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Strengthening the weakest link in peri-urban Medfly suppression

Final Report

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1 Executive Summary

Attempts to control or eradicate plant pests often fail due to a lack of pest control by urban and peri-urban landholders. This pilot project explores a novel approach to increasing landholder engagement to control Mediterranean fruit fly (Medfly) in the Peel Harvey region of Western Australia.

Behavioural economics makes use of social norm messages, also known as "nudges", to change people's behaviour in a beneficial way. For instance, social norm messaging has been heavily relied upon in encouraging COVID vaccine uptake often expressed through the message: "you should get the COVID vaccine to protect yourself, your family, and your community". The message provided to landholders about fruit fly was that they were expected to control Medfly on their properties for their own and their neighbours' benefit. Trapping data were presented to indicate how towns in the treatment region performed relative to each other in controlling fruit fly. This was a "nudge" to landholders to engage in Medfly control measures on their property. In addition, landholders were given four straightforward Medfly control measures to follow named *The CUBE Strategy*.

The effectiveness of different Medfly 'treatments' was assessed through an economic field experiment. Six towns were allocated to three information treatments, two per treatment. All six towns had access to information available on the Peel Harvey Biosecurity Group (PHBG) fruit fly website. Dwellingup and North Dandalup were control towns and received no specific messages; Byford and Serpentine received social-norm messages or "nudges" specific to their towns and Mundijong and Jarrahdale had access to face-to-face training in the towns, free traps, and social norm messages specific to their towns.

The Medfly trapping results showed that Medfly numbers were highly variable within towns and through time with a strong seasonality related to temperature, rainfall, and food availability. There were a small number of hotspots where landholder engagement could be focussed. The treatment effects were mixed: two treated towns had a significant reduction in flies trapped, one had no change, and one had a borderline significant increase in fly numbers. Byford, one of the towns with increased fly numbers, is prone to regular Medfly incursions from Perth's southern suburbs.

PHBG and UWA will continue the project through to June 2022. This will provide additional trapping data and further development of strategies to increase landholder engagement in Medfly control.

2 Introduction

Mediterranean Fruit Fly (*Ceratitis capitata*) or Medfly is a serious pest of horticultural crops in Western Australia (Broughton et al., 2014; Cook and Fraser, 2015). It is a declared pest in some shires under the Biosecurity and Agriculture Management Act 2007 (Western Australia Online, 2021). Where Medfly is declared, there is a legal requirement to undertake control using a range of 'acceptable' measures. Methods specified include clearing infested fruit at least every 48 hours, and killing larvae by solarisation, freezing and deep burial of fruit (Western Australian Government, 2013). Within the Peel Harvey, only the Shire of Serpentine Jarrahdale is declared for Medfly. However, there have been calls for extending the declared status to other areas, such as the Shire of Harvey (ABC, 2016). Medfly control traditionally relied on broadly and routinely applied cover sprays such as Fenthion (APVMA, 2014). However, the withdrawal of this option places a greater need for other control options that were previously considered supplementary.

The aim of this pilot project was to assess if targeted information and communication "nudges" can be used to change landholder behaviour and suppress Medfly populations in the Peel Harvey region. Projects that aim to change behaviour, such as this one, are becoming more important as they can increase landholder engagement across a peri-urban and urban environments (Florec et al. 2012; Arevalo-Vigne, 2017; Kruger, 2016, 2017). They also provide an approach to implementing controls in declared pest areas when strict compliance monitoring is prohibitively expensive for the regulator and the only option is engagement with landholders.

This project is designed as a field experiment that applies behavioural economic treatments, see List (2009) for a review of field experiments in economics. Ferraro and Price (2013) exemplifies a field experiment to improve natural resource management. They conducted a large-scale field experiment where some treatment households were sent modified water bills with a social norm message (a "nudge") about their water consumption compared to other households in their neighbourhood. This "nudge" led to a reduction in water use in treatment households. The design of this study as an experiment allowed a measure of the change in household behaviour in response to the "nudge". Another result from this literature is that the effectiveness of "nudges" declines through time (Ferraro et al., 2011) and therefore these interventions must be long term and constantly adapting to maintain interest.

Behavioural economics has developed from the application of psychological models to design policy interventions that improve economic outcomes in a range of settings, including health and financial decision making (Thaler and Sunstein, 2008). Arevalo-Vigne (2017) used a related model from psychology, the theory of planned behaviour (Ajzen, 1990), to design the "Low-Fly Zone'' information campaign, to persuade a community in the South West of Western Australia (outside this study area) to increase engagement in Medfly control. The theory of planned behaviour postulates that when individuals make choices, they are influenced by the behaviours and opinions of people around them, such as family, friends, and business contacts (Arevalo-Vigne, 2017). Increased knowledge about Medfly influences an individual's decision to adopt management practices for Medfly control by increasing their competence and determination to act.

In this project, there were three main stages in applying behavioural economics principles to reducing Medfly damages to crops in the Peel Harvey. First a landholder survey assessed the importance of Medfly in terms of treatments cost, and crop damage. The survey informed the design of the "nudge" treatments by providing information on crops grown, their value, and susceptibility to Medfly. Second, trapping provided information on Medfly prevalence across the peri-urban landscape in four Shire of Serpentine Jarrahdale towns (Byford, Serpentine, Mundijong, and Jarrahdale) and the two Shire of Murray towns (Dwellingup and North Dandalup). The allocation of towns to the treatments given below was also informed by the declared status of Medfly within the Shire of Serpentine Jarrahdale, whilst Medfly is not declared in the Shire of Murray (Western Australian Government, 2013). The trapping data is also a tentative measure of the effectiveness of the field experiment treatments. Third, the six towns were allocated to three Medfly treatments, two towns per treatment:

- Treatment 1, the control towns (Dwellingup and North Dandalup), had a Medfly trapping grid, but no specific information or resources were provided to manage Medfly.
- Treatment 2 (Byford and Serpentine) was an information only treatment, which provided feedback to the community on the status of Medfly trapping, but no further resources were provided.
- Treatment 3 (Jarrahdale and Mundijong), the intensive treatment, provided free Medfly traps and training courses in the target towns in addition to the information provided to treatment 2 towns.

The project was implemented by Peel Harvey Biosecurity Group (PHBG) and the fruit fly website was made freely available to all towns. Notably, it was not possible to exclude residents from the control towns accessing information on fruit fly control from the PHBG website. Treatment 2 and 3 towns are all in the Shire of Serpentine Jarrahdale.

