United States Department of Agriculture

Marketing and Regulatory Programs

Animal and Plant Health Inspection Service

Plant Protection and Quarantine

General Reference for Fruit Fly Programs

Tephritidae

Developed by: USDA,APHIS,PPQ, Pest Detection and Management Programs
Prepared by: Jeffrey N.L. Stibick
Date: March, 2004

NOTICE

PURPOSE AND DISCLAIMER

These New Pest Response Guidelines indicate how to survey for and control fruit flies of the dipterous family Tephritidae or true fruit flies.

They may aid States in developing action plans. The procedures were developed by staff members of Plant Protection and Quarantine (PPQ), through discussion, consultation, or agreement with other Animal and Plant Health Inspection Service (APHIS) staff members, the Agricultural Research Service (ARS), State private and University advisors.

This document is not exhaustive. It summarizes available literature.Some articles may not have been seen, nor have all pertinent specialists and other members of the research community been consulted for their advice.

1 General Information

General Reference for Fruit Fly Programs

Contents

Action Statement

This reference provides background information only on fruit flies in the Tephritidae (Diptera). For PPQ Programs on Tephritid fruit fly pests such as Medfly, Oriental Fruit Fly, Melon Fly, Peach Fruit Fly, etc., please use the appropriate action plan prepared for these specific pests. These action plans are applicable only to the Continental United States and its Territories.

The information contained in this document is intended as a guide in designing a program to detect and respond to an infestation of fruit flies in the family Tephritidae. These general reference provides information on implementing detection, control, containment or eradication programs. You must base specific emergency program action information following the concept of Total Population Management (Hendrichs, 1996).

Initial Program Procedures

Identification and Detection

Determine identification and detection procedures which will be used throughout the program. Use options given in **Identification Procedures** and Appendix D and G of this document.

Scoping the Problem

Determine the extent of the infestation and the difficulties faced by program managers using surveys and determine the biological (**Appendix H**—History) and practical realities in advance of any active program.

No Action to Eradication

Consider the effectiveness of the various control options, including regulatory action (Section 4, Regulatory Procedures), available options for control or suppression of the pest population, and destruction or treatment of the hosts (Section 5, Control Procedures and Addendum E). From this information, and in the light of available resources, decide to either take no action (a program is impractical, or to control, suppress, or eradicate the target population, if possible (see 5. Control Procedures and specifically Table 2.2.1 for Decision options).

Background Information

Tephritid Fruit Flies are a group of small (1/5” to 1/3”) to medium sized (3/4”) flies, with reddish-brown to orangish, yellowish or blackish body colors. The wings generally have brownish streaks, and there may be scattered dark spots as well. The eggs are slender, white, with an elliptical shape less than 4 to 8 hundredths of an inch long and laid in batches of 3 to 40 under the skin of the host. The larvae are headless, cylindrical maggots, about 1/2” long with stubby ends, creamy white in appearance, through which gut contents may be visible. The larvae feed inside host material in large numbers. The puparium is generally dull white to dark brown to black, just over an inch long and usually found in soil to 2" or rarely 6" deep.

All species are damaging to fruit and some species will attack flowers and stems. Some species are regarded as beneficial and are used in biocontrol efforts. Others attack plants of value to man and agriculture and are regarded as pests. To give an impression of the movement of fruit flies, both harmful and beneficial, the following is taken from the on-line version of the Diptera Site <www.sel.barc.usda.gov/Diptera/tephrev/TephInSp.htm> on Invasive Species and biological control agents (Nov.,2000):

At least 43 species of Tephritidae have been spread intentionally or accidentally by man beyond their natural ranges.

Species that have spread beyond their natural ranges or that have been released in other areas are listed below by genus in alphabetical order. Refer to White & Elson-Harris (1992) and Foote et al. (1993) for references if not stated below. Http://www.sel.barc.usda.gov/Diptera/tephriti/pests/adults/ may also present up to date information as well as the Diptera Site.

Pest Fruit Flies of the World

The following information on worldwide movements were taken from the Diptera Site, online as cited.

Acinia picturata Native to North and South America, was introduced for weed biocontrol to Hawaii and accidentally to several other Pacific islands.

Anastrepha fraterculus A probable complex of species native to much of the Neotropics, was introduced but eradicated in Chile (Enkerlin et al. 1989), and also introduced to the Galapagos Islands (Harper et al. 1989).

Anastrepha ludens Believed by Baker et al. (1944) to be native only to northeastern Mexico, and they considered its presence south to Costa Rica due to spread by man. An introduction to California was eradicated.

Anastrepha obliqua A widespread neotropical species, was established in southern Florida (Key West) from 1931-1937 (McAlister 1936), but there is no evidence of a breeding population being present since then (G.J. Steck, pers. comm.). It has been trapped in California, but is not established there. It was not introduced in Bermuda as once reported (Woodley & Hilburn 1994).

Anastrepha serpentina* and *A. striata Widespread neotropical species, have been trapped in California, but are not established there.

Anastrepha suspensa Native to the Greater Antilles and the Bahamas, was introduced to Florida in 1965. An earlier introduction in the 1930=s did not survive (Weems 1965, 1966).

Bactrocera carambolae Native to the Oriental Region, was introduced in Surinam prior to 1975 and has spread to French Guiana, Guyana and northern Brazil (Amapá) (Sauers-Muller 1991, Drew & Hancock 1994, Food &Agriculture Organization 1994, Carambola Fruit Fly Programme Website).

Bactrocera correcta Native to the Oriental Region, has been trapped in California, but is not established there.

