of host plants.

   These species included *B. tryoni* , *B, neohumeralis* and the non pest species *B. bryoniae*.

2. Jagged, discrete changes in abundance.
    a. Species present most times of the year;
    b. Rapid changes in population levels at regular intervals;
    c. Discrete breeding periods;
    d. Little overlap in generations; and
    e. Low population levels during late autumn and winter.

   Species included *B. jarvisi*, *D. aequalis, B. chorista* and *D. bellulus*.

3. Erratic changes.
    a. Rare and absent altogether at different times during the year.

   These species included *D. newmani*, *B. alyxiae, D. axanus*, *D. secamoneae, D. absonifacies* and *B. aurea. D. secamoneae, D. absonifacies* and *B. aurea* were caught briefly during Sept 2008 - March 2009.

Table 4.1. Distribution and seasonality of fruit fly species captured in cue-lure and *Bj* traps: August 2006-March 2009.

Species	Rank	**Peak Trapping Period**	**Distribution - Bowen Region**	**Queensland Distribution (Hancock *et.al.* 2000)**
B. tryoni	1	Spring/Early Summer	Widespread	Inland Queensland as far west as Mt. Isa and eastern Australia.
B. neohumeralis	2	Late Winter/Early Summer	Widespread	Eastern Australia south to Coff's Harbour, NSW.
B. jarvisi	3	Summer	Widespread	Eastern Australia from Cape York to Sydney NSW.
B. bryoniae	4	Autumn/Sprin g	Widespread	Eastern Australia as far south as Sydney NSW.
D. aequalis	5	Spring	Widespread	Eastern Queensland to central NSW.
B. chorista	6	Autumn/Sprin g	Widespread	Eastern Queensland.
D. bellulus	7	Summer	Widespread	Coastal areas of northeast Queensland as far south as Ayr.
B. alyxiae	8	Spring/Summ er	Widespread	Northeast Queensland as far south as Ayr.
D. axanus	9	Spring/Summ er	Bootooloo, Lower Don, Inverdon and Euri Creek East.	Northwestern and northeastern Australia as far south as Ayr.
D. newmani	10	Summer	Mt. Dangar and Case Park.	Semi-arid areas of northwest, central and eastern Queensland.
D. secamoneae	11	Early Spring	Dry Creek	Chillagoe, North Queensland.
D. absonifacies	12	Early Autumn	Bowen Township	Southeast Queensland to central NSW.
B. aurea	13	Early Summer	Dry Creek	Southeast Queensland.

Host Fruit Collection:

Table 4.2. Summary of infested fruit collected in the Bowen Region 2006 – 2009.

FRUIT (Family, species, common name)	Months collected	No. fruit collected (samples)	% Total fruit infested	No. flies/kg	Fruit fly and parasitoid species
ANACARDIACEAE					
Anacardium occidentale **Cashew**	November	16 (2)	31.2	670	*B. tryoni*
Mangifera indica **Mango**	December - February	242 (36)	64.0	10	*B. tryoni, B. jarvisi*
Pleiognium timorense **Burdekin Plum**	May - December	1214 (77)	43.6	30	*B. tryoni, B. neohumeralis D. kraussi*
APOCYNACEAE					
Ochrosia elliptera **Bloodhorn**	May - March	379 (30)	66.7	160	*B. tryoni D. kraussi*
Neisoperma kilneri	November - February	79 (7)	97.5	80	*B. tryoni*
CAPPARACEAE					
Capparis canescens **Wild Orange**		7 (2)	14.3	2	*B. tryoni*
CLUSIACEAE					
Calophyllum inophyllum **Beach Calophyllum**	All Year	776 (47)	78.4	160	*B. calophylli*
COMBRETACEAE					
Terminalia arenicola **Brown Damson**	May - March	604 (30)	74.3	240	*B. tryoni D. kraussi*
Terminalia catappa **Indian Almond**	August, February, March	107 (16)	44.0	50	*B. tryoni B. jarvisi*
Terminalia porphyrocarpa	May	43 (3)	58.1	200	*B. tryoni D. kraussi*
Bandicoot plum ***Terminalia* sp.**	May, October	44 (2)	43.1	380	*B. tryoni D. kraussi*
LECYTHIDACEAE					
Planchonia careya **Cocky Apple**	January	134 (15)	97.7	760	*B. jarvisi D. kraussi*
MORACEAE					
Ficus racemosa **Cluster Fig**	September, October, Nov, March	143 (14)	58.7	100	*B. tryoni*

Table 4.2. Summary of infested fruit collected in the Bowen Region 2006 – 2009.