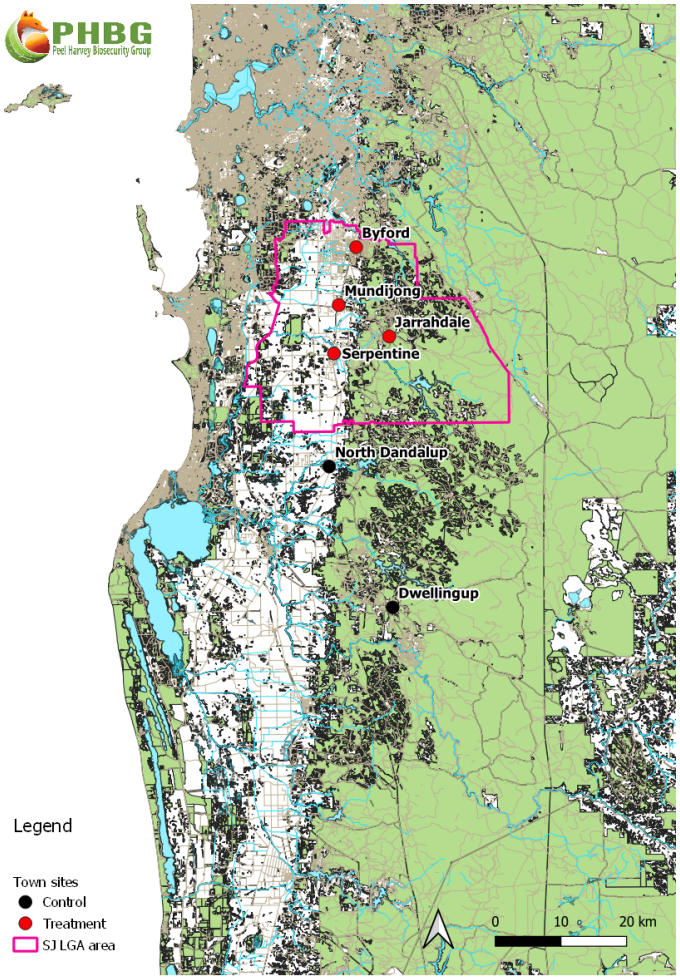
Applying economic field experiments to plant biosecurity is challenging for three reasons. First, we only observed landscape outcomes from Medfly trapping not individual landholder outcomes. Second, we depend on households opting into fruit fly training and paying attention to the "nudges" provided through the Peel Harvey Biosecurity Group (PHBG) webpage. Third, the treatments largely involved spreading information which is non-excludable. In the sense that we did not exclude anyone from consulting the information on the PHBG website or attending workshops. However, It was assumed information 'spillovers' would be negligible, for the following reasons:

- advertising was focussed on the treatment towns where the workshops were held.
- the distance from the workshop locations (between 30 and 60 km) to control towns effectively limited attendance from control towns.

Economically, policy intervention are only successful if the increase in landholder welfare exceeds the project cost. Landholder welfare, due to reduced Medfly costs, are difficult to measure. Therefore we use a reduction in trapped male Medfly as a proxy for the Medfly population density in the towns and associated crop damage (Florec et al., 2012). Although flies trapped is a stochastic signal, it reflects the effectiveness of all the activities taken by landholders to control Medfly. Notably fruit fly trapping is widely used internationally to support fruit fly management initiatives and determine trade access (Florec et al. 2012).

3 Methods and results

The project study region shown in Figure 1 extends 55 kms from Byford in the Shire of Serpentine Jarrahdale in the north to Dwellingup Shire of Murray in the south. The towns have different characteristics. Byford is on the Swan Coastal Plain and is increasingly part of Perth's urban fringe. Jarrahdale and Dwellingup are on the Darling Scarp and were originally timber towns. Mundijong, Serpentine and North Dandalup are also situated on the Swan Coastal Plain; they are small towns with an expanding perimeter due to the sub-division of surrounding farmland into "hobby farm" blocks.



3.1 Trapping network

A trapping grid was established over the six towns in February 2020 to June 2021 to measure the distribution of Medfly across the towns; increase understanding of the spatial correlation between the number of flies trapped; and measure whether any progress has been made through the behavioural treatments introduced. The trapping network was, where possible, on a fixed grid of approximately 200 metres. The number of traps by towns is given in Table 2.

Table 1 Population of treatment towns

Town	Population	Families	Private Dwellings	Median age	Shire
North Dandalup (ND)	712	195	294	42	Murray
Dwellingup (D)	557	145	308	46	Murray
Byford (B)	14908	4091	5389	29	Serpentine Jarrahdale
Serpentine (S)	1265	364	451	38	Serpentine Jarrahdale
Mundijong (M)	1232	334	459	39	Serpentine Jarrahdale
Jarrahdale (J)	1192	331	490	42	Serpentine Jarrahdale
Total	19866	5460	7391		

Source: ABS 2016, QuickStats Community Profiles.

The placement of traps was a trade-off between aiming for a 200m spacing, trap access and security. Most traps were in verge trees. The aim was to deploy fifteen traps per town. Jarrahdale had twenty traps because it has two residential clusters with larger blocks. Landholders that became aware of the project asked to hang extra traps in their area leading to additional traps in both Mundijong and Serpentine.

Traps were the Bio-Trap V2 X, purchased from BIO-TRAP P/L of Ocean Grove Victoria. The trap was set up with a Trimethoate lure (TML 3G), a sticky insect trap and a DDVP insecticide cube. All traps were visited at approximately 30 day intervals. A picture of a Bio-Ttrap is given in Appendix 3.

Table 2 Trap numbers by town and treatments

Treatment	Location	Towns	Number of traps	Local Government Authority and altitude (Alt)
Control (1)	Coastal plain	North Dandalup	15	Shire of Murray, Alt 54m
	Hills	Dwellingup	15	Shire of Murray, Alt 267m
Information only (2)	Coastal plain	Byford	15	Shire of Serpentine-Jarrahdale Alt 63m
	Coastal plain	Serpentine	17	Shire of Serpentine-Jarrahdale, Alt 35m
Training and information (3)	Coastal plain	Mundijong	16	Shire of Serpentine-Jarrahdale Alt. 43
	Hills	Jarrahdale	20	Shire of Serpentine-Jarrahdale, Alt. 228m

Note: the altitude data is used in the analysis of the trapping data to link towns with weather stations.