Bactrocera cucurbitae Probably native to the Oriental Region, has been introduced to East Africa, Mauritius, the Ryukyu Islands of Japan, New Guinea and nearby islands, Guam and Hawaii (Munro 1984, Hooper & Drew 1989, Kakinohana 1994). It has recently been detected in West Africa in Gambia (I. M. White, pers. comm.). Hardy & Foote (1989) also list northern Australia in its range, but it does not occur there (Drew 1982, D.L. Hancock, pers. comm.). It has been eradicated from some islands of Japan (Koyama 1989), and has been trapped occasionally in California, but is not established there.

Bactrocera dorsalis, also native to the Oriental Region, has been introduced to Hawaii, Guam, Nauru, and Mauritius. It was eradicated from the Ryukyu Islands of Japan (Drew & Hancock 1994) and the Northern Mariana Islands, and was introduced, but eradicated in California. It is not present in Australia as was once reported (Drew 1976, Drew &Hardy 1981).

Bactrocera frauenfeldi Has been introduced into northern Australia from New Guinea (Drew 1976, Hooper & Drew 1989).

Bactrocera latifrons Native to the Oriental Region, was introduced into Hawaii (E.J. Harris 1989).

Bactrocera oleae Considered by Munro (1984) to be native to Africa and spread to the Mediterranean area and Canary Islands with cultivated olives. It also now occurs in India and Pakistan. Recently it was discovered in California, where it appears to be well established (Rice, 2000).

Bactrocera papayae Another native of the Oriental Region and perhaps the western Australasian Region (Indonesia: Maluku), was introduced to Indonesia (Irian Jaya), Papua New Guinea, and northern Queensland, Australia (Allwood 1995); it has been eradicated from Australia. However, it may have spread to Taiwan (Chen & Tseng, 1992 - Probably misidentified as *Bactrocera pedestris*).

Bactrocera tryoni Native to Australia, has been spread to New Guinea, New Caledonia, Austral Islands, and Society Islands. It has been eradicated from Easter Island and Western Australia (Hooper & Drew 1989, Fisher, 1994), and it has been trapped in California, but is not established there.

Bactrocera zonata Native to the Oriental Region, has been introduced to the Middle East (Egypt, Saudi Arabia, Oman) and Mauritius (I. M. White, Identification of Peach Fruit Fly, Bactrocera zonata (Saunders), in The Eastern Mediterranean), although reports that it occurs on Reunion were based on misidentifications (D.L. Hancock, pers. comm.). It has been trapped but is not established in California.

Carpomya pardalina Native to the Middle East and western Oriental Region, has recently been spread to Turkmenistan.

Cecidochares connexa Native to South America, has been released in Indonesia and is being tested for release in Guam, for control of the weed *Chromolaena odorata* (R. Muniappan, pers. comm.).

Ceratitella tomentosa Native to the Oriental Region, was released in Trinidad for weed biocontrol, but is not established.

Ceratitis malgassa Native to Madagascar, may have spread to Granada (Southern Spain) and thence to Puerto Rico (Steyskal, 1982), but it has not been found since then and apparently is not established.

Ceratitis capitata Native to tropical Africa, is now one of the most widely distributed fruit flies. It is established in the Mediterranean area, southern Africa, various islands of the Atlantic and Indian Oceans, western Australia, Hawaii, Central America, and much of South America (Metcalf 1995, De Meyer 2000). It was once widely established in eastern Australia, but has not been collected there since 1931 (Permkam & Hancock 1995). It has been introduced and eradicated in southern Mexico (Hendrichs et al. 1983), northern Chile, and the United States (various times in Florida, Texas, and northern California). It has also been eradicated from southern California several times, although a current infestation is being treated, and Carey (1991, 1995) considers the recent infestations to be the result of a single introduction (i.e., the recent eradications were not completely successful). The population in Bermuda is extirpated (Woodley & Hilburn 1994). Considerable recent molecular research has focused on differentiating the geographic populations of C. capitata and determining the pathways of its spread (McPheron et al. 1995).

Chaetorellia acrolophi* and *C. australis Native to the western Palearctic Region, have recently been successfully introduced to North America for weed biocontrol (Turner 1996).

Chaetorellia succinea Has been accidentally introduced to Oregon and California (E. Fisher, pers. comm.).

Craspedoxantha marginalis A specimen of *Craspedoxantha marginalis* was reported from Switzerland by Merz (1994), but this species does not appear to be established there (B. Merz, pers. comm.).

Dacus ciliatus Native to Africa, has been introduced to the Middle East, southern Asia east to Burma, and to Mauritius and Reunion.

Dacus longistylus Is from Africa and has been reported from India, Pakistan and Sri Lanka (Kapoor 1993), but these records are probably all misidentifications of D. persicus (D.L. Hancock, pers. comm.).

Dacus bivittatus Was trapped in California in 1987, butis not established there.

Dioxyna sororcula A widespread species in the southern Palearctic, Afrotropical, Oriental and Australasian Regions. Its occurrence in Hawaii, and perhaps other parts of its range, appears to be the result of introduction. Hardy (1988) and Foote et al. (1993) incorrectly considered *D. picciola* to be a synonym, and *D. sororcula* does not occur in the Americas.

Dirioxa pornia Occurs in Australia and New Caledonia, also has been reported from New Zealand, Vanuatu, American Samoa, Fiji, and the Society Islands, but probably based only on erroneous interception records (Permkam & Hancock 1995).

