Economic Importance and Control/Eradication of Peach Fruit Fly, *Bactrocera zonata*

M. Alzubaidy

CDFA, P.O. Box 11239, Costa Mesa, California 92627, USA

Abstract

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Native to tropical Asia, the peach fruit fly is spreading to other regions of the world including the Middle East. The fly seriously damages a variety of commercially valuable crops. Infested areas incur high production costs due to extra labor and material needed for controlling and eradicating the pest. Producers deploy costly commodity treatments to meet trade requirements. Inevitable increases in pesticide use can adversely impact the environment. International cooperation of regulatory agencies is vital in mitigating the risk of pest spread. Success in preventing the establishment of invasive fruit flies in California is a result of high degree of integration between pest exclusion, early detection, and fast eradication response. Numerous infestations by *Bactrocera* species, including four breeding populations of peach fruit fly have been eradicated using a combination of methods including Male Annihilation Technique (MAT), foliar and soil pesticide treatments, and fruit removal. Intensive monitoring follows to verify effectiveness of eradication efforts.

Economic Importance

With its wide host range, fast population build up, and great dispersal ability, the peach fruit fly represents a significant threat to agriculture. In Pakistan (18), the peach fruit fly is often responsible for 25-50% reduction in Guava production. In severe peach fruit fly infestations, up to 800 pupae are recovered from one pound of Guava (11). The fly is so destructive that commercial production of valuable crops like Guava and Mango is often abandoned.

Unhampered by its native natural enemies, the peach fruit fly can be even more destructive outside of its original homeland. The establishment of the peach fruit fly in Egypt has been costing over $177 million annually (12). It has the potential of impacting over 35,000 square kilometer of currently developed agricultural land. Also, an additional 1.5 million feddans, earmarked for future agricultural projects could be severely impacted by the pest. If left unchecked, the peach fruit fly will inevitibley find its way to neighboring countries. This will result in further crop loses, adverse environmental impact due to extensive use of pesticides, more production costs due to post-harvest treatments, and more stringent quarantine measures by trading partners.

In the Mediterranean region, agriculture represents the backbone of the economies of many countries. It represents one third of the gross national product in Syria, and a fifth of that of Egypt's. The region deserves better than such a destructive foe as the peach fruit fly.

Life Cycle

Eradication elements including pesticide treatments, trapping, and quarantine activities are affected by duration of life cycle. Like other fruit flies, duration of developmental stages in the peach fruit fly is temperature dependent. Development of egg, larval, and adult stages are influenced by air temperature, while the pupal stage is affected by soil temperature. The air as well as the soil environments has temperature thresholds below which no measurable development takes place. Taken from studies on the Oriental fruit fly these thresholds are assumed to be 12.2 °C in air and 9.4 °C in soil (3).

Countries bordering the Mediterranean have warm summers and mild winters and are favorable to establishment of the peach fruit fly with a number of generations a year. Depending on temperature, peach fruit fly completes its life cycle in 25-40 days. The female deposits her eggs under the skin of ripening fruit in batches of 10-100, and can lay up to 600 eggs in her lifetime. The egg stage lasts 1-5 days and larvae feed within the fruit for 10-15 days before pupating in the soil. The pupal stage takes another 10-15 days after which the adult emerges. Newly emerged adults reach sexual maturation in 10-19 days. Mating takes place in a lek followed shortly by egg laying.

Host Range

The peach fruit fly has been recorded on 32 host plants, including peach, guava, mango, fig, dates, okra, and tomato (Table 1). Like many other fruit flies, the peach fruit fly is capable of expanding its host range as it gets established in new areas, inflicting great damage to commercial and backyard plantings of fleshy fruits and vegetables.

Geographical Distribution

Originating in tropical Asia, the peach fruit fly has spread to other regions of the world including Africa and the Arab World. It currently occurs in Bangladesh, Egypt, India, Laos, Mauritius, Moluccas Islands, Myanmas, Pakistan, Reunion Island, Sri Lanka, Thailand, and Vietnam.

Geographical barriers are no more a hindrance to peach fruit fly movement. Many of the modern means of transportation that allowed man to reach remote areas of the globe quickly and comfortably are the very same that allowed exotic pests to invade new areas, often with devastating consequences.

Control and Eradication

Although pest control and pest eradication often utilize the same treatment methods, the two strategies are very different in their objectives. Control seeks keeping the pest population below a certain threshold so that economic damage remains within acceptable range. Control operations are ongoing, and have to be repeated whenever the pest population exceeded a certain level.