FRUIT (Family, species, common name)	Months collected	No. fruit collected (No. samples)	% Total fruit infested	No. flies/kg	Fruit fly and parasitoid species
MYRTACEAE ***Psidium guajava*** **Guava**	February	14 (4)	100.0	250	*B. tryoni* *B. neohumeralis* *B. jarvisi* *D. kraussi*
Syzygium samarangense **Wax Jambu**	November, December	110 (10)	98.1	130	*B. tryoni* *B. neohumeralis* *D. kraussi*
PUNICACEAE ***Punica granatum*** **Pomegranate**		2 (1)	100.0	10	*B. tryoni*
RHAMNACEAE ***Ziziphus mauritiana*** **Chinee Apple**	May, August, September	689 (33)	33.5	70	*B. tryoni*
ROSACEAE ***Prunus avium*** **Cherry**		39 (1)	100.0	900	*B. tryoni*
RUBIACEAE ***Nauclea orientalis*** **Leichhardt Tree**	January - March	135 (11)	76.3	70	*B. tryoni*
SAPOTACEAE ***Chrysophyllum cainito*** **Star Apple**	August - November	57 (10)	63.1	400	*B. tryoni* *B. neohumeralis*

A total of 382 samples including 5236 fruits weighing 209.0 kg were collected from 32 plant species representing 24 genera and 18 families. Fruit flies were reared from 20 of the 32 plant species assessed (Table 4.2). The samples yielded 8820 adult fruit flies representing 4 species: *B. tryoni, B. neohumeralis, B. jarvisi* and *B. calophylli* and 248 adult parasitoids, *Diachasmimorpha kraussii* (Table 4.3).

Table 4.3 Summary of all fruit flies and parasitoids reared and their hosts in the Bowen region.

Species	% Flies caught	Fruit Fly host plants in the Bowen region (% fruit flies and parasitoids reared).							
		Cocky Apple	Mango	Guava	Star Apple	Burdekin Plum	Indian Almond	Wax Jambu	Ochrosia
B. tryoni	48.3	0.0	26.75	93.0	94.4	98.4	98.75	99.7	100.0
B. jarvisi	35.2	100.0	73.25	2.3	0.0	0.0	1.25	0.0	0.0
B. neohumeralis	0.4	0.0	0.0	4.7	5.6	0.06	0.0	0.03	0.0
B. calophylli	16.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D. kraussii	-	17.7	0.0	0.0	0.0	3.6	60.5	6.1	12.1