Ensina sonchi	A Widespread Palearctic species, has been introduced to tropical Asia, Ethiopia, and Hawaii. Steyskal (1970) reported it from Peru based on his synonymy of other Ensina species with sonchi, but the others appear to be distinct, and sonchi does not occur in the Americas (Norrbom et al. 1999).
Euaresta aequalis	Was successfully introduced from North America to Australia for weed biocontrol. It also was released, but not established, in Fiji. Euaresta bella, native to North America, was released in eastern Europe for weed biocontrol, but is not established (Turner 1996).
Euaresta bullans	Was accidentally introduced from South America to the United States (California), South Africa, Australia, Europe, and the Middle East. It is now among the most widespread tephritid species.
Eutreta xanthochaeta,	Is native to Mexico and Central America, was successfully introduced to Hawaii for weed biocontrol, and was released but did not establish in Australia and South Africa (Freidberg & Mansell 1995, Turner 1996).
Procecidochares alani* and *P. utilis	Is native to Mexico, were successfully introduced to Hawaii and Australia for weed biocontrol.
Procecidochares utilis	Was also introduced to India, Nepal, New Zealand, South Africa and China (Zhang et al. 1988, Kapoor 1993, Freidberg & Mansell 1995, Turner 1996), and it has also been released in Madeira.
Rhagoletis completa* and *R. cingulata	Misidentified as indifferens, Norrbom, pers. obs. have recently been introduced from North America to Italy and Switzerland (Merz 1991, Duso 1991, Ciampolini & Trematerra 1992, Mani et al. 1994),
R. meigenii	From the Palearctic Region, was introduced to northeastern North America prior to 1977 (Norrbom et al. 1999).
Rhagoletis completa* and *R. pomonella	Another native of North America, extended their ranges to the west coast of the United States (Boyce 1929, Brunner 1987).
Rhagoletis conversa	Native to Chile, has been reported from Easter Island, but it may not be established.
Tephritis dilacerata	A Palearctic species, has been released in North America for weed biocontrol, but is not established.
Tephritis postica	Also a Palearctic species, has been released recently in Australia (Turner 1996).
Terellia fuscicornis* and *T. ruficauda	Both native to the Palearctic Region, were introduced to North America, the former only very recently (in California).

Terellia virens Also from the Palearctic Region, was recently successfully introduced to North America for weed biocontrol (Turner 1996).

Tetreuaresta obscuripennis Native to the neotropics, was introduced for weed biocontrol in Hawaii and Fiji. It also now occurs on Tonga and New Caledonia.

Toxotrypana curvicauda Native from the United States (Texas) to Venezuela and the Antilles, was introduced and established in Florida about 1905. A record from India is doubtful (Kapoor 1993).

Urophora The following species of *Urophora* are all native to the Palearctic Region. *Urophora affinis, U. cardui, U. quadrifasciata, U. sirunaseva, U. solstitialis*, and *U. stylata* have been introduced to North America for weed biocontrol (Turner et al. 1994, Turner 1996, Wheeler &Stoops 1996, P.Tipping, pers. comm.).

Urophora solstitialis Also has been introduced to Australia and New Zealand for weed biocontrol (Woodburn 1993, Turner 1996).

Urophora stylata Has also been reported from India (Kapoor 1993).

Urophora jaceana Was accidentally introduced to eastern Canada in 1923 (Shewell 1961).

Urophora jaculata Was released in California for weed biocontrol, but is not established.

Urophora cardui Was released in New Zealand, and *U. stylata* in South Africa and Australia, but neither is established (Freidberg &Mansell 1995, Turner 1996).

Urophora quadrifasciata* and *U. stylata Were reported as accidentally introduced to Australia (Hardy & Foote 1989, White & Elson-Harris 1992), but according to Hardy & Drew (1996) and D.L. Hancock (pers. comm.), these species are not established.

Xanthaciura connexionis A nearly circum-Caribbean species, was released in Hawaii for weed biocontrol, but is not established.

More important agricultural pest species as considered in this document

TABLE 1-1

Scientific Name	Common Name	Hosts	Distribution	Citation
Anastrepha fraterculus	South American Fruit Fly	A wide range of commercial and wild hosts	Central and South America, Mexico, Texas, Trinidad and Tobago	White & Elson-Harris, 1992

TABLE 1-1

Add photos of important species!!!

Scientific Name	Common Name	Hosts	Distribution	Citation
Anastrepha ludens	Mexican Fruit Fly	Many commercial hosts	Central America, Mexico, Texas	White & Elson-Harris, 1992
Anastrepha obliqua	West Indian Fruit Fly	A number of tropical commercial fruits, including spanish plum, mango, citrus	Central America, South America, West Indies, Mexico	White & Elson-Harris, 1992
Anastrepha serpentina	Sapote Fruit Fly	A number of tropical commercial fruits, including sapodilla, sapote, mango, citrus, apple	Central America, South America, Texas, Dominica, Trinidad	White & Elson-Harris, 1992
Bactrocera carambolae	Carambola Fruit Fly	A wide range of commercial and rainforest fruits	Asia, Surinam, French Guiana	Drew & Hancock, 1994
Bactrocera minax	Chinese Citrus Fly	A wide range of Citrus, including citron, lemon, tangerine, sour and sweet oranges, etc. and other fruits such as kumquat, and pummelo	India, China	White & Elston-Harris, 1992
Bactrocera cucumis	Cucumber Fruit Fly	Cucurbits, tomato, papaya	Australia	White & Elson-Harris, 1992
Bactrocera cucurbitae	Melon Fly	Cucurbits of many kinds, may attack flowers, stems and roots, also beans, quince, tomato, some citrus, scattered other hosts	Egypt, Kenya, Tanzania, Mauritius, Reunion, South Pacific, Guam, Hawaii, Asia, Iran	White & Elson-Harris, 1992
Bactrocera dorsalis	Oriental Fruit Fly	A wide range of commercial and rainforest fruits	Asia, Hawaii & Mariana Islands	Drew & Hancock, 1994
Bactrocera latifrons	Malaysian Fruit Fly	Solanaceous crops	Asia, Hawaii	White & Elson-Harris, 1992