Eradication on the other hand, aims at complete elimination of the pest population from a defined area. The goal is to reduce the target population below the critical size needed to maintain pest reproduction. This requires deployment of treatment methods that focus on increasing death rate and interfering with reproduction. Successful eradication efforts negate the need for further treatment unless the pest is reintroduced and reestablished. For peach fruit fly, a combination of treatment methods each targeting one or more stages of the life cycle is often used. However,

the adult stage is the primary focus of eradication because it is the most accessible and susceptible part of the life cycle for the treatment methods now available.

Table 1. List of host plants known to support peach fruit fly larval development. It is worth mentioning that the potential host list may be much longer due to the fly ability to expand its host range in newly infested regions

Common Name	Scientific Name
Apple, common	*Malus spp.*
Custard apple	*Annona squamosa*
Custard apple, Annona	*Annona reticulata*
Date palm	*Phoenix dactylifera*
Eggplant	*Solanum melongena*
Fig, common	*Ficus carica*
Gourd, Ivy	*Coccinia grandis*
Guava	*Inga laurina*
Indian bael	*Aegle marmelos*
Kaenth	*Pyrus pashia*
Loquat	*Eriobotrya japonica*
Mahua	*Madhuca longifolia*
Ma-kok-nam	*Elaeocarpus madopetalus*
Mamee-sapote	*Pouteria sapota*
Melon, long	*Cucumis utilissimus*
Okra	*Abelmoschus esculentus*
Olive, wild; Indian amulet plant	*Putranjiva roxburghii*
Orange, sweet	*Citrus sinensis*
Papaya, common	*Carica papaya*
Peach	*Prunus persica*
Pear	*Pyrus communis*
Pear, sand	*Pyrus pyrifolia*
Phalsa	*Grewia asiatica*
Pomegranate	*Punica granatum*
Quince	*Cydonia oblonga*
Sapodilla	*Manilkara zapota*
Tomato	*Lycopersicum esculentum*
Tropical almond	*Terminalia catappa; Terminalia chebula*
White flower; bottle gourd, calabash gourd	*Lagenaria siceraria (L. vulgaris)*
No common name available	*Amygdalus Persia*
No common name available	*Bassia latifolia*
No common name available	*Careya arborea*

Eradication Protocol for Peach Fruit Fly, A California Perspective

California protocol for eradicating *Bactrocera* spp, including peach fruit fly consists of three phases, namely pre-eradication activities, pesticide treatment, and post-treatment monitoring (2). Pre-eradication activities consist of intensified trapping and larval surveys to determine the limits, magnitude, and distribution of life stages present. In the treatment phase, appropriate methods are used to eliminate the pest. In post-treatment monitoring, intensive trapping is conducted, often in conjunction with ongoing fruit cutting activities, to determine if any residual populations have survived eradication treatment. Quarantine is imposed as needed to prevent the pest from spreading.

Pre-eradication Activities

There are three components to pre-eradication activities. They are detection trapping, delimitation, and larval survey. The goal of detection trapping is to discover fruit fly infestation before it spreads for more than a mile. Delimitation trapping determines the extent of the infestation, and larval survey identifies breeding sites.

Detection Trapping

California has a statewide trapping program charged with the early detection of fruit fly introduction and colonization. Trap distribution and density are determined by a number of factors including potential range of the fly in California, lure attractiveness, risk of introduction and establishment, and resources available to implement the trapping program.

Bactrocera species including the peach fruit fly are detected using two types of traps. The first is the delta shaped Jackson trap. It is constructed of cardboard and baited with a liquid lure consisting of 99% methyl eugenol, and 1% Dibrom by volume. It primarily targets the male adults, which upon feeding on the lure are killed by the toxic effect of Dibrom. Trapped flies are collected on a removable sticky board at the bottom of the trap.

The second detection tool for adult *Bactrocera* is the McPhail trap. It consists of a glass reservoir containing a solution of water and torula yeast. Attracted to fermenting yeast, flies enter the trap through an opening in the bottom, and eventually drown. Although deployed primarily for the detection of Anastrepha spp, the McPhail is a good general-purpose trap since both sexes of most tephritids are attracted to it, regardless of their degree of sexual maturation.

Trapping is conducted on a year-round basis in the coastal and warm desert regions of Southern California. In other susceptible but cooler areas of the state, the trapping period varies from seven to nine months depending on local climatic conditions and host availability.