Figure 4.3. Fruit fly parasitoid *Diachasmimorpha kraussii*, on Guava fruit

Figure 4.4 Cocky apple tree with mature fruits

Figure 4.5 Burdekin plum fruits

Figure 4.6 Calophyllum fruits

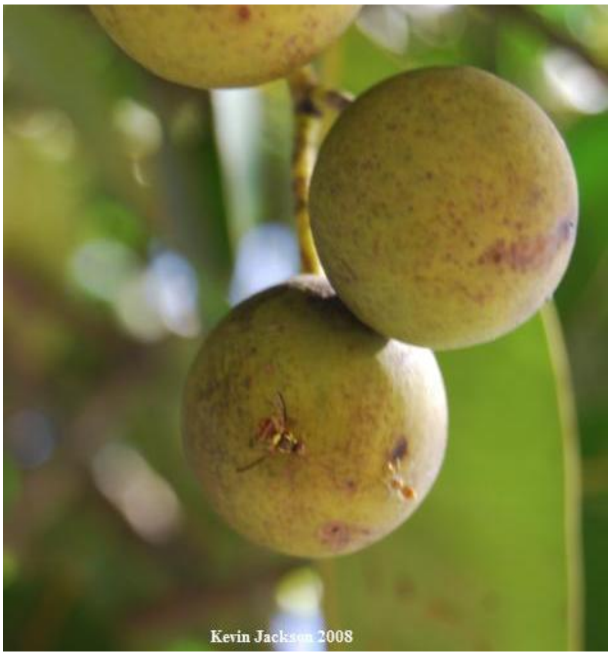
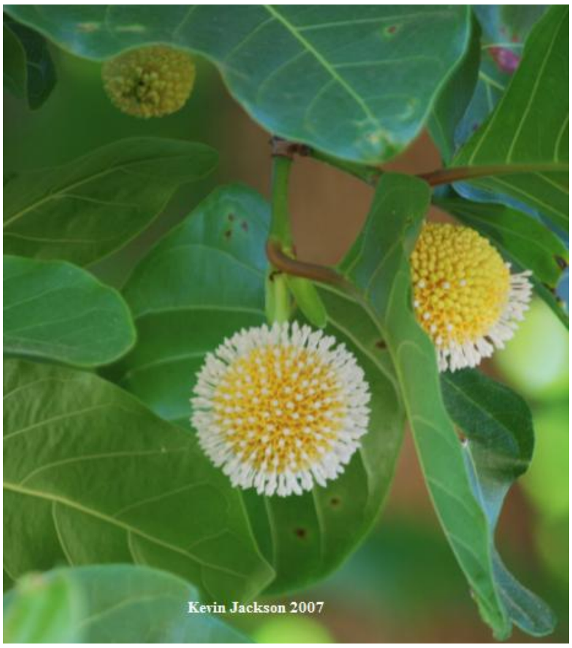


Figure 4.7 *Nauclea* flowers and immature fruit



B. tryoni activity peaked in December and January and declined between May and August (Figure 4.1). *B. tryoni* represented 77.1% of flies caught in cue-lure traps during the study period.

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Table 4.4. Host plants, infestation times and population dynamics of *B. tryoni*: 2006-2009

++ Recorded major hosts (Hancock *et al*. 2000). * Identified major hosts.

Host	**Population Increase**				**Peak Activity**		**Population Decrease**					
	A	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**
***Cashew++**				X								
++Mango					X	X	X					
Burdekin Plum		X	X						X	X		
Ochrosia elliptera		X	X	X	X					X	X	
Neisosperma kilneri				X	X	X						
****Terminalia arenicola++***	X	X	X						X	X	X	X
++*T. catappa*							X	X				
T. porphyrocarpa										X		
***Terminalia* sp.**			X							X		
Cluster Fig			X									
***Guava++**							X		X			
++Wax Jambu				X	X							
Pomegranate									X			
Chinee Apple		X										
++Leichhardt Tree							X	X				
***, ++Star Apple**			X									

Host fruit assessments detected *B. tryoni* in 18 different plant species. A total of 4258 flies were reared from host fruit collections. The recorded hosts, infestation times and population dynamics of *B. tryoni* are summarized in Table 4.4. Eight of the 18 host species sampled during the study period are recorded as major hosts (Hancock *et al*. 2000). Results of the limited fruit collections identified only four of these species as major hosts in the Bowen region. The remaining four species could be considered minor hosts because of the impact of local biotic and abiotic environmental factors. It appears that the wide range of host plants and their fruiting times is sufficient to ensure *B. tryoni* can breed continuously throughout the year

B. neohumeralis activity peaked between August and October with a secondary peak in December/January (Figure 4.1). *B. neohumeralis* represented 20% of fruit flies caught in cue-lure traps during the study period. Although the major native hosts found in the Bowen region belong to the genus *Terminalia* (Bostock and Holland 2010; Hancock *et al.* 2000), *B. neohumeralis* was only detected in small numbers in guava (16), star apple (11), Burdekin plum (7) and wax jambu (1).