TABLE 1-1

Scientific Name	Common Name	Hosts	Distribution	Citation
Bactrocera oleae	Olive Fly	Olives	Africa, Europe, in Mediterranean USSR (Georgia), Middle East, India, Pakistan, California	White & Elson-Harris, 1992, California (Rice, 2000)
Bactrocera papayae	Asian Papaya Fruit Fly	Many hosts, including; Papaya, mango, peppers, guava, oranges, various apples	Thailand, Malaysia, Indonesia, Christmas Island	Drew & Hancock, 1994
Bactrocera tryoni	Queensland Fruit Fly	All commercial fruit crops other than pineapple and strawberry, many wild hosts	Australia, New Guinea, French Polynesia, New Caledonia	White & Elston-Harris, 1992
Bactrocera tsuneonis	Japanese Orange Fly	Citrus	China, Japan	White & Elson-Harris, 1992
Bactrocera zonata	Peach Fruit Fly	Peach, sugar apple, guava, mango, and others	Mauritius and Tropical Asia	White & Elson-Harris, 1992
Ceratitis capitata	Mediterranean Fruit Fly	Many, many hosts, the most serious pest in the family	Africa, Atlantic Islands, Central America, Western Australia, Europe, Indian Ocean, Middle East, California, Hawaii, Mariana Is., South America, Jamaica	White & Elson-Harris, 1992
Ceratitis malgassa	Madagascan Fruit Fly	Citrus, guava, mandarin orange, maroola plum, nutmeg	Indian Ocean, Puerto Rico	White & Elson-Harris, 1992
Ceratitis rosa	Natal Fruit Fly	Many commercial and wild hosts	Africa, Mauritius, Reunion	White & Elson-Harris, 1992
Dacus bivittatus	Pumpkin Fly	Cucurbits, coffee, papaya, tomato	Africa	White & Elson-Harris, 1992

TABLE 1-1

Scientific Name	Common Name	Hosts	Distribution	Citation
Dacus ciliatus	Lesser Pumpkin Fly	Cucurbits	Africa, St. Helena, Indian Ocean, Middle East, Asia	White & Elson-Harris, 1992
Rhagoletis cerasi	European Cherry Fruit Fly	Cherries	Europe	White & Elson-Harris, 1992
Rhagoletis cingulata	Eastern Cherry Fruit Fly	Cherries	North America, Switzerland	White & Elson-Harris, 1992
Rhagoletis indiferens	Western Cherry Fruit Fly	Cherries, plums	North America	Wilson & Elson-Harris, 1992
Rhagoletis pomonella	Apple Maggot	Apple, hawthorn, plum, peach, crabapple, roses, sour cherry, apricot	Mexico, North America	Wilson & Elson-Harris, 1992
Toxotrypana curvicauda	Papaya Fruit Fly	Papaya, mango	Central America, South America, Florida, Texas, West Indies	Wilson & Elson-Harris, 1992

Life Cycle Information

Insect development is temperature dependent. Egg, larval, pupal and adult reproductive development are influenced by air temperatures. In the environment, there is a minimum temperature threshold below which no measurable development takes place. A developmental model that uses modified air temperature data for all life stages can be used to predict the entire life cycle. The temperature for these developmental thresholds has been determined for a number of Tephritidae. The number of degrees accumulated above the developmental threshold for a life cycle are called day degrees (DD). One day degree is one day with the average temperature one degree greater than the threshold for development.

Overwintering of larval or pupal stages for any period of time will result in substantial extensions of the life cycle and these formulas must be used with caution, especially for species from temperate climates which are more likely to exhibit cold tolerance than the more tropical forms.

Overwintering of adults is also likely with some species. Female ovaries may stop development in early fall and began again about mid-April. Adults also seek out places to overwinter. Such a response will make it necessary to reset DD accumulations to a figure appropriate for the specific species. In some cases, this behavior or the resorption of the follicles (testes) in either sex may make it necessary to reset the DD accumulations to 0 for adults and count to at least 400 DD to be sure of covering the life cycle.

In any event, caution should be exercised in the use of any models for DD. For example, the thermal limit may be reached in areas exposed to sunlight earlier than areas less exposed to solar warmth.

Another note of caution covers pupal development. As far as is known, Tephritids pupate in the soil. However, they may sometimes shelter in otherwise protected places which might influence development.

Genetic variations may also occur, such as hybridizations between nonspecific varieties of subspecies. For the air temperature model, depicted in **Table 1-2**, a specific number of DD must be accumulated before one life cycle has been completed.

The known developmental thresholds and accumulated DD for some Tephritids are known. Such data is given in Addendum H.

