AN ANALYSIS OF TRAVELLERS CARRYING FRUIT NEAR GRIFFITH, NSW, DURING EASTER 1996 TO ASSESS THE RISK FOR QUEENSLAND FRUIT FLY (*BACTROCERA TRYONI* (FROGGATT))

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Summary

Roadblocks were conducted on the entry side of the Fruit Fly Exclusion Zone near Griffith (NSW) during 5 days covering the Easter 1996 period to determine the rate of fruit carrying by tourist traffic into the Murrumbidgee Irrigation Area (MIA). A high proportion (80.2%) of the traffic passing the site during the operation was stopped, asked to answer a questionnaire, and inspected for fruit brought into the MIA. The 1595 completed forms were analysed for trends according to types of travellers, origin and destination of travellers, and fruit carried by travellers. Travellers from Queensland, and families and retirees were found to be the highest risk groups which carried fruit into the quarantine zone.

INTRODUCTION

Queensland fruit fly (Qfly) *Bactrocera tryoni* (Froggatt) is a serious pest of horticultural crops in Queensland, and north eastern and many coastal parts of New South Wales. Its occurrence in south eastern regions of Australia becomes more sporadic towards the south. Froggatt (1909) observed that the natural southern limit of Qfly was about Gosford, north of Sydney. Sproule (1975) reported that Qfly were apparently common around Sydney at the turn of the century. Qfly was recorded in the Murrumbidgee Irrigation Area (MIA) in the 1930's and by 1946 in Melbourne and Gippsland in Victoria, and Adelaide in South Australia.

Importing countries are sensitive to receiving produce from areas known to have infestations of Qfly. The three States of Victoria, South Australia and New South Wales, agreed in 1994 to jointly manage a Fruit Fly Exclusion Zone (FFEZ) to maintain access to these markets without the added costs of disinfestation (Anon. 1993). The FFEZ covers the major horticultural production areas mainly on the Murray River and its major tributaries; the FFEZ covers the south western New South Wales, eastern South Australia and northern Victoria. Management strategies have been coordinated between the three States to prevent Qfly outbreaks inside the zone. Assuming these strategies eliminated any resident populations of Qfly from within the FFEZ, fruit fly outbreaks could only result from new introductions from outside the Zone.

Qfly are unlikely to fly in or be blown into the monitored areas of the FFEZ from wild populations in the Risk Reduction Zone (RRZ) surrounding the FFEZ. Within New South Wales, a system of quality assurance and inspections currently exists for approved importers of fruit into the FFEZ to minimise the chance of sale and spread of Qfly infested produce by commercial fruit traders. The only other avenue for introduction of infested produce is the travelling public who might carry fruit into the Zone. Sproule (1975) commented that the greatest risk of infested fruit came from fruit being carried from home gardens by the travelling public. Roadblocks are one of the strategies which might minimise introductions by the general public.

The value of roadblocks to protect horticultural production areas has always been contentious. Use of the roadblock strategy varies depending upon the needs of different States, the perceived value of roadblocks compared with the perceived level of threat from fruit fly introductions from endemic areas, and the size or value of markets to be protected.

Harris *et al.* (1982) reviewed research and indicated that only about 12% of introduced fruit flies were likely to survive to become sexually mature. The dispersal characteristics of Qfly did not favour establishment in new areas. The chances of establishment increased if the initial introduction was large or if multiple introductions occurred close together in space and time. Another option not mentioned by Harris *et al.* (1982) would be that a small colony, resulting from an introduction, might combine with a small overwintering population, assuming adults matured at the same time; the combined population may possibly develop more quickly than either of the single populations.