Trap density varies from 2 to 5 per square mile, and is based on the potential for introduction, climate, seasonal host availability and succession, and historic catch data. Each trap is moved every 6 weeks to maximize the area covered by trapping, and utilize the best available host fruit in the season.

Delimitation Trapping

When an exotic tephritid pest is detected, trap density is increased in an area of 81 square miles (a 9 x 9 mile grid) surrounding the fly find site. For peach fruit fly, 25 Jackson and 25 McPhail traps are deployed in the core square mile surrounding the find site. Density of each trap drops to 5 in each of the remaining 80 square miles. Following the last fly find, delimitation trapping continues for three life cycles as determined by a temperature-dependant developmental model (10).

Larval Survey

Larval survey, often referred to as “fruit cutting”, aims at locating breeding sites. Fruit cutting crews in search of eggs and larvae of the targeted pest slice samples of host fruits in the field, and submit suspect specimens to the laboratory for determination. Positive identification of a breeding site prompts eradication response, and leads to a number of actions including fruit destruction, soil drenching with pesticides, foliar pesticide bait application, and male annihilation technique (MAT).

Eradication Project

Eradication efforts are initiated after a breeding fruit fly population is detected. The guidelines for presence of a reproducing population are:

1. Two or more flies trapped within 3 miles of each others during a time period of one or less life cycle; or
2. The capture of a single mated female; or
3. The presence of fruit fly larvae within, or pupae associated with, locally grown fruits or vegetables.

The secretary of the California Department of Food and Agriculture issues a proclamation, which establishes a fruit fly eradication area. The proclamation may impose quarantine to stop pest spreading. Experts in areas of exotic pest eradication, public and animal health, and public information advise the secretary. In consultation with local agricultural authority, the secretary will designate a project leader who is responsible for directing the eradication efforts (1).

Treatment Methods

Treatment starts as soon as an infestation is confirmed, and proper public notification is given. The size of a treatment area varies with the type of treatment to be applied. When male annihilation technique is use, the size of the treatment area is usually no less than 9 square miles (3 x 3 mile grid) around any property where larvae or adult flies have been found. If ground-applied foliar bait sprays are used, all properties within 200-meter radius around finds are treated. Fruit removal and soil drenches are usually limited to properties on which larvae have been found and to those adjacent to them.

Male annihilation and foliar bait treatments are continued for two life cycles after the date of the last fly find. Following fruit removal, soil drenches of Diazinon are applied from the trunk to the drip line of host trees. Three applications at two-week intervals are usually sufficient to kill adults emerging from the soil.

Male Annihilation Technique (MAT)

Different forms of MAT have been in use against *Bactrocera* for the last 48 years (4, 5, 6, 7, 8, 9, 13, 14, 15, 16, 17). Mass trapping of male oriental fruit fly *Bactrocera dorsalis* resulted in more than 99% reduction in fly population in a 63 ha papaya orchard (8). In the mid sixties oriental fruit fly was eradicated from the Mariana Islands after 10 applications of MAT using cane fiberboard squares (1x3.5x3.5 cm) saturated with methyl eugenol and naled (95:5). The boards were dropped every two weeks in lines 320 meter apart from a plane flying at 240 km/hr. Pretreatment population was 0.108 flies/trap/day. No flies were trapped in the 5 months following 10 MAT applications. Vargas *et al*. (19) deployed MAT as a component of an integrated pest management program against *B. dorsanlis* and *B. cucurbitae* in Hawaii. Bucket traps containing methyl eugenol and malathion were effective against *B. dorsalis* for 16 weeks. Similarly, traps baited with cue-lure and malathion were effective against B. cucurbitae for 8 weeks.

Vargas *et al*. (19) also reported that bucket traps and canec disks (fiberboard blocks) were equally effective for the first 14 weeks, after which bucket traps were slightly more attractive than canec disks. Fiberboard blocks were cheaper than traps but their negative effects being in direct contact with the environment have not been determined. The extra cost of using traps may be justified because of safety and environmental considerations.

The male annihilation technique has been the method of choice against *Bactrocera* species in California for over 25 years (1). The peach fruit fly infestations of 1984, 1987, 1990, and 1997 were all eradicated using this method. In the last three years alone, 22 infestations involving *Bacrocera dorsalis*, *B. correcta*, as well as *B. zonata* were eradicated from California using MAT. The technique makes use of small amounts of attractant (methyl eugenol) and pesticide (naled) to lure all the male flies in a population to bait stations. The flies are killed when they feed on the stations. Min-U-Gel (7) is added to the naled/lure solution, and the viscous mixture is applied to utility poles, street trees, and other unpainted surfaces (such as fences) using pressurized tree-marking guns. Application is made every two weeks at a rate of 600-bait station per square mile. The treatment continues for 2 life cycles from the date of the last fly find.