TABLE 1-2: Day Degree Calculations

Minimum Daily	**Maximum Daily**	**Total**	**Average Daily**	**Threshold**	**Day Degrees**
Temp °F +	Temp °F =	Temp °F 2	Temp °F -	Temp °F =	# of DD
EXAMPLE: for *Bactrocera tryoni*, the Queensland fruit fly with a threshold of 52.7 °F from egg to adult in air with a total of 599 DD and for a maturing female with a threshold of 55.4 °F from 599 to 753.4 DD before a life cycle is completed:					
From Egg to Adult:					
54 °F +	74 °F =	128 °F = 2	64 °F -	52.7 °F =	11.3 in °F
From Emergence to Mature Female:					
54 °F +	74 °F =	128 °F = 2	64 °F -	55.4 °F =	8.6 in °F

However, most Tephritids do not have such details on day-degree accumulation. In the absence of this data for a particular species, one can use the averages or the most applicable figures taken from known data and extrapolate to the target pest. The averages and applicable figures are (for the known six species whose thresholds and total DD are known):

Average Of All Lower Thresholds:	47.35^0F (in air)
Average Of All Total DD:	1,116.61 DD

If a range of thresholds and DD are given, use the *Highest Lower Threshold* and Highest *DD Accumulation*.

It should be noted that for program purposes, the lowest known thresholds and highest DD accumulations are generally used. This is to permit variations in developmental time, such as may be caused by host or microclimate, to be covered by the program.

The life cycle biology for those species for which information is known is summarized in the table below. This data is useful in the design and development of a program for a given Tephritid species.

To the extent possible, some comparisons between different related species can also be made from this table. In addition, it may be possible to derive some general overall guidelines for a Tephrid for which no or few details are known.

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Anastrepha antunesi	N/A	Tropical	Sapodilla, Mombin, Hog-plum			
Anastrepha bistrigata	N/A	Tropical	Guavas			
Anastrepha carambolae	N/A	Tropical	Carambola, mango, tomato, cashews, citrus, guava, banana, various apples, jackfruit, bread-fruit	Strong fliers and will fly long distances for food or a site to lay eggs	?	egg = 1-2 days larva = 6-9 days pupa = 8-9 days preovi. = 8-10 days Life cycle = 30 days minimum
Anastrepha distincta	N/A	Tropical	Star-apple, Mango			
Anastrepha fraterculus (APHIS. 1982b)	N/A	Tropical to Subtropical	Numerous hosts, inc., Walnuts, Apples, Cherries, Coffees, Citrus, Grapes, Plums, Cherries, Pears, Mangos, etc.	To next host	?	egg = 3-6 days larva = 9-25 days pupa = 12 days extended = 25 days to 18 months Life cycle = 64-109 days. Adults live 3 months
Anastrepha grandis (Silva & Malavasi, 1996)	?	Tropical to Subtropical	Watermelon, Pumpkins, Gourds Guava	?	?	egg = 3-7 days larva = 13-28 days pupa = 14-23 day Life cycle = 43 - 71 days
Anastrepha leptozona	N/A	Tropical	Star-apple, Eggfruit tree			
Anastrepha ludens (APHIS, 1986)	N/A	Tropical to Subtropical	Many hosts, inc., Cashew, Apples, Papaya, Citrus, Coffee, Quince, Persimmons, Mango, Plums, Peaches, Guavas, Pears, etc.			egg = 7 days larva = 10-42 days pupa = 10-50 days preovi. = 11-25 days Average life cycle lasts 3 months
Anastrepha macrura	?	Tropical to Subtropical	Star-apple			

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species (continued)

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Anastrepha obliqua (Celedonio-Hurtado, et al, 1988)	N/A	Tropical to Subtropical	Many hosts, inc., Cashew, Apples Carambola, Citrus, Coffee, Mango, Sapote, Sapodilla, Plums Granadilla, Guava			egg = 3.14 days larva = 9.03 days pupa = 14 days Preovi = 10 days Life Cycle = 36.67 days
Anastrepha ocresia	?	Tropical to Subtropical	Grapefruit, Guava, Sapodilla			
Anastrepha ornata	N/A	Tropical	Guava, Pears			
Anastrepha pseudoparallela	?	Tropical to Subtropical	Mango, Granadilla, Passionfruit			
Anastrepha serpentina (Celedonio-Hurtado, et al, 1988; anon., 2000h)	N/A	Tropical to Subtropical	Apples, Citrus, Quince, Mango, Sapodilla, Avocado, Sapote, Guava, Peach, Pear, Plums		In air = 47.8^{0}F egg = 140 DD larva = 565.7 DD pupa = 525.6 DD Egg-Adult = 1231.4 DD	egg = 3.41 days larva = 8.77 days pupa = 14.7 days Preovi = 10 days Life Cycle = 36.91 days
Anastrepha sororcula	N/A	Tropical	Coffee, Cherries, Guava			Av. life span of adult is 2.6-4.9 weeks Max. life span of females is 12.9 weeks (Bressan & Teles, 1991). Average age to mating is 24 days (Silva, et al., 1985)
Anastrepha striata	?	Tropical to Subtropical	Soursop, Star-apple, Oranges, Mango, Avocado, Peaches, Guavas, Apples			

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species (continued)