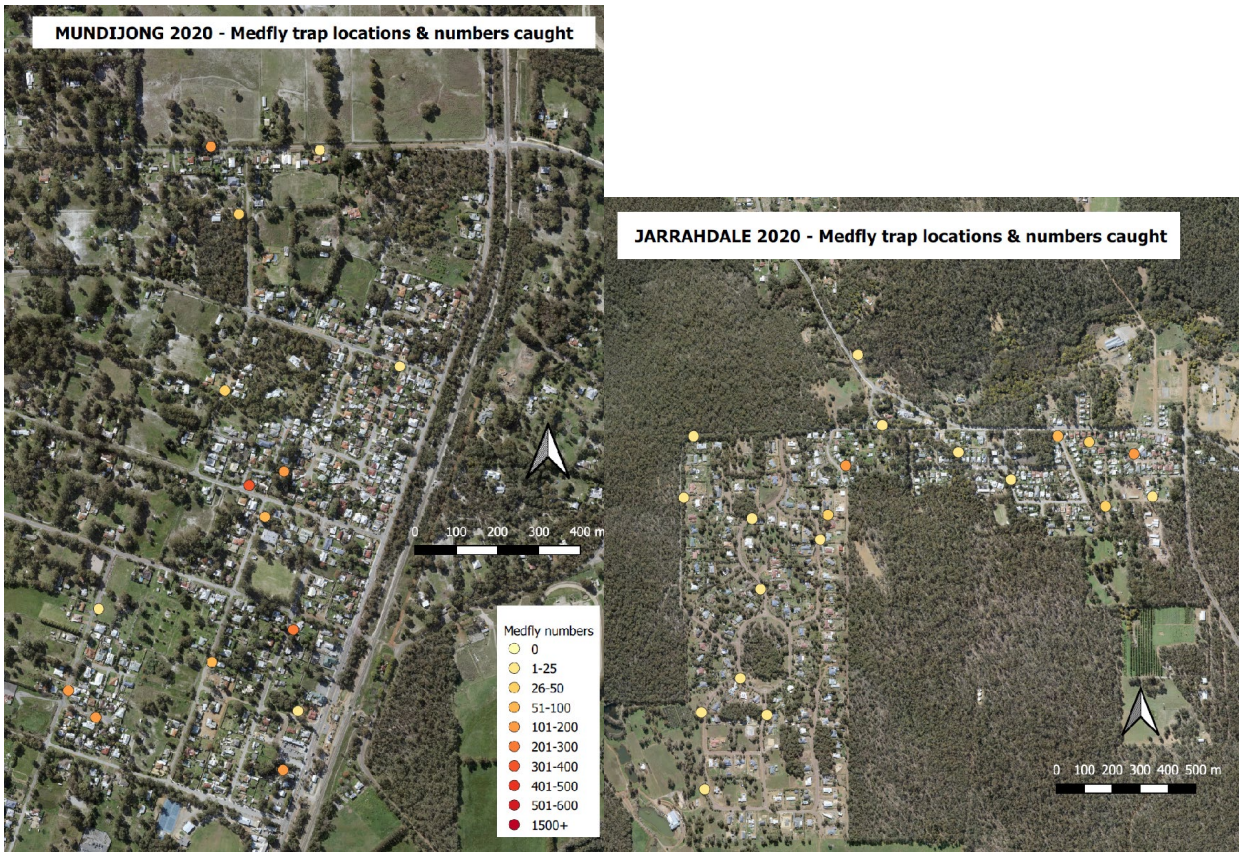


Figure 2 The Mundijong and Jarrahdale trapping grid

3.2 Landholder survey

The aim of the landholder survey was to provide baseline data on garden and small landholdings in the towns of Byford, Mundijong, Jarrahdale, Serpentine, North Dandalup and Dwellingup. The survey focussed on fruit and vegetable crops that were hosts to Medfly. The online survey was open for seven months from November 2020 through to May 2021. The relatively long period that the survey was open for was to increase survey participation in the absence of face-to-face surveys. The response rate was adversely affected by COVID lockdowns. The final number of surveys completed was 25.

The survey questions were organised into four main themes. First, information on crops. Second, perceptions of significant pests. Third, opinions on community engagement in Medfly control and information sources and fourth, the organisations and individuals that influenced Medfly management decisions. The online survey was promoted through a postcard, shown in Figure 3, which was delivered to letterboxes and left at pickup points such as local cafes and post offices. Completing the survey itself probably led some respondents to increase their efforts to manage Medfly.

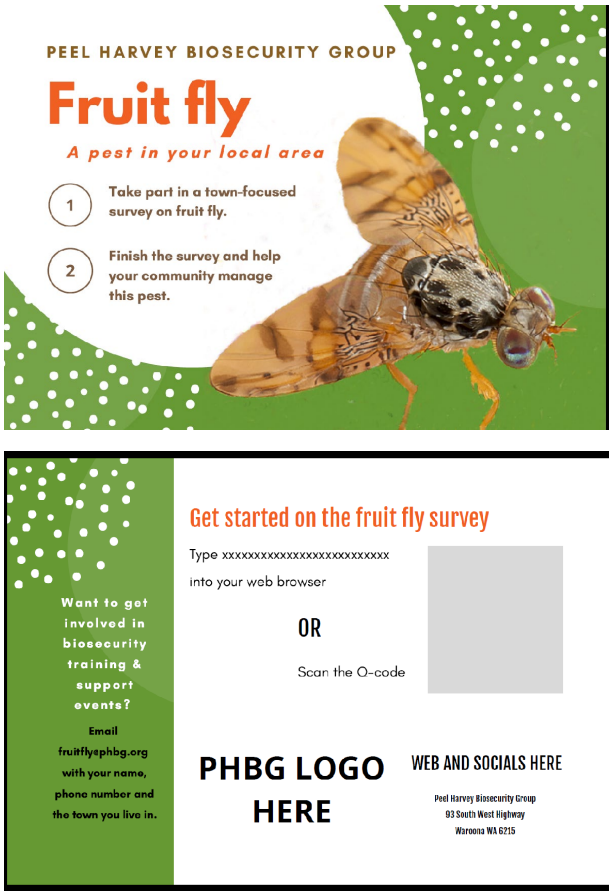


Figure 3 Recruitment postcard for survey

3.2.1 Crops grown

The area of fruit and vegetable crops grown by respondents indicates that the sample splits into two groups: gardens and larger rural blocks, Table 3. The median area of holdings was around 4000m^2. However, the data falls into a group with less than 6,000 m^2 and those with more.

Table 3 Area of block, fruit trees and vegetables

	Observations	Mean	SD	Min	Max
Gardens holdings ≤6000m^2					
Area of fruit trees	15	329	369	0	1080
Area of vegetables	15	238	277	0	900
Block area	15	2518	1756	340	6000
Rural block holdings >6000m2					
Area of fruit trees	10	14360	27319	911	89962
Area of vegetables	10	6165	12791	0	41521
Block area	10	91661	82043	20234	230671

Source: landholder survey

The landholders produce a wide range of fruit and vegetables known to host Medfly. Table 4 summarises crops grown, the yield per plant, total harvest, and estimated Medfly damage. The most widely grown crop category on both small and large properties are citrus, especially lemon, limes, and mandarins. This is followed by pome fruit and summer stone fruit (nectarines, peaches and apricots) . The largest estimated losses to Medfly are in apricots, nectarines, and peaches across both property types. The Department of Primary Industries and Regional Development advice on potential hosts (DPIRD, 2021) includes the list of crops given in Table 4. These crops are identified by DPIRD as Medfly hosts, however, the perception of respondents is that some of these crops are not significantly damaged by Medfly.