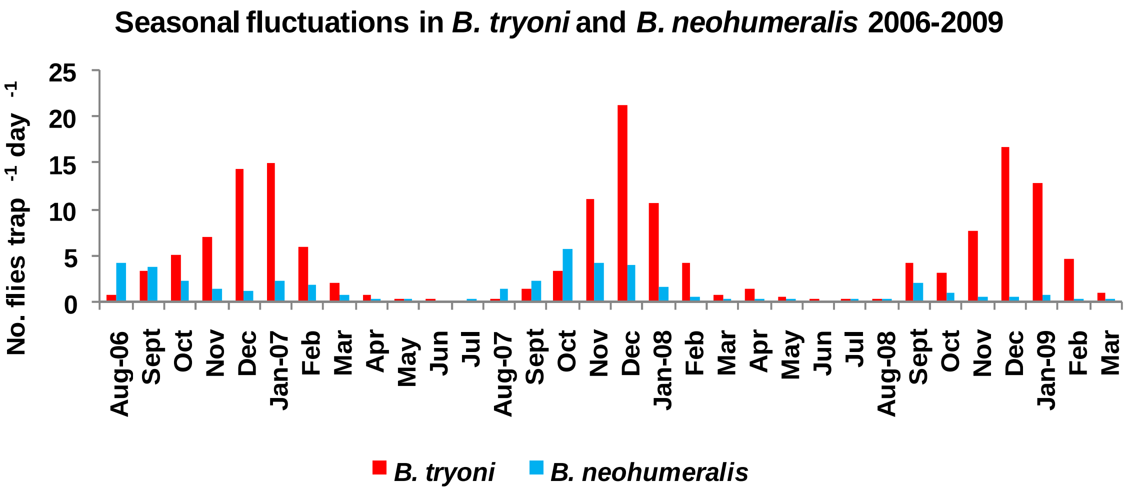

Figure 4.1. Seasonal fluctuations in *B. tryoni* and *B. neohumeralis.*

B. jarvisi has been primarily reared from cocky apple (*Planchonia careya*) (2630) and mango (*Mangifera indica*) (460). The mangoes sampled were untreated and collected from the Bowen Research Station's varietal orchards. Other hosts included guava (8) and Indian almond (*Terminalia catappa*) (7).

Cocky apple (*Planchonia careya*) is a highly desirable host for *B. jarvisi* (760 flies/kg). Cocky apple is widely distributed throughout the Bowen region and its fruiting season occurs from December to January (Beasley 2006) coinciding with the District's mango production season. Analysis of fruit collection data on early and late mango varieties (Table 4.5) showed an increase in *B. jarvisi*/kg from 3 to 10 during the period December 2008 to February 2009.

Table 4.5. *B. jarvisi and B. tryoni* reared from Mangoes during the 2008/09 production season.

Mango Variety	Harvest period	% Total. fruit infested	No. flies		% flies		No. flies/kg	
			B. jarvisi	***B. tryoni***	***B. jarvisi***	***B. tryoni***	***B. jarvisi***	***B. tryoni***
R2E2/KP	Dec/Jan	53.0	86	83	50.9	49.1	3	3
Keitts/Brooks	Jan/Feb	77.0	374	85	81.5	18.5	10	2

Trapping data (Figure 4.2) and fruit assessment confirmed that the annual peak in the *B. jarvisi* population occurred after the major mango harvesting period in December but coincided with the harvest of late varieties (Brooks and Keitts) in January/February. Host fruit collections did not detect any potential host(s) in the Bowen region outside the cocky apple/mango fruiting season.

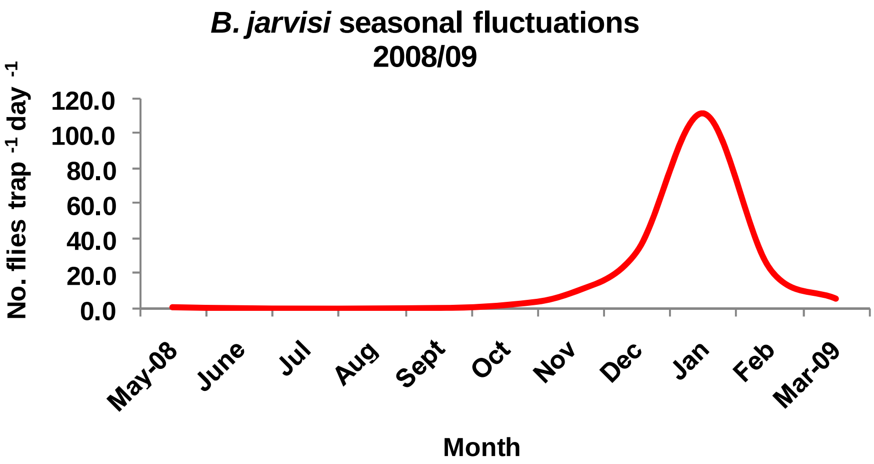

Figure 4.2. Seasonal fluctuations in *B. jarvisi* 2008/09.