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Anastrepha suspensa (Brown, 1985) (Weems, 1965b)	N/A	Tropical to Subtropical	Many hosts, inc., Apples, Carambola, Cinnamon, Citrus, Persimmon, Loquat, Cherries, Figs, Plums, Kumquats, Tomatoes, Mangos, Peaches, Guava, Pears			egg = 2-3 days larva = 10-14 days pupa = 10-14 days preovi.= 14 days Life Cycle = 42 days optimum Adult Life Span = 17-49 days
Bactrocera albistrigata	N/A	Tropical	Apples. Almonds			
Bactrocera aquilonis	N/A	Tropical	Many hosts, inc., Cashew, Apples, Carambola, Peppers, Citrus, Tomatoes, Mangos, Banana, Avocado, Peaches, Guavas			
Bactrocera atrisetosa	N/A	Tropical	Watermelon, cucumber, Pumpkin, Tomatoes			
Bactrocera carambolae	N/A	Tropical	Star-apple, Citrus, Tomatoes, Mango, Banana, Guava, Apples	Males and females are strong flyers and will fly long distances (over 30 miles) to find food or lay eggs, but tend to remain in place if host is present.		Egg = 1-2 days Larva = 6-9 days Pupa = 8-9 days Post-ternal = 8-12 days Life Cycle = appr. 30 days
Bactrocera caryeae	N/A	Tropical	Jackfruit, Citrus, Mango, Guava			
Bactrocera caudata	N/A	Tropical	Pumpkins			egg = 2.5 days larva = 9-15 days pupa = 11.5 days Egg to adult = 23-29 days (Oakley, 1950)

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species (continued)

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Bactrocera correcta	?	Tropical to Temperate (?)	Oranges, Coffee, Mango, Peaches			
Bactrocera cucumis	?	Tropical to Temperate	Papaya, Melons, Cucumber, Pumpkin, Squash, Tomatoes, Gourds			Egg = 2.125 days Larva = 5-7 days Pupa = 7 days Egg to adult = two weeks (May, 1946)
Bactrocera cucurbitae (USDA, 1984a; anon., 2000g)	?	Tropical to Temperate	Many hosts, inc., Peppers, papaya, Watermelon, Citrus, Melons, Cucumbers, Squashes, Pumpkins, Figs, Strawberries, Gourds, Tomatoes, Mango, Avocado, Beans, Peaches, Eggplant		In air = 46.5^{0}F egg = 38.1 DD larva = 183.1 pupa = unknown preovi. = 494.9 DD	Egg = 6-28 hours Larva = 4-17 days Pupa = 7-13 days Post-ternal = 11-12 days Total Life cycle = usually 1-2 months, extended = 7 months
Bactrocera curvipennis	N/A	Tropical	Oranges, Bananas			
Bactrocera decipiens	N/A	Tropical	Pumpkins			
Bactrocera depressa	?	Tropical to Temperate	Watermelon, Cucumbers, Pumpkins, Gourds Tomatoes			
Bactrocera distincta	N/A	Tropical	Breadfruit, Star-apple			
Bactrocera diversa	Adult	Temperate (?) Northern plains, foothills of Pakistan	Oranges, Pumpkins, Gourds, Mango, Banana, Guava	Active throughout most of year, mostly in Fall		egg = 29.5-33 hours larva = 5.7 days pupa = 8.6 days preovi. = 8-39 days Life cycle = 23.5-54.5 days

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species (continued)

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Bactrocera dorsalis (Stibick, 1989; annon., 2000f)	Pupae can overwinter. Adults can survive frosts and light snowfall.	Tropical to Temperate	Many, many hosts, inc., Apples, Papaya, Chili, Citrus, Persimmon, Figs, Kumquat, Mango, Banana, Peaches, Nectarines, Peach, Guavas, Grapes, Pears	Nondispersive movement = 656 yds. Dispersive movement = 3+ miles, 40 miles over water. Feeding in morning, mating at dusk.	In soil = 49.4 °F In air = 54.3 °F egg = 34.5 DD other stages, not specified Life Cycle = 620 DD	egg = 1-20 days larva = 6-35 days pupa = 10-12 days extended to 120 days preovi. = 8-12 days Life cycle = 25-67 days + up to 4 months if overwintering
Bactrocera facialis	N/A	Tropical	Cashew, Pineapple, Peppers, Citrus, Tomatoes, Mango, Avocado, Peach, Guava			
Bactrocera frauenfeldi	N/A	Tropical to Subtropical	Breadfruit, Papaya, Mango, Banana, Guava, Rose-apple, Malay-apple	Mate at dusk.		Egg = 2 days Larvae = 10.5 days Pupa = 11 days egg to adult = 21.5 days
Bactrocera jarvisi	?	Tropical to Temperate	Papaya, Citrus, Quince, Persimmon, Tomato, Apple, Mango, Banana, Apricot, Peach, Guava, Pomegranate, Pear	Emerges later in the season than other fruit flies (Jarvis, 1927)		egg = 9-10 days larva = 8-9 days (Fitt, 1986) pupa = 22 days (Jarvis, 1927) Preovi. = 15 days Life cycle = 55 days
Bactrocera kandiensis	N/A	Tropical	Grapefruit, Mango, Eggplant			
Bactrocera kirki	N/A	Tropical	Pineapple, Carambola, Peppers, Citrus, Cherry, Mango, Granadilla, Peach, Guava			

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species (continued)

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Bactrocera latifrons (Stibick, 1993)	?	Tropical to Temperate	Carambola, Peppers, Citrus, Gourds, Cucumbers, Pumpkins, Tomatoes, Apples, Mango, Banana, Guava, Eggplant,	?	?	egg = 1.9-2.7 days larva = 8.4-8.6 days pupa = 10-10.4 days Preovi. = 6-17 days Total life cycle = 31 days
Bactrocera melanota	N/A	Tropical	Oranges, Mango, Guava			
Bactrocera minax (Wang & Zhang, 1994)	Pupae overwinter.	Tropical to Temperate	Citrus, Kumquat	Nondispersive movement only = 1500 m		egg =? larva =? pupa = 180 days Life Cycle = 1 year
Bactrocera musae (Smith, 1977)	N/A	Tropical to Subtropical	Papaya, Banana, Guava	Apparently nondispersive		egg = laid in green & young fruit, hatch in 3-11 days larva = 7-11 days pupa = 7-10 days egg to adult = 17-32 days
Bactrocera neohumeralis	?	Tropical to Subtropical	Apples, Citrus, Coffee, Tomatoes, Loquat, Strawberry, Mango, Apricot, Plums, Peach, Guavas, Pear, Raspberries,			
Bactrocera occipitalis	N/A	Tropical	Mango, Guava			