O'Loughlin (1983) reported that following large numbers of fruit fly outbreaks in Victoria in 1956, road blocks were set up along the Victoria–New South Wales border. By 1961, there were 21 roadblocks established, and 28 operating in 1971. Following a review, this was reduced to 13 in 1979 and discontinued in 1983. O'Loughlin (1975) reported

that, after the introduction of border roadblocks, the number of fruit fly infestations in Melbourne were eliminated. However, Kinsella (1983) reported during years when the climate was favourable for Qfly development, roadblocks alone were not sufficient to prevent fruit fly infestations from developing in protected areas. O'Loughlin (1983) suggested that the effects of climate, particularly rainfall, might override the effect of infested introductions and that Victorian outbreaks might be due more to the increases and spread of local endemic populations. Early detection with improved trapping techniques, followed by pesticide control strategies were also necessary. A system of inspection or treatment of all susceptible host produce also minimises the number of fruit fly outbreaks (Kinsella 1983).

The experience of South Australia appears different to Victoria and could be due to differences in climate and other regional issues. Harris *et al.* (1982) noted that the west Victorian roadblocks intercepted fruit which might otherwise be intercepted by the South Australian roadblocks. van Velsen (1987) noted that it was difficult to assess the significance of increased interceptions at road blocks since the probability of a fruit fly population developing from the introduction of infested fruit was unknown. van Velsen (1987) also reported an increasing number of fruit fly outbreaks with 2.6 outbreaks per year in the previous decade compared with 2.1 outbreaks per year in the initial 30 years. However it was perceived that increasing traffic flow, particularly holiday makers, would increase the threat of fruit fly outbreaks in South Australia.

Maelzer (1990a) reported that the outbreaks in Adelaide were becoming more frequent and Qfly was becoming more abundant. There appeared to be a steady increase in roadblock interceptions from 1983 onwards. However, this may have been due to increased vigilance at road blocks in South Australia following the closure of roadblocks in Victoria and New South Wales. In some years, there is a high correlation between road block interceptions and the number of Qflies trapped in Adelaide. Maelzer (1990b) reported that the percentage of fruit confiscated on the South Australian border in October and November of each year increased significantly ($P < 0.01$) from about 9% in 1965 to about 13% in 1985. Baker (pers. comm.) indicated that the number of interceptions at Yamba road block was a good indicator of the fruit fly season in South Australia.

In any fruit fly free areas which are not ecologically favourable to the establishment of fruit fly, the traffic of infested material into fly free areas is the most important cause of introduction. Inspection at road sites on major highways is necessary to prevent the introduction of infested hosts. However, exclusion of infested fruit is only part of an overall program to maintain fruit fly free areas. The other components are early detection, eradication or population management, and public information (Malavasi *et al.* 1994).

Roadblocks are a comparatively resource hungry mechanism to prevent the entry of Qfly. They are considered to be an effective public awareness strategy by raising the alertness of the travelling public to quarantine issues. Unfortunately, despite years of roadblock campaigns in all three States, very little data from roadblocks has been analysed in detail and published.

In New South Wales, roadblocks on the edge of quarantine zones ceased to operate in about 1980. Horticultural Policy Council (HPC) (1991) urged the re-examination and possible reinstatement of roadblocks, and roadblocks were re-examined in a research project in 1994/95 (NSWA 1997). The random roadblock program was reintroduced in 1996 on a trial basis. The initial program was conducted during the 1996 Easter period and is the subject of this manuscript. It was designed to create a high profile with the travelling public and to evaluate the fruit carrying habits of the travelling public in the holiday period and hence to assess the risk created by travellers who bring fruit into the Fruit Fly Exclusion Zone.

METHODS

The roadblock sites and timings of the roadblocks were chosen based on experience: they are identified in table 1. There was a wine and food festival in the MIA during Easter 1996. Roadblocks were timed to catch the largest flow of traffic, including festival visitors, based on local knowledge. The roadblock on 4 April, Thursday, was conducted from 3.00 p.m. till 11.30 p.m. and was designed to inspect non-locals going to the festival. Roadblocks on 5 April, Good Friday, 6 April and 7 April were conducted from 8.30 a.m. to about 4.30 p.m. Roadblocks on 8 April, Easter Monday, were conducted from 8.30 a.m. to 12 noon on the Newell Highway, the main East-West route to South Australia, and from 2.00 p.m. to 5.00 p.m. on the Sturt Highway, the main North-South route to Melbourne, to ensure the sampling of a range of traffic travelling through the Fruit Fly Exclusion Zone.