Calophyllum inophyllum (Beach calophyllum) is the major host for *B. calophylli;* 72.8% of the fruit assessed were infested. Peak activity occurred during the period May - July. Although *C. inophyllum* is regarded as an occasional host of *B. jarvisi*, *B. frauenfeldi*, *B. tryoni* and *B. neohumeralis* (Hancock *et al.* 2000), these fruit fly species were not detected.

Calophyllum inophyllum is a native tree of the sandy beaches and dune systems of coastal central and northern Queensland. It is used as a shade tree and windbreak and for the stabilization of foreshore coastal dunes and revegetation of hind dune parklands/recreation areas. Bi-annual flowering occurs in January and July and results in continual cropping throughout the year.

B. calophylli is monophagous and is classified as a non pest species. *B. calophylli* does not respond to male lures and the species was not been found beyond the coastal foreshore and hind dunes of the Bowen region.

4.4 Discussion

Fourteen species of fruit flies were captured during the study. QFF (*Bactrocera tryoni*), lesser QFF (*Bactrocera neohumeralis*) and *B. jarvisi* predominated and occurred throughout the year. These species together with the non pest species *B. bryoniae, D. aequalis* and *B. chorista* are widely distributed throughout eastern Queensland. The non pest species *B. calophylli, B. alyxiae, D. axanus, D. bellulus, B. aurea, D. absonifacies* and *D. secamoneae* were not previously recorded in the Dry Tropics. *D. newmani* is distributed throughout the semi-arid areas of northwest, central and eastern Queensland and its presence in the Dry Topics could be reasonably expected.

As the species composition of the local fruit fly population was largely unknown prior to this study, the species identified to date could be either endemic or due to population migration. Based on Hancock *et al.* (2008), a pattern of migration north and south into the coastal areas of central eastern Queensland could be occurring with subsequent radiation outwards into the surrounding horticultural areas from the major river systems of the Don River and Euri Creek East.

Classification of the host status of a plant is dependent on a complex interaction of biotic and abiotic factors which may vary from season to season and between localities within a region.

Examples:

- *Terminalia* sp. dependent on accessibility and faunal predation.
    - *T. catappa* – limited fruit availability/low infestation levels.
        - Major street tree in the older sections of the township;
        - Poor canopy accessibility - large mature trees & pruning/maintenance activities;
        - Single annual crop; and
        - High faunal predation - major food source for black cockatoos.
    - *T. arenicola* – continual cropping/high infestation levels.
        - Small suburban street tree;
        - Limited tree population;
        - Good canopy accessibility;
        - Continual cropping throughout the year except in late winter; and
        - Periodic harvesting (supplementary food source) by black cockatoos.
- *Pleiognium timorense* (Burdekin plum).
    - Three diverse locations:
        - o Coastal urban foreshore (low maintenance/high maintenance) – moderate infestation;
        - o Rural-urban – high infestation; and
        - o Rural – low infestation.
    - Canopy accessibility; and
    - Fruit maturity – fruit do not mature on the tree with one exception - rural-urban.
- Mango: dependent on maturity status and time of harvest.
    - Untreated trees in windbreaks, abandoned orchards and residential areas:

  - o Early varieties (R2E2 and KP) - unharvested fruit on ground/high infestation;
  - o Late varieties (Keitts and Brooks) high infestation levels in fruit from the tree and the ground.
  - o Untreated trees and late varieties are a major source of food for rainbow lorikeets.
- Cocky apple, chinee apple and Leichhardt tree: dependent on fruit retention on trees.
  - Faunal predation; and/or
  - Onset of rainy season.