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species (continued)

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Bactrocera oleae (Christenson & Foote, 1960; HYPPZ, 1998a)	Pupal Stage in soil Some to a few adults may survive, depending on climate.	Subtropical to Temperate	Olives	Local dispersal up to 4300 meters only. Barriers, such as pine woods serve to hinder spread. (Pelekassis, et al., 1988)	44.6^{0}F = Threshold temperature for development	egg = 2-4 days in summer, 10-16 days, winter larva = 9-14 days pupa = 10-14 days, up to 3 months delay preovi = 2-10 days (with host present) remains in an immature state or reproductive diapause until host is present. Life cycle = 23-42 days Adult life span = exceeds 6 months, oviposition period = 25-100 days may be interrupted for 5-6 months
Bactrocera papayae	N/A	Tropical	Apples, Jackfruit, Carambola, Peppers, Papaya, Oranges, Mango, Granadilla, Guava			egg = 1-2 days larva = 7-12 days pupa = 10-14 days Preovi. = 1-2 weeks Life cycle = 25-42 days Adult life span = 3-4 months
Bactrocera passiflorae	N/A	Tropical	Cashew, Breadfruit, Papaya, Citrus, Mango, Granadilla, Avocado, Guava, Eggplant, Cocoa			Egg = 1.5 days Larva = 7-16 days Pupa = 8-10 days Preovi = 18 days Life cycle = 34.5-45.5 days
Bactrocera philippinensis	N/A	Tropical	Breadfruit, Papaya, Mango			
Bactrocera psidii	N/A	Tropical	Citrus, Mango, Granadilla, Guava	Adults mate during the day when light intensity is high.		egg = 3 days larva = 6-7 days
Bactrocera pyrifoliae	N/A	Tropical	Peach, Guava, Pear			

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species (continued)

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Bactrocera tau	3rd instar larva (?)	Temperate(?) Absent during summer, appears in late autumn in Nov.-Dec.	Cucumber, Watermelon, Pumpkin, Gourds, Mulberry	Adults mate about sunset. 1-6 days later, fe males fly from host to host search for a place to lay eggs		egg = 20.4-21.7 hours larva = 7-21 days pupa = 7-10 days Preovi. = 18-20 days Life cycle = 33-52 days
Bactrocera trilineola	N/A	Tropical	Mango, Papaya, Avocado, Cashew, Guava, Citrus	Long mating periods in morning when light intensity is high.		egg to adult = 21-22 days Preovi. = 11 days Life Cycle = 32-33 days
Bactrocera trivialis	N/A	Tropical	Peppers, Peach, Guava			
Bactrocera tryoni (Stibick, 1990)	Adult	Tropical to Temperate	Many, Many hosts, inc., Citrus, Quince, Persimmon, Loquat, Kumquat, Plum, Walnut, Tomatoes, Mango, Apple, Mulberry, Granadilla, Apricot, Cherry, Peach, Guava, Pomegranate, Pear, Blackberry	Migratory phase of 2-3 weeks of up to 4 miles av. dispersal, extends up to 6-10 miles after 2 weeks, 10 to 16 miles after 3-7 weeks. 2nd dispersal for host fruit. 3rd dispersal in response to adversity. Adults, seek shelter, and overwinter.	egg-adult = 52.7°F preovip. = 55.4°F Below 55.4°F causes resorption of follicles. After several weeks, mortality of immatures at 100%. 4-5 day periods below 28.4°F kills all immatures.	egg - adult = 0-599 DD Maturing female = 599-753.4 DD Total Life Cycle = 753.4 DD. This is a period of 2-3 weeks in summer and 2 months in fall or spring
Bactrocera tsuneonis (Wang & Zhang, 1994)	Pupae overwinter.	Tropical to Temperate	Citrus, Kumquats	Nondispersive movement only = 1500 m		egg =? Larva =? pupa = 180 days Life Cycle = 1 year
Bactrocera tuberculata	N/A	Tropical	Mango, Peach			
Bactrocera umbrosa	N/A	Tropical	Breadfruit, Jackfruit, Citrus, Gourds, Granadilla			egg =? Larva = 9 days pupa = 9 days Female life span = 30 days

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species (continued)