Once the roadblock was established, vehicles were directed into the inspection bay until the bay was full. Any traffic entering the roadblock site after the inspection bay was full was waived through the roadblock site without entering the inspection bay. Numbers of all vehicles entering the roadblock site

and the inspection site were recorded. The driver of each vehicle stopped in the inspection bay was asked two questions: 'Where did your trip originate?' and 'where are you going?' Inspectors also recorded observations on the type of vehicle, type of traveller, fruit carried and if any fruit fly were found in confiscated fruit.

While 1595 survey forms were submitted, a small percentage of forms did not have all data lines completed and this lack is reflected in the respective tables. Origin of trip, destination and travelling types were analysed.

Statistical analysis

The aim of this analysis was to relate the frequencies of fruit traffickers to the explanatory variables; that is origin of trip, destination, types of travellers and days of the Easter break. The relationship was examined using a logistic regression analysis (Nelder and Wedderburn 1972) where errors were assumed to be binomially distributed and the logit link function below was used to linearize the relationship:

$$log(p/(1-p)) = day(highway)\ effects + origin\ effects + destination\ effects + type\ effects$$

The likelihood ratio test was used to test the overall differences between levels of each explanatory variable whereas pair-wise comparisons between levels were determined by comparing the predicted proportions with their 95% confidence intervals which were calculated by back-transforming the logit scale to the proportional scale. This analysis was run using SAS Statistical software (SAS Institute, Inc. 1990).

RESULTS

There was no significant difference in the proportion of travellers carrying fruit into the MIA region between the five days (six periods) of the survey period with an average of 13% (range 11–17%) of fruit carriers (P>0.05; table 1). Good Friday (5 April) and Easter Monday (8 April) had a tendency for higher rates of carrying. Comparisons of fruit carrying characteristics between our study and other Easter roadblock reports are given in table 2. Generally, Good Friday and Easter Monday were the days with the highest rates of fruit carriage by travellers.

There was no difference in the rate of fruit carrying by people travelling on the Newell and Sturt highways; this differs from NSWA (1997) which found the Newell was a greater risk than the Sturt Highway.

The characteristics of fruit carriers were significantly correlated with the origin of travellers (P<0.001) with 35% of Queensland travellers carrying fruits, and only 15–16% of travellers from Australian Capital Territory, Greater Sydney and South Coast New South Wales (table 3). The results of two other roadblock results are also given in table 3; the high rate of fruit carriage by travellers from Queensland is also reflected by NSWA (1997). Destinations (into Griffith and non Griffith), on the other hand, had no significant correlation with the rate of fruit carriers (table 3).

Among types of travellers, family travellers (17%) were significantly more likely to carry fruit than single travellers (7%) (table 4). Retirees had the average rate (13%) which is between the family and single groups and not significantly different from either group; however this sample group was smaller and had a wider confidence interval (16%) than did the other two groups (5%). Table 4 also contains the results from two other surveys and all three surveys generally indicate that families and retirees carry more fruit than other groups. Day trippers consistently carried (about 6%) fruit in all three surveys.

The variety of fruits (table 5) found in the roadblocks included pome (37%), tomatoes (23%), bananas (16%), citrus (10%) and stone fruit (4.5%). Comparisons with three other surveys are also included. Pome fruit is generally the most commonly carried fruit although the proportions vary considerably. Citrus appears to remain at the same proportion (8–10%) in all three surveys.

Table 1. Details of roadblock activity for the six periods during Easter 1996 (figures in brackets are 95% confidence intervals).