Table 4 Fruit and vegetable crops grown, harvest, yield and Medfly damage

	Gardens, properties less than or equal to 6000m^2						Smallholding, properties more than 6000m^2					
	Observation	Average number trees/plants	Harvest kg	Yield kg per plant	Number of respondents reporting Medfly damage	percent damage	Observations	Average number trees/plants	Harvest kg	Yield kg per plant	Number of respondents reporting Medfly damage	percent damage
apples	8	1.8	3.4	3.8	4	0	7	5	28.2	10.9	3	18
apricots	6	1.3	10.3	8.0	4	12.5	6	2	6.7	6.3	2	95
avocadoes	5	1.4	0.2	1.0	1	0.0	4	5	1.0	0.2	1	0
blackberry	1	2.0	0.0	0.0	0	0.0	2	2	0	0	0	0
blueberries	4	3.5	1.0	0.4	4	0.0	6	2	0.5	0.4	2	3
capsicums	6	3.8	3.4	0.8	5	0.6	6	5	1.5	0.7	2	13
cherries	1	1.0	0.0	0	0	0.0	3	5	2.0	1.3	1	0
citrons	2	1.5	10.0	7.5	2	12.5	2	3	40.0	40.0	1	75
eggplants	3	4.3	3.0	0.8	3	3.3	2	2	1.0	0.5	1	10
figs	8	1.9	5.6	3.7	6	5.3	7	3	2.6	1.1	4	4
finger lime	3	1.0	0.7	1.0	2	0.0	3	1	1.0	0.5	1	0
grapefruit	5	1.2	30.3	30.1	4	0.0	4	4	9.0	4.5	1	0
grapes	5	3.2	5.8	1.6	5	6.2	7	5	4.6	4.5	3	2
kiwi_fruit	0	0	0	0	0	0.0	1	6	20.0	3.3	1	0
kumquats	1	2.0	4.0	2.0	1	0.0	2	2	15.0	7.5	1	20
lemons	12	1.3	7.4	7.1	8	6.3	10	3	10.6	10.6	6	14
limes	12	1.3	2.6	3.2	8	0.0	8	2	8.5	7.7	6	0
mandarins	8	1.8	8.7	5.7	6	3.3	7	2	19.6	11.3	5	17
mulberries	7	1.4	6.5	5.2	6	0.0	9	3	22.3	8.2	7	5
Nashi pears	0	0	0	0	0	0	3	3	1.0	0.4	1	0
nectarines	5	1.4	4.0	4.2	3	16.7	5	2	6.7	10.0	1	60
olives	3	3.0	13.3	6.3	2	0.0	5	102	936.7	7.9	2	0
oranges (Valencia)	4	1.3	5.0	7.5	2	25.0	5	10	10.0	10.0	1	0
oranges (navel)	9	1.1	33.4	39.0	6	8.2	7	5	33.3	31.8	3	0
passionfruit	6	2.0	1.7	1.1	3	0.0	5	2	3.4	2.3	5	0
peaches	4	1.5	6.5	4.5	3	28.3	2	2	0.0	0.0	0	0
pears	3	2.3	6.7	3.3	3	3.3	4	2	0.0	0.0	0	0
persimmons	1	1.0	0.0	0.0	0	0.0	1	1	0.0	0.0	0	0
plums	4	2.0	6.5	4.7	3	0.0	5	3	14.0	7.3	3	16
pummelo	0	0	0	0	0	0.0	1	1	0.0	0.0	0	0
quinces	1	1.0	10.0	10.0	1	0.0	0	0	0	0	0	0
raspberries	1	1.0	2.0	2.0	1	0.0	1	1	0.0	0.0	0	0
strawberries	4	31.3	19.0	0.4	3	0.0	4	13	4.3	0.7	3	10
tangelo	1	1.0	10.0	10.0	1	10.0	4	2	6.0	5.2	2	6
tomatoes	10	11.2	82.1	2.9	8	2.9	8	6	7.8	2.0	6	4

Source: landholer survey

Table 5 Medfly control strategies, number of respondents

Strategy	High intensity	< < ----------	<---------->	----------->>	Low intensity
Fruit clearing	weekly	fortnightly	monthly	once a season	never
Number of respondents	13	2		1	
Lure and Kill traps	two per tree	one per tree	one every two trees	one every three trees	none
Number of respondents	2	7	2	1	5
Organic bait spray (Naturelure)	weekly	once a month	once every two months	once a year	never
Number of respondents		2	3	2	10
Netting and Bagging trees	all trees	most trees	half the trees	quarter of the trees	none
Number of respondents		4		4	9
Tree removal in last 5 years	5	3	2	1	none
Number of respondents	1			1	15

Source: landholder survey

Table 5 shows that basic Medfly control is followed by most respondents with fruit clearing, at least fortnightly, adopted by 88% of respondents who controlled for Medfly. Notably the recommendation from the Medfly declaration is that fruit clearing occurs every two days (Government of Western Australia, 2013) Trapping was used by more than half the respondents. The other strategies were not used by most respondents.

3.2.2 Labour effort and expenditure

The survey indicates that, on average, about two hours a week is dedicated to Medfly control strategies during the cropping season. Table 6 reports expenditure on bait sprays, lures and netting is, on average, $155 per landholder. Sixty percent of respondents identified themselves as “organic gardeners”.

Table 6 Effort and expenditure in Medfly management in the main fruiting season

	Observations	Mean	Standard Deviation	Minimum	Maximum
Average hours per week	17	2.06	2.11	0.4	9
Maximum hours per week	17	3.26	2.88	0.5	10
Annual expenditure on Medfly control $	17	155	239.57	0	1000

Source: landholder survey

3.2.3 Community response to Medfly and information sources

Table 7 indicates that most respondents view Medfly control as a community responsibility. Respondents perceived that some neighbours were not managing Medfly effectively. Around

44% of respondents felt some demotivation towards controlling Medfly due to the high levels of Medfly in their neighbourhood.

Table 7 Agreements with statements about community engagement

Statements	agree	neither agree nor disagree	disagree
Everyone in my neighbourhood manages the fruit fly on their property	1	16	8
I manage fruit fly on my property but my neighbours don't.	8	15	2
Fruit fly on my neighbours' property are so bad, I have given up trying to control fruit fly on my property	1	10	14
I think fruit fly should be managed by the entire community.	24	0	1
I would help my neighbour manage fruit fly if asked	18	5	2
I manage fruit fly to help protect commercial fruit producers	10	12	3
I have better things to do than manage fruit fly on my property	2	4	19

Source: landholder survey

Developing a strategy to manage fruit fly requires access to information from a range of sources. Respondents identified DPIRD and TV gardening experts as the most important sources of information (Table 8). Neighbours are least important. Around a quarter of respondents had attended a training course or information session on Medfly management.

Respondents were also asked how they would like to receive information on Medfly management in their area. Respondents indicated a preference for email followed by a dedicated website and face-to-face information. SMS was acceptable to about half the group, while Facebook and Twitter were not preferred. This may be a function of the average age of respondents, from Table 1 the rural towns have a higher average age than the urban fringe town Byford.

Table 8 Source of technical advice on fruit fly management?

Statements	agree	neither agree nor disagree	disagree
Retail hardware shops and stock feeders (Bunnings, Mitre 10, Landmark, Elders)	12	11	2
WA Department of Agriculture/Primary Industries (DPIRD)	19	6	
TV gardening experts (Gardening Australia, Gardening Gurus)	19	6	
Neighbours	6	13	6
Shire Council	10	10	5
Community garden groups	10	12	3

Source: landholder survey

Note: strongly and somewhat agree/disagree have been combined into the categories “agree” and “disagree”.

3.2.4 Summary of survey results

Landholders grow a wide range of crops that are potential Medfly hosts. Of these apricots, nectarines, peaches, and pome fruit are viewed by respondents as the most susceptible to significant damage. Most respondents put some effort into controlling Medfly. There is evidence, given in Table 7, that most respondents were not confident that their neighbours were engaging in adequate Medfly control. The most important sources of advice on Medfly control are DPIRD, TV gardening experts and farm supply and hardware retailers.

3.3 Behavioural intervention

The project developed a communication strategy to encourage landholders in the treatment towns to manage Medfly. The five steps in communication included: a postcard linked to the online survey; the survey itself; trapping activity; a website that also included a Medfly Newsletter (Fly Cast); and a set of strategies that households could use to tackle Medfly infestations on their property named “*The CUBE Strategy”;* and information sessions in Mundijong and Jarrahdale.

