REPRODUCTIVE CAPACITY OF QUEENSLAND FRUIT FLY *BACTROCERA TRYONI* FROGGATT IN DIFFERENT HOST FRUIT – A FIELD ASSESSMENT IN SOUTHERN NEW SOUTH WALES.

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Summary

Tephritid fruit flies are major economic pests and are an impediment to trade. Different host fruits are known to vary in their capacity for fruit flies to complete their life cycle. However, currently there are few reports that identify the capacity for Queensland fruit fly (Qfly) (*Bactrocera tryoni* (Froggatt)) to complete their life cycle in different hosts. Here, we harvested backyard fruit from infested areas and assessed how many adult flies could be produced from a kilogram of fruit after field infestation. We found loquat, kumquat, peaches and nectarines (in that order) produced the highest number of Qfly adults (>175 adults per kg). This knowledge will assist pest managers and the development of trade standards.

Key words: trade, market access, management, fruit flies

INTRODUCTION

The fruit fly family (Tephritidae) contains some of the world's most serious economic pests (Vargas *et al*. 2015). In eastern Australia, Queensland fruit fly (Qfly) (*Bactrocera tryoni* (Froggatt)) is the most economically important fruit fly pest for market access and fruit production (Dominiak and Mapson 2017). Qfly infests 117 hosts from 49 plant families (Hancock *et al*. 2000). There is little published knowledge on the capacity of Qfly to complete their life cycle. Hancock *et al*. (2000) examined historical records and databases in a review of host status (host or non-host) but made no attempt to rank different hosts. Bateman (1991) broadly categorised fruit into three categories, high, medium or low risk status. A better defined fruit-host ranking may be a useful component of risk mitigation in a systems approach (Dominiak 2019a; van Klinken *et al*. 2020) because there are some fruits that are intrinsically poor hosts. Some host fruit have a high capability to produce large numbers of adult Qfly and need to be managed differently from fruit which produce low Qfly populations.

The capacity of fruit fly to complete their life cycle depends on characteristics of the fruit. In their search for fruit, Qfly are drawn to colours and tree shapes (Meats 1983). After Qfly have detected fruit, Qfly must penetrate fruit skin to lay eggs and start the life cycle. Characteristics such as fruit size, peel toughness, pericarp thickness and Brix level influence oviposition (Muthuthantri and Clarke 2012; Unahawutti *et al*. 2014). Utilisation of fruit and survival of larvae may depend, at least partly, on the water-soluble carbohydrates (Dominiak and Fanson 2017). Given all these variables, there may be considerable variation of oviposition preference within host families (Balagawi *et al*. 2013) and the fruit flies' ability to complete their life cycle. Additionally, there are losses in each life stage before Qfly adults appear in the environment. For Qfly management and trade, there is a need to be able to compare the flies' reproductive potential in different fruit.

A three-tiered assessment was proposed by Cowley *et al*. (1992) involving laboratory cage tests with (1) intact and (2) punctured fruit, and (3) field cage tests with intact fruit attached to the tree. Each fruit would be assessed by counting the number of pupae and adults per kg of fruit. This measure (adults per kg) was used to assess host utilization by *B. invadens* (Drew, Tsura & White, 2005) (Mwatawala *et al.* 2006). Similarly, the susceptibility of hosts was ranked by Lloyd *et al*. (2013) based on the number of fruit flies produced per gram of fruit subjected to an infestation rate of one egg per gram of fruit. In our paper, we used a ranking similar to those suggested by Cowley *et al.* (1992) and Mwatawala *et al.* (2006).

We found that loquat (*Eribotrya japonica* (Thunb.) Lindl.) and kumquats (*Citrus japonica* Thunb.) were most able to support Qfly reproductive capacity with >200 adults per kg (A/kg). Peaches (*Prunus persica* L. (Batsch)) and nectarines (*Prunus persica* var. *nucipersica*) produced up to 175 A/kg. Guava (*Psidium guajava* L.) supported about 100 A/kg. Apricots (*Prunus armeniaca* L.), feijoa (*Acca sellowiana* (O. Berg) Burret), pears (*Pyrus communis* L.), grapes (*Vitis vinifera* L.) and quince (*Cydonia oblonga* Mill.) supported up to about 50 A/kg.