4.5 Conclusion

Results of limited fruit collections indicated the presence of seven major, six moderate and five low or occasional hosts for *B. tryoni* in the Bowen region. Major hosts included cherry, cashew, star apple, guava, *Terminalia* sp., *T. arenicola* and *T. porphyrocarpa. Ochrosia elliptera*, wax jambu, cluster fig, *Neisosperma kilneri*, chinee apple and Leichhardt tree were classed as moderate hosts. Occasional or incidental hosts included *T. catappa*, Burdekin plum, mango, pomegranate and wild orange. *Neisosperma kilneri* was a new host record for *B. tryoni*. Low infestation rates recorded for R2E2 and KP mango varieties and *T. catappa* could be attributed to harvesting of mangoes at mature green stage and the high predation of *Terminalia* fruits by black cockatoos.

Limited fruit collections did not detect any major hosts for *B. neohumeralis* although the trapping survey demonstrated the presence of large populations of this species in the region. This could indicate that specimens captured in traps during Spring and Summer could be the result of immigration.

The trapping and fruit assessment surveys demonstrated the presence of large populations of *B. jarvisi* in the region associated with the cocky apple fruiting season. The peak trapping time occurred after the peak fruiting times of mangoes and cocky apple indicating that the rapid increase and decrease in population levels in January/February could be due to immigration and emigration. As an alternative host has not been detected outside the cocky apple fruiting season, the status of *B. jarvisi* as a pest of economic significance in the Bowen region could remain low. It is possible that the Bowen region could be an important breeding area for *B. jarvisi.*

As fruit assessment has demonstrated, the host status classification determined under the current methodology is not indicative of the true attractiveness of a species as a major host and may vary for a species with the current biotic and abiotic environmental conditions and between different habitats within a region.

A comprehensive ecological study of the spatio-temporal distribution of *B. neohumeralis* and *B. jarvisi* in the Bowen region would be advantageous in determining the significance of these pest species in development of a systems based approach for maintaining market access of Bowen horticultural commodities in the future.

5. Technology Transfer

The following industry meetings were conducted and media articles published to inform project activities, research updates and Dimethoate and market access issues.

1. Capsicum and tomato growers meeting, Bowen 23 Feb 2006 – presentation on Dimethoate and market access issue by Kevin Bodnaruk, Area wide fruit fly management in citrus by Ed Hamacek, and proposed fruit fly project for capsicum and tomato by Siva Subramaniam.

2. Capsicum growers meeting, Gumlu 06 Apr 2006 - presentation on Dimethoate and market access issue by Bob Williams, Area wide fruit fly management in citrus by Ed Hamacek, and proposed fruit fly project for capsicum and tomato by Siva Subramaniam.

3. Capsicum and tomato growers meeting, Bowen 06 Apr 2006 – presentation on the project proposal and to facilitate tomato voluntary contribution

4. Bowen growers meeting 18 Oct 2006 – update on project progress and planned project activities for the 2006 season

5. Bowen Independent, 07 Jul 06 – media article released by Primary industry minister Tim Mulherin – to inform the DPI&F commitment for the fruit fly project

6. Fruit and Vegetable Newsletter (BDGA) Vol 14 Oct 2006 – an article published to inform the details of research activities to local growers

7. Bowen Independent, 03 Nov 06 – media article released by Whitsunday MP Jan Jarratt to inform the official start of the project and project staff appointments

8. Capsicum and tomato growers meeting, Bowen 11 April 2007. Up date on 2006 season project results and planning for 2007 fruit sampling.

9. Project Team meeting, Bowen 11 April 2007 was conducted to identify and develop work programs for the next season.

10. Capsicum growers meeting, Gumlu 16 May 2007. Up date on 2006 season project results and planning for 2007 fruit sampling.

11. Bowen District Growers Association meeting, 19 Sep 2007. A project update and interim results were presented to capsicum and tomato growers, and Chris Adriaansen gave presentation on the Dimethoate and Fenthion review.

12. Project progress report 2008 was submitted to the Bowen District Growers Association.

13. Capsicum and tomato growers meeting, Bowen on 10 May 2008

14. Market Access Program meeting, Indooroopilly 29 July 2008

15. Project progress report (2009) submitted to the Bowen District Growers Association.

16. Fruit fly area-wide workshop Gayndah 14 Oct 2010

17. Project (VG06028) Interim Report (March 2011) submitted to Horticulture Australia.

18. Tomato report (2011) ‘Evaluation of preharvest treatment and pack-house mitigation measures as fruit fly quarantine procedures in tomato production: A systems approach for tomato production in Bowen’ submitted to Biosecurity Queensland. DEEDI.