Some of the information is non-exclusive as it is passed around communities and between towns. However, the focus of specific information and education was in Byford, Jarrahdale, Mundijong, and Serpentine. North Dandalup and Dwellingup were separated geographically, see Figure 1, and not mentioned specifically in any of the social norm communications or training material.

The communication material was eye-catching and consistently branded with the Peel Harvey Biosecurity Group colouring and design. The training material aimed to motivate the control of Medfly through both self-interest and care for the community. The Fly Cast newsletter identified communities that had relatively high numbers of Medfly, based on the trapping data, to “nudge” them to take more action.

Training and information treatments were developed through three stakeholder group meetings during 2019 and 2020, followed by interactions with landholders at the Mundijong Farmers Market and the survey results. The interviews conducted at the market provided an informal way of gathering information on community attitudes to different strategies for Medfly control. A summary from the Mundijong Farmers' Market is given in Appendix 2.

3.3.1 Medfly management training workshops

The four Medfly management workshops, two in Mundijong and two in Jarrahdale were entitled: "Flattening the Medfly Curve" a reference to the COVID-19 outbreak. Workshop attendance was fifteen in the two Jarrahdale workshops and twenty in the two Mundijong workshops. The slides were based on a PhD study by Isabel Arevalo-Vigne (2017) that developed the Low Fly Zone campaign and associated promotional material. The workshop consisted of a three-part presentation which was also made available as a video on YouTube (White, 2020).

3.3.1.1 Part 1 - motivation and introduction

First the message conveyed was that Medfly is a public bad. If landholders do not control for Medfly, they and their neighbours will lose their crops. We also identified that there is a legal obligation to control Medfly as it is a declared pest in the Shire of Serpentine Jarrahdale.

Second, we focused on personal motivations for action. Using the message that home grown fruit and vegetables are healthy (chemical free), rewarding to produce and valuable. The presentation then provided evidence that Medfly threatened these values by damaging a wide range of fruit and vegetables.

Third, we then presented town specific information indicating, from the trapping data, that Medfly is a significant problem in their towns, (see Figure 4). We also indicated that there are no cheap and effective cover sprays available since Fenthion was banned. Therefore, there is no alternative to a community wide control effort.

Fourth we highlighted that Medfly reduces profitability and employment in commercial horticulture.

Fifth, the presentation re-emphasised the public bad aspects of Medfly and that freedom from Medfly depended upon the least vigilant neighbour – the "weakest link".

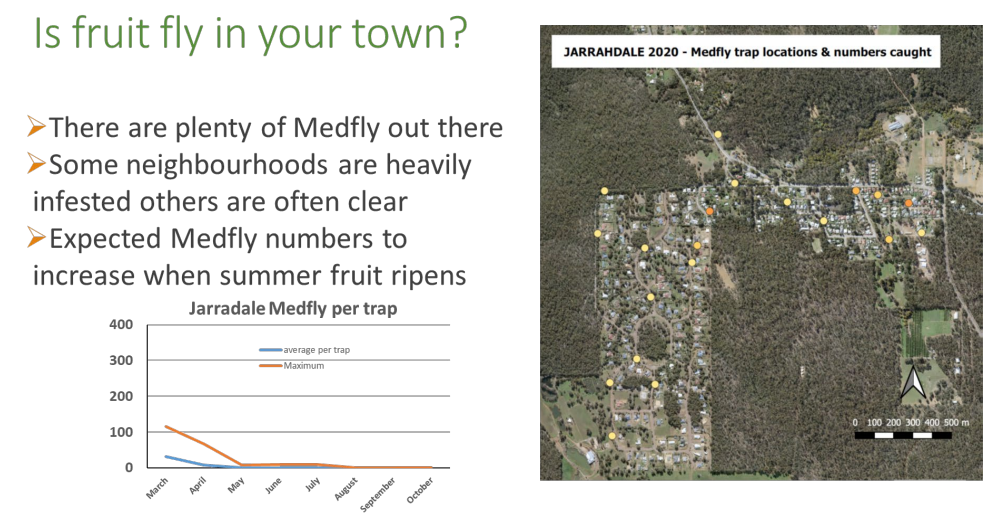


Figure 4 Example slide on trapping information

3.3.1.2 Part 2 – "knowing your enemy"

This section introduced Medfly biology and highlighted that flies are most vulnerable to control measures in early in the spring when adults start to emerge and look for food and egg laying sites.

3.3.1.3 Part 3 - The CUBE Strategy

This section outlined The CUBE Strategy which sets out straightforward steps that households can follow to manage fruit fly.

Figure 5 Slides introducing the Cube Strategy

For each of the strategies there is a slide that outlined the rationale (why), what to do, the cost, frequency and, if not obvious, where to apply. At the end of the workshop attendees were given a free fruit fly trap. Most options provided a low and a high cost option to allow landholders a choice between a cheap but labour intensive option and a ready-made solution from a hardware store.

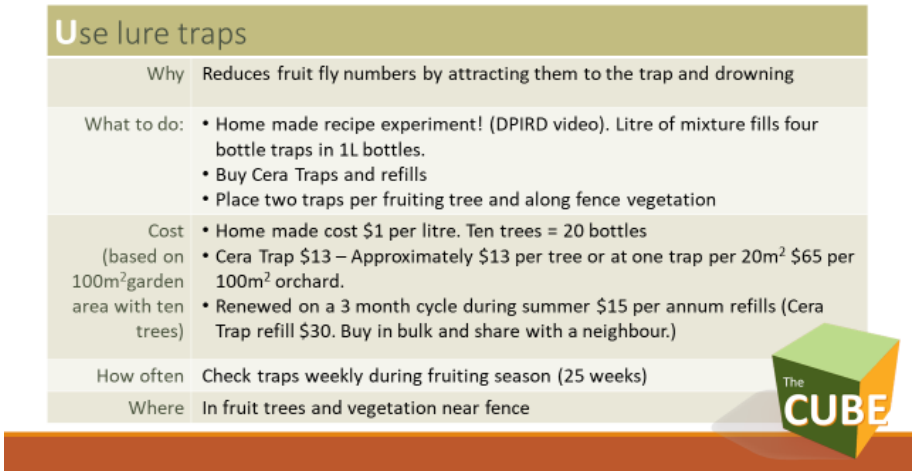


Figure 6 Example of a strategy description

3.3.2 Website and Fly Cast

The project website hosted by PHBG included control strategies and links to other advice on the DPIRD website. The website provides a report card – The Fly Cast contains information about Medfly trapping levels for the treatment towns and comparisons with trapping numbers in other towns (Figure 7). In behavioural economics this is called a “nudge”.