Date	Location	Total vehicles passing stop	Total vehicles stopped	Number of fruit carriers	Proportion of travellers carrying fruit
4 April	Kamarah	472	333	37	0.11 (0.08–0.15)
5 April	Kamarah	685	582	88	0.15 (0.12–0.18)
6 April	Kamarah	214	193	21	0.11 (0.07–0.16)
7 April	Kamarah	153	139	16	0.12 (0.07–0.18)
8 April	Newell Hwy	211	145	25	0.17 (0.12–0.24)
8 April	Sturt Hwy	255	182	26	0.14 (0.10–0.20)
Total		**1990**	**1574**	**213**	**0.13**

Table 2. Comparison of the percentage of travellers carrying fruit over Easter at different locations.

Day	Percentage of travellers carrying fruit			
	MIA 1996	Pinnaroo SA 1996	Euston 1973	Euston 1974
Thursday	11.1	10.7	6.5	4.5
Friday	15.1	14.6	9.4	5.8
Saturday	10.9	10.4	10.1	3.4
Sunday	11.5	13.2	6.4	3.3
Monday	15.6	17.4	6.4	4.3
Tuesday			7.1	2.6
Average for Easter	13.9	13.5	7.9	4.2
Average for non-Easter		8.6		
Source	Our study	Baker (unpub)	Sproule (1975)	Sproule (1975)

Table 3. The numbers and percentages of vehicles originating from different areas and the proportion of travellers (with 95% confidence limits in brackets) carrying fruit (proportions followed by the same letter are not significantly different). Comparisons with two other reports are also given.

Location details of trip	Origin or destination of trip	Number and percentage (in brackets) of vehicles stopped	Proportion of travellers carrying fruit		
			Our survey	NSWA (1997)	Ballantyne (1992)
Queensland	Origin	48 (3)	0.35 (0.23–0.50) a	0.31	0.11
Australian Capital Territory	Origin	123 (7.8)	0.16 (0.11–0.24) ab	0.16	
Greater Sydney	Origin	465 (29.8)	0.15 (0.12–0.18) b	0.25	0.16
South Coast New South Wales	Origin	13 (0.8)	0.15 (0.04–0.45) #	0.20	
Inland New South Wales	Origin	833 (53.3)	0.12 (0.10–0.14) b	0.12	0.10
North Coast New South Wales	Origin	27 (1.7)	0.07 (0.02–0.25) #	0.31	
Other	Origin	64 (4.1)	0.06 (0.10–0.15) b		
Griffith	Destination	879 (55.8)	0.12 (0.10–0.14) c		
Other	Destination	695 (44.2)	0.16 (0.13–0.19) c		

not contrasted due to low numbers of observations

Table 4. Types of travellers and the percentage (with 95% confidence limits) of different traveller types carrying fruit (proportions followed by the same letter are not significantly different). Comparisons with two other reports are also given.

Type of traveller	Number of vehicles stopped	Proportion of travellers carrying fruit		
		Our study	NSWA (1997)	Ballantyne (1992)
Business trip	7 (0.5%)	0.00 #	0.06	0.06
Day tripper	28 (1.8%)	0.07 (0.02–0.24) #	0.06	0.06
Singles	545 (35.6%)	0.07 (0.05–0.10) a	0.13	0.08
Retirees	67 (4.4%)	0.13 (0.07–0.23) ab	0.37	0.41
Families	885 (57.8%)	0.17 (0.15–0.20) b	0.29	0.38

not contrasted due to low numbers of observations

Table 5. Number and type of fruit intercepted during the six sample periods of the roadblock survey period, with percentages of the totals in brackets. Also given are the average number of fruit per carrying traveller and the proportion of fruit carriers with only one type of fruit.