MATERIALS AND METHODS

There were many Qfly outbreaks in the Riverina during 2010 and 2012 (Dominiak and Mapson 2017), and backyard fruit were inspected for Qfly damage as part of the outbreak response. Fruit suspected of being stung by Qfly were collected opportunistically from trees in urban areas in Balranald, Griffith, Leeton, Deniliquin and Yanco, and sent to the Orange Agricultural Institute. Fallen fruit was not sampled because of the state of degradation. A total of 102.3 kg of fruit was collected with an average sample weight of 1.1kg. Sample size (excluding small fruit such as grapes, cherries and olives) ranged from one nashi pear to 104 quandongs. On receipt, fruit was weighed and placed in growth cabinets. Each sample was held separately to identify insects that emerged. Fruit was held above vermiculite (1-4 cm deep) in a constant growth cabinet set at 26ºC (+/- 5ºC) and 80% (+/- 20%) relative humidity for 3 weeks to enable pupation and eclosion of adults. The adult flies were identified morphologically and the numbers counted. The number of adults per kg (A/kg) of fruit was calculated for each sample. The numbers were recorded in Table 1 with the lowest numbers on the left and the highest on the right side for each fruit.

RESULTS AND DISCUSSION

In 2010, there were 54 fruit samples submitted and 24 were infested with Qfly. In 2011, there were 88 samples submitted with 65 samples supporting Qfly adult development Many hosts supported less than 100 A/kg. Orange, peach and nectarine supported between 100 and 200 A/kg. Kumquat supported >200 A/kg. Loquat appeared to be an ideal host supporting a maximum of >300 A/kg (Table 1).

Historically, fruit were described as hosts or not hosts. Little allowance was made for any gradation of fruit-host capacity to support the Qfly life cycle. Bateman (1991) was the first to rank fruit into three levels: high, medium and low risk status. Novotny *et al*. (2005) found that fruit flies infested fruit at densities of 0-110 A/kg with a median of 0-12 A/kg. Lloyd *et al*. (2013) noted that there was no international standard to determine host susceptibility for fruit fly including Qfly. They reported on infestations based on adults per gram: we converted their results to A/kg and we compared our results on the A/kg basis. Our program collected 89 infested fruit while Lloyd *et al.* (2013) collected 66 infested fruit. Loquats were the most frequently fruit sampled in both surveys.

It is important to place the sequence of fruit in context for fruit fly management. Some citrus are left hanging on trees over winter and provide a winter host. Loquats are usually the first ripe fruit after winter in late August to mid-September. Grapefruit usually follow the loquat and then the early apricots. Stone fruit is usually ripe from early summer and grapes are a late season host.

We collected 26 samples of infested loquat with a maximum of 323.5 A/kg. Bateman (1991) ranked loquat as high risk status and Lloyd *et al.* (2013) reported loquat as their fourth highest risk host with a mean of 148 A/kg. Peaches and nectarines also were ranked as high pest status by Bateman (1991) but not reported by Lloyd *et al.* (2013). We found the maximum A/kg of 178.9 and 176.0 respectively. Peaches and nectarines would support a population increase, particularly at mid-season when these were ripe. We found ten infested samples of apricot with a maximum of 62.5 A/kg. We also found two infested samples of pears with a maximum of 55.9 A/kg. Bateman (1991) ranked apricots and pears as high pest status.

Bateman (1991) ranked capsicum, cherry, custard apple, feijoa, grapefruit, mandarin, pomegranate, tomatoes and walnuts with a medium risk status. We found none of these fruit exceeded 50 A/kg with two exceptions (Table 1). Quince supported up to 63.3 A/kg. We found orange supported up to 141.8 A/kg. Generally, based on our results, the difference between Bateman's medium and high pest status is about 50 A/kg, but there are some exceptions to this estimate. If we examine the rankings by Lloyd *et al.* (2013) in relation to the medium pest status in Bateman (1991), five of seven samples in the medium risk status category had a mean of <35 A/kg. The exceptions were Seville oranges and mulberry (*Morus nigra* L.) with a means of 237 A/kg and 209 A/kg respectively.

Grapes were considered to be a low pest status by Bateman (1991) and were treated as a non-host for many years. However, grapes have since been identified as a host (Dominiak 2011). Our work has verified that grapes are a host with >50 A/kg in two samples. Grape growers need to recognize that grapes can support Qfly populations at a level similar to feijoa or pears. Prickly pears and feral olives are weeds in the Riverina and are frequently found close to fruit production areas. We found one sample of prickly pear with a Qfly infestation (6.1 A/kg) equivalent to grapefruit. Dominiak *et al.* (2019) reported olives could produce up to 32.5 A/kg. Therefore, prickly pears and feral olives need to be managed particularly where these weeds occur near commercial fruit production. If fruit such as olives and loquats are grown in homestead gardens on orchards, these hosts need to be managed to prevent Qfly moving from these hosts into the commercial orchard.