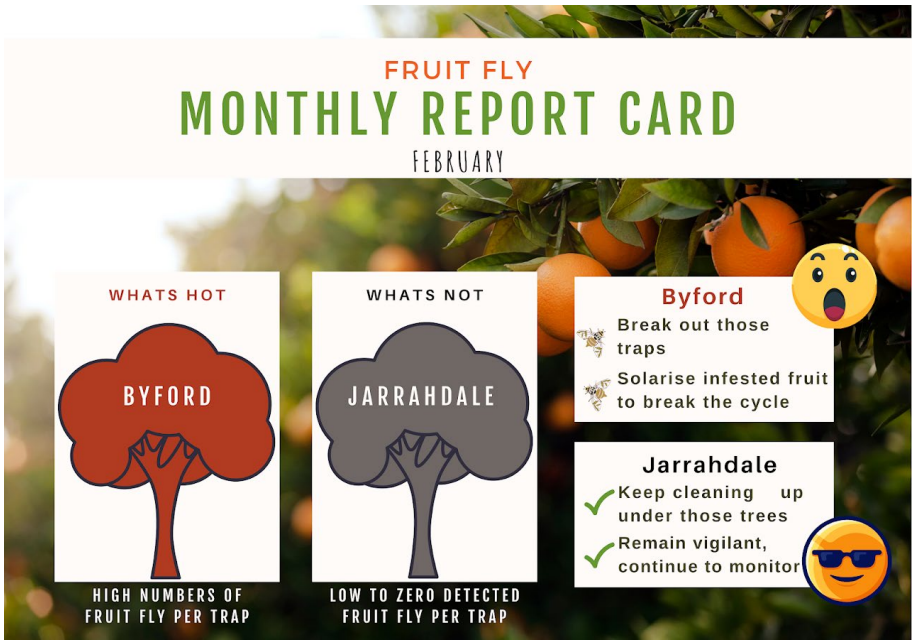


Figure 7 Example monthly report card

The Fly Cast newsletter is a one-page summary of the Medfly situation in the four treatment towns (Appendix 1). The design of the newsletter is based on the theory of planned behaviour (Arevalo-Vigne, 2017). The newsletter is designed to be colourful informative and encouraging. It gives information on the average number of flies trapped and a forecast of how they were expected to increases. Some towns are praised for doing well (smiley/cool emojis) while concern is expressed for other towns through concerned and frightened emojis. The implementation of The CUBE Strategy is related to the number of flies trapped. The section "*What's on the fruit fly menu?*" indicated crops likely to be damaged by Medfly. There were 130 visits to the Fruit Fly Page (between 20/12/2020 and 20/7/21) and 48 visited the fruit fly project page (Hooper-Worrell, personal communication, 2021).

Table 9 Average monthly trapping data March 2020 to June 2021

Town	Statistic	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Jarrahdale	Mean	24	8	1	1	1	0	0	0	0	0	2	4	0	1	1	0
	SD	34	16	2	2	2	0	0	0	0	1	3	13	1	1	1	0
	Min	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	116	67	7	9	9	1	1	1	0	2	12	57	3	6	3	0
Mundijong	Mean	55	41	4	1	1	1	0	0	1	4	17	14	19	26	10	4
	SD	63	49	5	3	3	2	0	0	2	10	40	30	49	36	10	7
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	187	188	12	13	13	8	1	0	8	42	151	120	193	142	31	23
Byford	Mean	66	66	37	6	6	3	3	3	14	26	35	11	11	31	13	11
	SD	149	149	102	12	12	6	13	11	21	36	73	29	18	79	33	32
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	587	587	403	47	47	22	50	43	64	100	292	115	66	311	128	124
Serpentine	Mean	28	23	5	2	0	1	0	0	0	8	21	4	2	5	2	1
	SD	62	82	14	6	0	2	1	0	0	25	74	10	5	10	5	2
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	233	341	57	24	1	10	5	1	0	102	305	35	19	42	21	7
Dwellingup	Mean	37	37	4	1	1	0	0	0	0	0	1	17	14	1	2	1
	SD	62	62	8	3	3	0	1	0	0	0	2	43	40	2	7	2
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	184	184	32	10	10	0	3	1	1	0	8	165	156	6	26	9
N. Dandalup	Mean	38	8	3	0	2	0	0	0	0	3	20	8	15	9	1	0
	SD	90	13	8	1	6	1	1	0	1	5	55	21	31	20	3	0
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	341	50	30	4	24	2	4	0	4	18	218	81	108	71	12	1

Source: PHBG trapping data

3.4 Analysis of the trapping data

3.4.1 Statistical model

The trapping data is monthly panel data with repeated observations for fixed traps. Fly numbers trapped are influenced by weather and location variables (Broughton et al., 2014), therefore, the model was estimated with fixed effects accounting for differences in the average number of flies caught in a trap. The data was estimated for count data. To avoid the over dispersion of the variance, where the sample variance is greater than the mean, the models were estimated as a negative binomial model.

Trapping data showed a strong seasonality and spatial variability, a result that was consistent with the findings of Broughton et al. (2014). The towns on the Swan Coastal Plain, namely, Mundijong, Byford, Serpentine and North Dandalup have a higher average number of flies than the towns in the hill, Jarrahdale and Dwellingup.

Other explanatory variables in the model included monthly maximum and minimum temperatures, and total monthly rainfall. The allocation of the three weather stations is given in Table 10. The pairings of weather stations to towns is based on distance to the weather station and altitude. Jandakot, is the only local weather station that has a similar altitude to the Swan Coastal Plain towns.

Table 10 Weather station allocation to towns

Weather station (BOM)	Town
Jandakot (Altitude 30m)	Byford, Mundijong, Serpentine and North Dandalup
Karnet (Altitude 286m)	Jarrahdale
Dwellingup (Altitude 267m)	Dwellingup

3.4.2 Trapping results

The treatment effects were measured by town specific dummy variables for information treatments period from in January 2021 to July 2021 and are included in the model as separate treatment dummy variables for all towns including the control towns.

The trapping results provide a measure of the success of the information treatments. Trapping numbers are highly variable between and within the towns. Notably, even in towns with high average trapping numbers there were traps with low numbers. Thus, some neighbourhoods are either relatively effective at managing Medfly or the environment does not support Medfly due to food resources. Other low catch traps are located away from Medfly host plants in native vegetation.

Table 11 Negative Binomial fixed effect model of flies caught

Variable	Parameters	Standard Error	Z	Pr>|z|	95% Confidence intervals	
Maximum temp	0.1173111	0.0468683	2.50	0.012	0.0254509	0.2091713
Minimum temp	0.1765606	0.0533366	3.31	0.001	0.0720228	0.2810984
Total Rainfall mm	0.0030668	0.0007932	3.87	0.000	.0015121	0.0046214
Byford treatment	0.3817959	0.1380929	2.76	0.006	0.1111388	0.6524529
Jarrahdale treatment	-1.663018	0.1681397	-9.89	0.000	-1.992566	-1.33347
Mundijong treatment	0.1993353	0.1289105	1.55	0.122	-0.0533246	0.4519953
Serpentine treatment	-0.828034	0.1752042	-4.73	0.000	-1.171428	-0.48464
N.Dandalup treatment	0.047026	0.1793398	-0.26	0.793	-0.3985255	0.3044735
Dwellingup Treatment	-1.680618	0.1850459	-9.08	0.000	-2.043302	-1.317935
Constant	-5.978094	0.6338464	-9.43	0.000	-7.22041	-4.735777
N =1,729 (Seven traps were excluded as all observations were zero)						
Wald chi2(9)= 504.72						
Groups (traps) 91						
Log likelihood,= -3265.6236						

For the information and training towns (treatment 3), flies trapped fell significantly in Jarrahdale and there was an insignificant increase in Mundijong. Of the two information-only towns, there was a small significant increase in Byford and a significant decrease in Serpentine. Of the control towns, North Dandalup had no change and Dwellingup a significant decrease.