Supplemental Foliage Pesticide and Bait Spray

Within 24 hours of discovering an infestation, the foliage of all shrubs on the infested and adjacent properties are treated with malathion and bait, using backpack mist blowers. Properties within 200-meter radius around an infested property will then be treated. This treatment particularly targets mated females. Two to three weekly applications are usually adequate to knock down the population, and give male annihilation technique a better chance to succeed in eradicating the infestation.

Soil Drenches

Soil drenches of diazinon will be made to the drip-line of trees with fruit known, or suspected to be infested, with fruit fly larvae. Application is made using hydraulic spray equipment operating at low pressure to wet the ground. The diazinon solution is then watered in to a depth of approximately one-half inch. Two to three Soil drenches at bi-weekly intervals are effective in killing larva, pupae, and emerging adults.

Fruit Stripping

Fruit will be stripped from host trees on all known-infested properties and adjacent properties. Fruit is placed in heavyweight plastic bags, fumigated, if possible, prior to removal to a landfill site where it is buried under at least one foot of fill. Fruit stripping is an effective way of reducing egg and larval populations. However, it presents a risk of encouraging females to disperse in search of ovipositing sites. Preceding fruit stripping with foliar pesticide and bait treatment may avert this potential problem.

Post-treatment Monitoring

The success of an eradication program is monitored with a trap density of 5 Jackson traps per square mile over 81 square miles with 25 McPhail traps and 25 Jackson traps in the square mile around each fly find. Larval survey is also used as a mean of monitoring eradication success. After the date of the last fly find, eradication will be declared when 3 successive life cycles of negative trapping and larval survey have elapsed.

Quarantine

Quarantine aims at preventing human-assisted dispersal of fruit flies to non-infested areas. Quarantine regulations are enforced in an area with 4.5-mile radius from any infestation

site. Residents and businesses within the quarantine area are notified about the restrictions in movement of susceptible commodities and articles. Restricted articles may include soil, raw cannery waste, fruits, vegetables, nuts, berries, and inedible fruits of ornamental and wild plants.

The quarantine requires sellers and transporters to protect susceptible commodities and articles against fruit fly infestation. Protective measures may include refrigeration of produce, enclosure in fly-proof packaging or container, and the use of air doors or screening to exclude fruit flies from areas where susceptible produce is present.

Pre-harvest protective measures including foliar and soil treatment may be required. The treatment or disposal options for harvested commodities include processing, cold storage, heat treatment, freezing, fumigation, burial, or destruction. Quarantine activities are discontinued after the exotic pest has been eradicated.

الملخص

الزبيدي، محمد. 2000. الأهمية الاقتصادية لذبابة ثمار الدراق *Bactrocera zonata* ومكافحتها. مجلة وقاية النبات العربية. 18: 139-142.

انتشرت ذبابة ثمار الدراق، التي نشأت في آسيا المدارية، إلى مناطق أخرى من العالم، بما في ذلك منطقة الشرق الأوسط. والحقت أضراراً هامة للعديد من المحاصيل. وتعاني المناطق المصابة من تكاليف إنتاج عالية نظراً للحاجة للمزيد من اليد العاملة ومواد المكافحة. ويلجأ الزراع إلى استخدام طرائق مكلفة للوفاء بحاجات التجارة من حيث نوعية الثمار. وتؤدي الزيادة الكبيرة في استخدام المبيدات إلى التأثير سلباً في البيئة. ويعد التعاون الدولي للهيئات المنظمة ضرورة للحد من خطر انتشار الآفة. وجاء النجاح في منع استقرار هجوم ذباب الفاكهة في كاليفورنيا نتيجة لدرجة عالية من التكامل ما بين استئصال الآفة، الكشف المبكر، والاستجابة السريعة للاستئصال. وقد تم استئصال عدة إصابات بأنواع ذباب الفاكهة، بما في ذلك ثلاث عشائر تزاوجية من ذبابة ثمار الدراق باستخدام توليفة من عدة طرق تشمل تقنية إزالة الذكور، معاملة التربة بالمبيدات، وإزالة الثمار. وتبع ذلك رصد مكثف للتحقق من فعالية جهود الاستئصال.

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