There were no other dacine fruit flies found in our samples. This is consistent with the range of *B. neohumeralis* (Hardy) and *B. jarvisi* (Tryon) and these species were not expected in the Riverina (Dominiak and Worsley 2016, 2017). *Dacus newmani* (Perkins) were not detected in our fruit samples and are not known to infest commercial fruit despite high populations in the Riverina

(Dominiak 2019b). We detected metallic-green tomato fly, *Lamprolonchaea brouniana* (Bezzi) (Diptera: Lonchaeidae) in six very ripe fruit. *Lamprolonchaea brouniana* occurs in ripe or damaged fruit and is not a serious primary invader (Blacket and Malipatil, 2010). We also reared a *Diachasmimorpha kraussii* (Fullaway) (Hymenoptera: Braconidae) from two samples, and five parasitoids from two other samples. Therefore, four of our 89 infested samples had parasitoids (4.5%). Our results are similar to those of Spinner *et al.* (2011) who reported 9% of samples supporting parasitoids. They also detected *D. kraussii* (known parasitoid of Qfly) in districts adjacent to our surveyed area.

Results from our work should be treated with caution where the number of samples was small (e.g. feija, lemons, prickly pear). The A/kg in our paper should be treated as an indicator of the maximum. More fruit sampling will need to be done to verify our findings. For trade, importing countries are only interested in the size of the threat posed from potentially imported fruit and therefore we did not calculate variance or other statistics. More work needs to be done on a standard or system of ranking host risk and the ability of Qfly to reproduce in different fruit. Fruit ranking is likely to be used in future systems approaches for trade (Dominiak 2019a; van Klinken *et al.* 2020).

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Table 1. Reproductive capacity of different fruit based on adult *Bactrocera tryoni* flies successfully completing their life cycle per kilogram of fruit harvested at Griffith, Leeton, Yanco and Balranald. Lowest numbers are on the left, progressing to highest numbers on the right for each row (fruit).

Fruit	**Adult emerged per kg fruit (A/kg)**
Acca sellowiana (O. Berg) Burret, Feijoa	45.8,
Annona reticulata L., Custard apple	25.9,
Capsicum annuum L., Capsicum	17.4, 24.3,
Citrus japonica Thunb., Kumquat	33.6, 35.2, 37.8, 233.8,
Citrus limon (L.) Osbeck, Lemon Lisbon	3.3,
Citrus x paradisi Macfad., Grapefruit	0.6, 2.1, 2.7, 2.9, 4.7,
Citrus reticulata Blanco 1837, Mandarin	43.3,
Citrus sinensis L., Orange	11.5, 34.6, 141.8,
Cydonia oblonga Mill., Quince	1.4, 1.5, 1.9, 2.2, 4.7, 63.3,
Eribotrya japonica (Thunb.) Lindl., Loquat	6.9, 10.4, 14.7, 28.6, 31.1, 33.6, 37.5, 38.1, 46.7, 57.1, 57.3, 72.7, 72.7, 79.8, 97.2, 97.3, 99.8, 108.6, 109.2, 115.4, 115.9, 147.1, 182.4, 199.6, 314.9, 323.5,
Juglans regia L., Walnut	14.1
Malus domestica (Borkh), Apple	12.0,
Mangifera indica L., Mango	4.2
Opuntia sp. Prickly pear	6.1,
Prunus avium L., Cherry	8.2, 8.9,
Prunus armeniaca L., Apricot	1.4, 6.0, 8.8, 12.1, 12.3, 17.5, 44.1, 48.1, 51.3, 62.5,
Pyrus communis L., Pear	13.9, 55.9,
Pyrus pyrifolia (Burm.) Nak, Nashi pear	13.9, 72.7,
Prunus persica L. (Batsch), Peach	<1, 5.0, 8.8, 18.8, 20.7, 178.9,
Prunus persica var. *nucipersica*, Nectarine	2.0, 3.2, 4.4, 25.8, 70.9, 176.0
Psidium guajava L., Guava	92.4,
Punica granatum L., Pomegranate	4.1
Solanum lycopersicum L., Tomato	<1,
Vitis vinifera L., Grapes	1.6, 7.9, 50.0, 52.6,