Conclusions from these results of the effectiveness of treatments are tentative; however, it appears that more remote (hill) towns are better able to manage Medfly. There may have been some information "spillover" to residents in Dwellingup that improved their management of Medfly. This could have occurred from receiving the survey postcard and completing the survey. Alternatively, environmental variables that explain the fall in flies trapped may have been omitted from the estimated model.

3.5 Project costs

The aim of the project was to establish a low cost, community-based approach to pest management using principles derived from behavioural economics. The main direct cost of the project was the establishment and maintenance of the trapping grid of 98 traps across six towns. Other costs included overhead costs related to running the project as a research project and would not apply to an operational project. Over two years the total cost of the project was $53,712 or around $27,000 per annum.

Table 12 Project costs for two years

	Hours	Cost
Setting up the trap sites, 11 days (83.6 hrs)	83.6	
Monitoring in the field to (May 21'), 45 days (342 hrs)	342.0	
Organising postcard drop-offs, mail out and SJ market attendance, 7 days (53.2 hrs)	53.2	
Organising/attending workshops 5 days (38 hrs)	38.0	
Administration (ordering monitoring supplies, record keeping, meeting notes, etc). 9.2 days (70 hrs)	70.0	
Sub-total monitoring hours	586.8	
Project promotion including fruit fly events: 6 hrs	6.0	
Promotion product design: 5 hrs	5.0	
Website project page development: 10 hrs	10.0	
Fly Cast newsletter delivery: 6 hrs	6.0	
sub-total media	27.0	
Project design/execution (planning meetings with project partners): 10 hours	10.0	
Staff management: 18 hours	18.0	
SJ Market and workshop attendance: 12 hours	12.0	
Sub-total administration	40.0	
Total cost at $65/hour PHBG charge out rate		42497.00
Total cost travel 8263 km at 78 cents per km		6445.14
Miscellaneous costs		
Tablet data - $15/month - $270	270.0	
Printing and advertising ~ $1000	1000.0	
Fruit fly trade stands and venue hire ~ $1500	1500.0	
Traps $2000	2000.0	
		4770.00
Total cost to the PHBG 2020 and 2021		53712.14

The benefits of this project, in terms of reduced costs for managing Medfly and reducing damage, are difficult to measure directly. From the landholder survey, the average expenditure on Medfly is $155 per household per year. The number of households in the Shire of Serpentine-Jarrahdale is 5,120. For the benefits of the project to exceed the annual cost, the annual benefits of the project in terms of reduced damage and cost related to Medfly would only have to have to be around $5.24 per household per year.[1] To put this in context, this would be achieved by reducing the average land holder cost of $155 per annum by 3%

4 Achievements, Impacts and Outcomes

This project has demonstrated that diverse stakeholders can come together to deliver a worthwhile research project. In this case, the University of Western Australia has shown its willingness to adopt a genuine partnership model - its community partners were consulted throughout the design and implementation phases of the project. More so input from community partners was valued, especially with regards to incorporating local knowledge on constraints and opportunities in the field.

A university who takes a leap of faith and places its trust in community, as well making an investment in building community capacity to deliver on ground aspects of a research project, can reap dividends. For example, there are a set of intermediary outcomes, facilitated by UWA, that have ultimately led to the extension of the project beyond the original funded scope.

The intermediary outcomes are:

- training of PHBG staff in Medfly monitoring
- supply chains for purchasing monitoring equipment and consumables set up for the PHBG
- data collection procedure established for the PHBG.
- data sharing procedure for the PHBG to routinely transfer of surveillance data to UWA

[1] That is ($53,712.14/2) to give an annual cost and then divided by the number of households in the treatment towns.

- analysed data provided by UWA to PHBG with clear end-use.

The main research achievement of this project was that we established a behavioural economics intervention to control a damaging pest across a region. The lessons learnt about analysing trap data and community information are readily transferable to other pests.

There is some evidence from the trapping data that the intervention was successful in some of the towns, most notably Jarrahdale and Serpentine, in terms of the main outcome which was to reduce the number of flies caught. The trapping data showed that Medfly numbers were concentrated in a few hotspots and that future interventions could be targeted to those neighbourhoods (e.g. a number of streets adjacent to the trap).

An outcome that is encouraging, but also presents challenges, is the increased expectations of highly engaged and invested community members. Several community members who have been engaged as an outcome of this project are very keen to see 'uncooperative' landholders brought into line, especially those that have large abandoned orchards. These requests have been directed to the PHBG. Yet, compliance is beyond the legislated scope of community groups, even when PHBG are a recognised biosecurity group under the Biosecurity and Agriculture Management Act (BAM) 2007.

If the PHBG is seen to have no power to influence non-compliant landholders, and DPIRD does not utilise provisions under the BAM Act to enforce compliance, then the positive impacts of this project, may be undermined or short-lived. This equally applies to other declared pest problems where recognised biosecurity groups are engaging landholders, but there is highly visible non-compliance. In other words, community engagement is most effective if it is reinforced by penalties and compliance monitoring for blatant and large scale non-compliance. High level non-compliance is often due to failed commercial enterprises and absentee hobby farmers.

5 Discussion and Conclusion

The project has developed a methodology for increasing community engagement in a biosecurity initiative based on behavioural economics. The initial results, in terms of access to the web resources and a reduction in the number of flies trapped, indicate that the project is engaging with the community and reducing Medfly numbers. The project will continue through to June 2022 and this will allow further analysis to be completed on the design of community engagement initiatives.

Aspects of the project that could have gone better include the survey participation rate. It was clear that residents were not inclined to take on-line surveys. In the original pre-Covid project plan, online surveys were to be supplemented by surveys administered face-to-face. This was not possible but may be revisited in the next Medfly season.

6 Recommendations

Recommendations from this project are as follows.

1. There is potential for the use of behavioural economics principles in pest management. The most important elements of this are that, if pest monitoring is feasible, the results can be reported back to landholders in a way that improves their management of the pest.
2. Further work would be beneficial on the interpretation and communication of trapping data as a forecasting tool so that the community are warned about pest activity before crop damage occurs.

3. The costs of monitoring are largely labour and travel. Substantial savings could be achieved by biosecurity groups monitoring for multiple pests in one location. Currently only Medfly are monitored using a fixed trapping grid by PHBG. The PHBG is keen to maximise efficiencies but the political and community appetite for biosecurity groups to be funded to undertake systematic surveillance is unclear.
4. The positive impacts of the project may be undermined by landholders who do not change their behaviours as the result of “nudges” and are viewed as getting away with poor pest management practices that contravene their responsibility to control Medfly under the BAM Act. Further clarification from DPIRD is needed on the policy and compliance framework to support recognised biosecurity groups in landscape-wide behaviour change.