19. Capsicum report (2011) ‘Evaluation of preharvest treatment and pack-house mitigation measures as fruit fly quarantine procedures in capsicum production: A systems approach for capsicum production in Bowen’ submitted to Biosecurity Queensland. DEEDI.

6.0 Recommendations

- The results of this project clearly demonstrate the efficacy of the field cover sprays and pack-house mitigation measures in controlling the risk of fruit fly infestation in tomatoes and capsicums. This extensive sampling has provided a very high level of assurance that the packed product is free from fruit fly infestation. On this basis, an interstate market access protocol could be developed based on preharvest cover sprays and postharvest inspection.

- District-wide trapping data clearly shows a “low fruit fly pest period” from March to August. These data further support the assertion that tomatoes and capsicums grown during this period are at minimal risk of fruit fly infestation. The industry should consider the establishment of a “seasonal window” for the production region.

- A standard rotational field spray program and pack-house mitigation measures (washing, sorting and grading to remove defective and damaged fruit), can be considered within a ‘systems approach’ to meet the interstate market access requirements as an alternative to a dimethoate post-harvest treatment.

- It appears from the trapping data that the cover sprays are probably having most of their influence from about mid-August to November. Therefore, a standardised spray program should concentrate on this period.

- The spray intervals of 10–14 day from April to August and then at 7-day intervals from mid August to November should be considered for the cover spray program.

- **Future Research** :

  Bowen and Gumlu region is well suited for an area-wide management for fruit fly. All the fruit fly host crops such as tomato, capsicum, eggplant and mango should be targeted in the management program. For the control of the peak fruit fly populations in late-spring and summer, supplementary methods such as male annihilation blocking and protein bait stations should be investigated.

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Acknowledgements

The project team acknowledge the following organisations and individuals:

- Horticulture Australia Ltd, Ausveg and Bowen District Growers Association for funding the project.

- Bowen & Gumlu tomato and capsicum farms collaborated in the study and provided fruit samples.

- Denise Kreymborg, Industry Development Officer, Bowen District Growers Association for coordinating tomato funding and communicating project activities at various meetings.

- Bob Williams, former Science Leader DPI & F, who provided guidance and direction for the project.

- Dr Harry Fay and Iain Kay provided technical advice, comments on and review of project reports.

- Ed Hamacek provided taxonomical and technical support for fruit fly identification.

- Bowen Research Station staff – Sandy Anderson, Steve Matheson, Ron Holt and Joe Collison supported in various ways.

- Technical and field staff including Grahame Gerard, Verni Sivasubramaniam Garry Maddern, Lorna MCQuade, Dan Kelly, Jennell Glover, Suranda Potgieter provided support for fruit sampling and assessment and fruit fly trapping.

Appendix 1.

Fruit sampling Protocol

Currently New Zealand and some interstate markets require the application of both pre- and post-harvest dimethoate to control Queensland fruit fly (*Bactrocera tryoni*). With the long term availability of dimethoate being very uncertain surveys to determine the levels of infestation without the pre-harvest and post-harvest dimethoate are being undertaken.

Fruit (2007 season) – from both Bowen and Gumlu

- Tomatoes – focus on the Gourmet tomato – grown on a trellis
- Capsicums – focus on red capsicum

Sample to determine the levels of infestation under the current pre-harvest spray regimes

- No post-harvest dimethoate, current pre-harvest spray regimes (farms currently export under ICA26 to Victoria under these conditions)
- No pre- or post-harvest dimethoate (farms available for survey under these conditions would be those currently sending to the Brisbane Markets only – not interstate or to New Zealand)

Sampling requirements

- **Capsicums**
  - To be harvested four times at six weekly intervals during the period mid May to September 2007 (Week 20, commencing 14 May – to Week 38, commencing 17 September) (5 months)
  - 3-4 properties for each of the two categories (see Table 1) – 3 (or 4) using dimethoate pre-harvest and a further 3 (or 4) with no dimethoate pre- or post-harvest; numbers of properties can be varied depending on what is available
  - Harvests to occur six weekly (see Table 1 for sequence) – each harvest to be sampled systematically from nominated rows.
  - The total sample size to be collected across all of the selected properties should be 4,000 fruit per sampling time – 1,500 fruit *at harvest* and 1,500 fruit *at pack* from properties w/o pre-harvest dimethoate and 500 *at harvest* and 500 *at pack* from properties with pre-harvest dimethoate.
  - The *at pack* sample should be collected **after quality assurance procedures if at all possible**.
  - A discard sample should be collected from the pack line when possible.