Fruit	Period of survey							Other surveys		
	4 April	5 April	6 April	7 April	8 April (Newell Hwy)	8 April (Sturt Hwy)	Total periods	NSWA (1997)	Ballantyne (1992)	O'Loughlin (1983)
Pome fruit	98	211	50	34	53	59	505 (37%)	24%	22%	24%
Tomatoes	65	126	37	17	52	9	306 (23%)	9%	13%	34%
Bananas	37	92	30	13	20	22	214 (16%)	13%		
Citrus	40	39	11	16	21	8	135 (10%)	9%	8%	10%
Tropical fruit	2	23	2	0	0	45	72 (5%)	5%		
Stone fruit	6	12	3	16	23	2	62 (4.5%)	27%		
Others	17	35	7	1	3	0	63 (4.5%)			
Total fruit	265	538	140	97	172	145	1357			
Average number of fruit per carrying traveller	7.3	6.3	6.1	6.1	7.2	5.6	6.4	5.2		
Percentage of fruit carriers with only one type of fruit	53%	59%	48%	75%	54%	85%	60.1%			

Kinsella (1983) reported that 0.48% of fruit samples entering the Mallee area were infested with fruit fly. Working Party (1990) noted that 0.057% of fruit was infested although the rate of infestation fluctuated from year to year. In the Murrumbidgee Irrigation Area, Sproule (1975) reported that 0.03% of vehicles carried infested fruit; NSWA (1997) reported 0.17% of vehicles carried infested fruit whilst our survey detected no infested fruit.

DISCUSSION

The percentage of fruit carriers (13%) caught by this survey appeared to be low but the actual number is high, particularly when the traffic flowing into the MIA region is high (1900 vehicles in 5 days). The number of fruit carriers is sufficient to make the region vulnerable to Qfly introductions. The rate of carriers (13%) obtained in this survey was much lower in comparison to early reports on holiday periods (20% reported by Sproule (1975) and 18% reported by NSWA (1997)). It was slightly higher than that reported by Kinsella (1983) who found 10.6% fruit carriers entered the Mallee area near Mildura.

The high risk groups identified by Ballantyne (1992) were people (families and retirees) on holidays, those travelling between December and April, people living in the Sydney area, coastal New South Wales and Queensland, and people who grow their own fruit, particularly tomatoes. Maelzer (1990b) noted that the peaks of Qfly trap catches in Adelaide mostly corresponded to those in Sydney. Sproule (1975) noted that in New South Wales Agriculture mobile roadblocks during weekdays, about 6% of cars carried fruit, while on holidays the carrying rate rose to 20%. The carrying public was made up of locals and non-locals; the rate of carriage of fruit by locals declined sharply following 68 prosecutions within a 12 month period.

Origin of journey

Origin of travellers entering the MIA is also a significant issue for the management of the FFEZ. Our findings were consistent with that of Ballantyne (1992) and NSWA (1997) in which travellers originating from Queensland were a high fruit carrying group. Since Queensland and North Coast New South Wales are the endemic home of Qfly, these origins are the highest risk group in relation to the management of the FFEZ. Fortunately, there is a relatively small proportion of travellers originating from Queensland which enter the MIA region. Nevertheless, travellers from other regions such as the Australian Capital Territory, Greater Sydney and Inland New South Wales cannot be discounted from introducing Qfly infestations into the MIA because a significant proportion of those groups are also responsible for carrying fruit into the Murrumbidgee Irrigation Area. Campbell *et al.* (1990) considered the major threat of fruit fly came from Queensland and from coastal and inland New South Wales, agreeing with the three survey results in table 3.

Ballantyne (1992) considered Sydney as a higher risk, however this did not agree with NSWA (1997) or with our survey. This may suggest a decrease in the risk posed by Sydney in recent years.

South Australian data (Baker unpublished) for the same Easter period indicated that 4.4% of traffic came from Queensland compared with our results of 3%. South Australians made up 44.5% of the Easter traffic at Pinnaroo with a high of 82.3% on Easter Monday, compared with less than 4.1% in our survey. Clearly the origins of carriers, and hence the risk of entry of infested fruit into the FFEZ, is determined by the location of the roadblock.