7 Appendices, References, Publications

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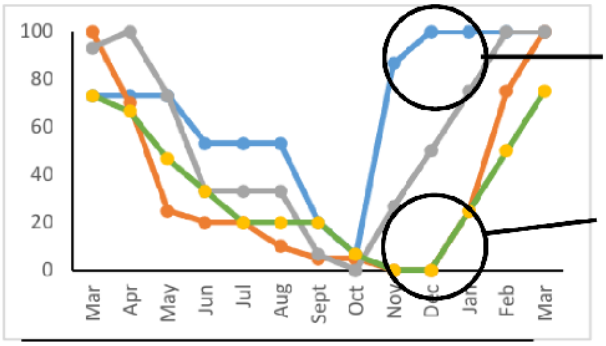
Appendix 1 Fly Cast issues

THE SHIRE OF SERPENTINE-JARRAHDALE **FLY CAST**

The SJ Fly Cast:

- reports on the trapping data for Mundijong, Serpentine, Jarrahdale and Byford
- warns you about what produce is on the fruit fly menu this month
- reminds you to use the C.U.B.E. strategy to protect your fruit trees and vegetables
- shares community feedback and answers common fruit fly questions

Fruit fly trap percentage figures observed - and forecast



REPORT CARD

BYFORD MUNDIJONG

Fruit fly numbers are rising activate the C.U.B.E strategy!

JARRAHDALE SERPENTINE

Well done no fruit fly numbers detected, stay vigilant!

What's on the menu for fruit fly in December?


MANDARINS


APRICOTS


LEMONS


LIMES

For these high alert products use the C.U.B.E. strategy to manage fruit fly impacts

What is the C.U.B.E. fruit fly strategy?

- Clear ripe and fallen fruit (garden hygiene)
- Use traps to drown fruit flies (homemade or commercial)
- Bait to kill flies with organic insecticide (spray or paint)
- Exclude flies from fruit, preventing fruit being stung (nets or bags)

If you are not looking after your trees, consider removing them. Your neighbours will thank you.

Want your fruit fly questions answered?
Email it to fruitfly@PHBG.org

LANDHOLDER COMMENTS

'I caught a fruit fly in the free trap I got at the recent fruit fly workshop- within the hour!'

Q AND A

Do fruit fly bait sprays harm honey bees?

A large number of insecticide products contain Spinosad which is highly poisonous to bees. Consider only using baits containing Spinosad when bees aren't active or using a trap with a homemade lure instead.

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THE SHIRE OF SERPENTINE-JARRAHDALE FLY CAST

The SJ Fly Cast:

- reports on the trapping data for Mundijong, Serpentine, Jarrahdale and Byford
- warns you about what produce is on the fruit fly menu this month
- reminds you to use the C.U.B.E. strategy to protect your fruit trees and vegetables
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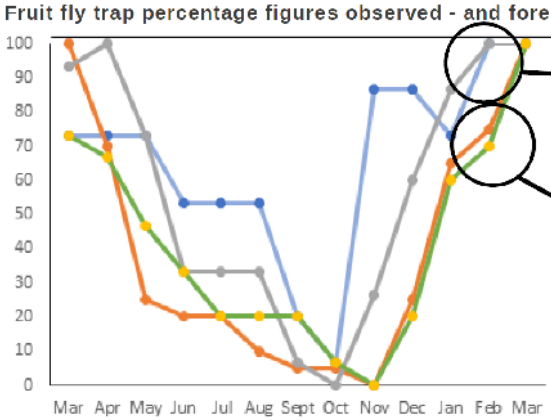

REPORT CARD

= BYFORD MUNDIJONG

Fruit fly numbers are HIGH activate the C.U.B.E strategy!

= JARRAHDALE SERPENTINE

Small numbers of fruit fly detected, but hot spots recorded

What's on the menu for fruit fly in February?

NECTARINES

PEACHES

PLUMS

APPLES

For these high alert products use the C.U.B.E. strategy to manage fruit fly impacts

What is the C.U.B.E. fruit fly strategy?

- Clear ripe and fallen fruit (garden hygiene)
- Use traps to drown fruit flies (homemade or commercial)
- Bait to kill flies with organic insecticide (spray or paint)
- Exclude flies from fruit, preventing fruit being stung (nets or bags)

If you are not looking after your trees, consider removing them. Your neighbours will thank you.

Want your fruit fly questions answered?
Email it to fruitfly@PHBG.org

Q AND A

How many different fruit fly are there?

In 2000, a study reported more than 4000 different fruit fly species. In our area there is only one to worry about the Mediterranean fruit fly, or MedFly. Queensland fruit fly was recently declared as an incursion in Perth, but has now been eradicated by DPIRD using trapping and bait spraying. Wouldn't it be great if we could eradicate Medfly in SJ. It is feasible, but we would need to work together

Appendix 2 Feedback from a farmers market in the treatment towns

From: Dr Jonelle Cleland, Chief Executive Officer, PHBG

The market was a really great opportunity to connect with locals on fruit fly (FF). People I spoke to came from Mundijong, Byford, Serpentine, Jarrahdale, Cardup and Oakford. There were a few from outside our operational area - Kelmscott, Armadale, Hilbert and Fremantle.

The test tube with real specimens (showing the FF life cycle) was the most popular item to launch a conversation, with kids and adults alike. Many paused to look at the oversized FF cutout, which was also a good talking point. Fun to go between the test tube and the cutout.

It was surprising the number of people who did not think that they had fresh produce susceptible to FF. The calendar on the DPIRD handout was handy to demonstrate all the fruit and veg that FF can impact.

The fruit/veg that people lamented the most about, in terms of losing their produce to FF, was apricots and figs. One landholder had removed their fig tree for this reason.

Quite a few people indicated that they had made their own 'fly' trap out of a milk bottle. Some indicated that they had found info on the web. However, all the people that I spoke to did not include the yellow lid/band to attract the FF. A more in-depth conversation with a stallholder makes me think that there is a little bit of confusion between traps for your annoying household flies and FF. There was also confusion about the number of traps required. There was a mixture of homemade and commercial lures; however, no-one could remember the name of the commercial product they were using.

People indicated that they were interested in attending the FF workshop. With the four options, people were weighing up which one they would attend - only one person committed to a specific workshop. I was very excited when I discovered a young lady who hand delivers brochures etc. in Jarrahdale. She charges $100 for a delivery run. I think it will be worth engaging her to deliver workshop flyers for Jarrahdale. Mundijong can be covered with the Examiner delivery.

Many people took the survey postcard. We may need to be open to people who are just on the outskirts of town being eligible - in their mind they are 'townies'. Also, Cardup people were very interested in doing the survey and participating in the workshops. Ben, Cardup lies between Mundijong and Byford.

A couple of older gentlemen wanted the return of banned chemicals for FF. One was an ex-orchardist and the other was a current commercial orchardist. The latter wanted elimination, not suppression, and referenced aerial spraying programs in California. The former wanted abandoned orchards and neglected backyard trees removed.

A few people complained about their neighbours not caring about fallen fruit, and that being the source of their problem with FF.

Afterwards, I visited the Mundijong Stockfeeder. I have taken photos of their products and prices, and will send these through. They have also put up one of our posters advertising the workshops.

Appendix 3 Bio Trap picture

Australian Plant Biosecurity Science Foundation

E: info@apbsf.org.au
www.apbsf.org.au

PLANT BIOSECURITY
science foundation