- **Tomatoes**
  - To be harvested four times at six weekly intervals during the period June to October 2007 (Week 23, commencing 4 June – to Week 41, commencing 8 October) (5 months)
  - Three properties for each of the two categories (see Table 1) – three using dimethoate pre-harvest and a further three with no dimethoate pre- or post-harvest
  - Harvests to occur six weekly (see Table 1 for sequence) – each harvest to be sampled systematically from nominated rows.

- The total sample size to be collected across all of the selected properties should be 4,000 fruit per sampling time – 1,500 fruit *at harvest* and 1,500 fruit *at pack* from properties w/o pre-harvest dimethoate and 500 *at harvest* and 500 *at pack* from properties with pre-harvest dimethoate.
- The *at pack* sample should be collected **after quality assurance procedures if at all possible**.
- A discard sample should be collected from the pack line when possible.

Detection levels

- The maximum number of fruit which can be handled by the storage facilities is approximately 4,000 at any time (3,000 sampled from no pre-harvest dimethoate and 1,000 from pre-harvest dimethoate). This number can only be handled if labelling of each fruit is not required.
- To detect an infestation level of 0.1% with 95 % confidence need to get a sample of 2995. Larger samples will enable detection of lower infestation levels.
- *For fruit from properties without pre-harvest dimethoate* (6,000 *at harvest* and 6,000 *at pack* – total across all harvests for each commodity from properties under a common regime): would allow detection of an infestation level of 0.05% with 95% confidence at each of harvest and pack. If no infestation was found we could have 95% confidence that the proportion of uninfested fruit would exceed 99.95%. Should we be unable to combine across all harvests then this percentage would reduce.
- *For fruit from properties with pre-harvest dimethoate* (2,000 *at harvest* and 2,000 *at pack* – total across all harvests for each commodity from properties under a common regime): would allow detection of an infestation level of 0.15% with 95% confidence at each of harvest and pack. If no infestation was found we could have 95% confidence that the proportion of uninfested fruit would exceed 99.85%. Should we be unable to combine across all harvests then this percentage would reduce.
- It may be possible (under certain circumstances) to combine the at harvest and at pack samples and demonstrate lower detection levels.
- Results collected in 2006 may be used to supplement the collections in 2007 and give increased sample sizes.

Sampling procedure - at harvest

- **This sample must be taken prior to the regular pick**
- Sample systematically – for example, collect 5 fruit every 10 metres (cannot be finalised till more details on farms) – Jorgensen *et al* (2003) indicate that random sampling may be ineffective in detecting a pest at low pest levels and that systematic sampling can provide a better chance of detection
- Sample fruit which meet the farmer's criteria for harvest (.size and colour.); must not avoid picking fruit which look blemished nor selectively choose them
- If there are insufficient fruit at the nominated interval then sample the remainder of the fruit from the next bush in the same row
- Fruit do not need to be labelled indicating from which row/bush/sample point the sample was drawn. The trial aims to identify the overall infestation levels and not to locate the field position of any infested fruit.

Sampling procedure - at pack

The fruit will go through packing according to the bins used for harvesting so we need to select the cases from the packing line to cover the block used for the *at harvest* sample. It would not be possible to determine where individual fruit have originated without selecting and then packing the sample separately. This may be too artificial and not properly represent normal procedures - it would be easier to be more careful and the resultant sample would not be properly representative of normal QA results. As for the *at harvest* sample it is probably more desirable to have an increased sample size and forfeit knowledge of the field position of each fruit.

- Sample should be taken from fruit picked from the same block and on the same day as the *at harvest* sample

Assessment of infestation

- Fruit should be held for 5-7 days prior to assessment