Local residents of the FFEZ should be more aware of the implications of carrying fruit and hopefully transport less fruit into the Fruit Fly Exclusion Zone. Ballantyne (1992) reported that 90% of MIA residents were aware of the restrictions in their area regarding fruit fly, compared with only 9% of Sydney travellers. Ballantyne (1992) reported that 11% of travellers into Sunraysia were aware of the restrictions yet still carried fruit into the Mildura quarantine area. NSWA (1997) found only 5.6% of travellers returning to the MIA carried fruit; this agreed with Ballantyne (1992) who claimed that about 5% of vehicles would still carry fruit, regardless of the intensity and effectiveness of any public awareness campaign. In our survey, 12% of travellers going to Griffith destinations carried fruit compared with a 16% carrying rate for those not going to the MIA. However these rates were not statistically different.

Types of travellers

In our survey, families were the highest risk type of traveller with 17% of families carrying fruit followed by 13% of retirees carrying fruit. These rates are much lower (table 4) than the 28.9% of families and 37.1% of retirees reported by NSWA (1997) which agreed with the retirees (41%), and families on holidays (38%) reported by Ballantyne (1992). Families and retirees carried all types of fruit while young couples tended to carry more pome fruit (Ballantyne 1992). Families presumably carry fruit to keep children content during the trip.

Fruit

Fruit found in our survey are compared with other surveys in table 5. In our survey, the proportion of tomatoes being carried was 23% going against the trend of 34% (O'Loughlin 1983), 13% (Ballantyne 1992) and 9% (NSWA 1997); these three surveys were results from annual surveys while ours was from a short holiday period. Ballantyne (1992) noted the large variations in individual months compared with annual figures.

Sproule (1975) noted that the greatest threat challenging the New South Wales road blocks were travellers with fruit from home gardens. Fourteen percent of fruit intercepted at South Australia was obtained from domestic gardens. However 35% of all tomatoes intercepted were obtained from home gardens and were carried mainly in December, January, February and March (Ballantyne 1992). NSWA (1997) noted that only 7.4% of fruit came from domestic gardens. Historically, tomatoes have presented a high risk with O'Loughlin (1983) reporting 34% of infested fruit was tomatoes and 50% reported by Ballantyne (1992). Tomatoes were the most infested fruit from Sydney and Queensland (Ballantyne 1992) with 71% and 16% of infested fruit coming from Sydney and Queensland respectively.

Traffic flow and traffic volume

Holidays are higher risk periods compared with non-holiday periods as reported by Sproule (1975), Ballantyne (1992), and NSWA (1997). This is due to increased traffic flow and increased fruit carriage. NSWA (1997) reported a fruit carrying rate of 18.9% for holiday periods compared with 14.6% for non-holiday periods. The South Australian data showed a slight increase (3.2%) in weekly traffic flow (table 2) along with an 80% increase of fruit (450 kilograms) confiscated during the Easter week compared to the usual weekly average of about 250 kilograms.

Location of roadblocks appears to influence the proportion of traffic carrying fruit. O'Loughlin (1983) noted that the proportion of fruit carrying remained relatively constant over six years at each town roadblock site, varying from about 23% at Genoa, a town with high holiday traffic, to about 2% at Wodonga, where most traffic was local traffic. The proportion of infested fruit varied from 0.3% at Genoa, a holiday destination, to 0.1% at Wodonga (O'Loughlin 1983).

If random roadblocks are to have maximum effect in New South Wales, other States or any national strategy, the high fruit carrying types of travellers should be targeted. Families are the highest fruit carrying group and should be treated as a priority group. Families usually travel during holidays and holidays coincide with higher traffic flows and higher rates of fruit carrying. The conduct of roadblocks during holidays should have priority. Retirees are not restricted to holiday periods, although they often travel during holidays. Retirees from Victoria often travel through the FFEZ to Queensland in winter; however it is when they return from Queensland to Victoria through the FFEZ that they become a higher risk group; this would appear to be a second priority for roadblocks. The seasonal travelling of retirees between north and south has significant implications, however more research is needed to more clearly identify when this migration occurs. Strategies, such

as a community awareness program, should target families and retirees to decrease the rate of fruit carrying by these two groups.

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