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Bactrocera xanthodes	N/A	Tropical	Pineapple, Breadfruit, Papaya, Watermelon, Mandarin, Tomato, Mango, Granadilla, Lychee, Guava			eggs = 2-3 days Larvae = 5-6 days pupae = 11-12 days oviposi =? Life Cycle = 18-21 days
Bactrocera zonata (Stibick,1988)	This species (the pupae?) can apparently survive winters in temperate climates.	Tropical/ Temperate	Okra, Sugar-apple, Papaya, Watermelon, Orange, Melon, Quince, Fig, Gourds, Tomato, Apples, Mango, Peach, Guava, Pomegranate, Eggplant	Tend to remain in an area if food and hosts available. Local dispersal to host, food and shelter. Capable of flight up to 25 mi. in search of suitable conditions. Flight affected by wind direction.	?	eggs = 2-3 days larvae = 1-3 weeks pupae = 4 days to 6 weeks Preovi. = 10-23 days Total life cycle = 20 days average
Capparimyia savastani	Adult	Temperate	Caper			eggs = 2 days larvae = 4-7 days pupae = 14-28 days Preovi. = 2 days Total life cycle = 22 to 63 days
Carpomya incompleta	?	Temperate	Jujube			pupa = two weeks (Oakley, 1950)
Carpomya vesuviana (Basha, 1952; Narayanan & Batra, 1960)	pupae apparently overwinter and hibernate after that until fall.	Tropical to Temperate	Guava, Jujube,	Local, but very active and fast flyers.		eggs = 2-3 days Larvae = 15-20 days pupae = 12 to 305 days prepovi. = 1-2 months Life Cycle = 24 days to 388 days
Ceratitis anonae	N/A	Tropical	Soursop, Coffee, Guava			

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species (continued)

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Ceratitis capitata (APHIS, 1982a; 1993; anon, 2000e; Duyck & Quilici, 2002)	Adults can survive winters in temperate climates. Pupae stage survives temperature extremes.	Tropical to Temperate	This species has the largest number of known hosts, over 400. Papaya, Sapote, Citrus, Coffee, Quince, Persimmon, Loquat, Cherries, Figs, Kumquat, Walnut, Cherries, Plums, Apricot, Apple, Avocado, Mango, Plums, Guava, Nectarine, Peach Pear	Fly a short distance, winds will carry them 2.4 km or more. (APHIS, 1982c)	In soil = 49.4°F In air = 61.9°F Lower larval dev. thresh. = 10.2 °C egg = 52.4 DD Larva = 204.6 DD pupa = 328.3 DD (soil) Preovi. = 79.6 DD (Total immature stages = 260 DD) Life Cycle = 664.9 DD	egg = 2-3 days Larva = 6-10 days pupa = 6-15 days Prepovi. = 2 days (very variable) Life Cycle = 16 - 30 days Duration of immature stages = 14.5 to 63.8 days
Ceratitis catoirii (Duyck & Quilici, 2002)	N/A	Tropical	Custard-apple, Carambola, Peppers, Papaya, Citrus, Loquat, Tomatoes, Mango, Avocado, Peach, Guava, Plums		lower larval dev. thresh. = 8.9°C Total immature stages = 356 DD	Duration of immature stages = 16.8 - 65.8 days
Ceratitis colae	N/A	Tropical	Abata cola			
Ceratitis cosyra	?	Tropical to Temperate	Custard-apple, Sour orange, Mango, Avocado, Peach, Guava			
Ceratitis malgassa (Dubois, 1965)	N/A	Tropical	Citrus, Nutmeg, Guava			eggs = 3-4 days larvae = 13-19 days pupae = 13-36 days preovi. = 4-14 days Life Cycle = 33 to 73 days Adult life span = 100+ days

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species (continued)

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Ceratitis pedestris	?	Tropical to Temperate	Tomato			
Ceratitis punctata	?	Tropical to Temperate	Coffee, Melons, Mango, Cacao Granadilla, Guava			Said to be similar to Ceratitis capitatia (Gowdey, 1913)
Ceratitis quinaria	?	Tropical to Temperate	Citrus, Fig, Apricot, Peach, Guava			
Ceratitis rosa (Weems, 1965; Duyck & Quilici, 2002)	Adult	Tropical to Temperate	Many hosts, inc.,. Custard-apple, Carambola, Pepper, Papaya, Plums, Citrus, Coffee, Quince, Persimmon, Loquat, Fig, Lychee, Tomato, Apples, Mango, Sapodilla, Banana, Avocado, Apricot, Plum, Peach, Guava, Pear, Blackberry, Cocoa, Grapes		lower larval dev. thresh. = 3.1^{o}C Total immature stages = 405 DD	egg = 4 days larva + prepupa = 12 days pupa = 10-20 days preovi. = 7 days Life cycle = 36-46 days Duration of immature stages = 18.8 - 65.7 days Adult Life Span = several months
Ceratitis rubivora	?	Tropical to Temperate	Star-apple, Berries			
Dacus axanus	N/A	Tropical	Gourds			
Dacus bivittatus	Adult	Tropical to Temperate	Papaya, Watermelon, coffee, cantaloupe, Cucumber, Squash, Pumpkin, Gourds, Tomatoes, Granadilla			egg = 3-5 days larva = 18-29 days pupa = 12-24 days egg to adult = 33-58 days (Oakley, 1950)
Dacus ciliatus (Narayanan & Batra,1960)	pupae overwinter	Tropical to Temperate	Okra, Peppers, Watermelon, Cantaloupe, Melon, Cucumber, Squash, Pumpkin, Cotton, Gourds, Tomatoes, Beans	Local		egg = 2-4 days or less larva = 4-6 days Pupa = 6-8 days or longer preovi. = 4 days Life Cycle = 16-22 days

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species (continued)

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Dacus demmerezi	N/A	Tropical	Watermelon, Melon, Cucumber, Pumpkin, Gourds			
Dacus frontalis	?	Tropical to Temperate	Watermelon, Gourds, Melons, Cucumber, Pumpkins			
Dacus lounsburyii	?	Tropical to Temperate	Watermelon, Melon, Pumpkin			
Dacus punctatifrons	?	Tropical to Temperate	Cucumber, Pumpkin, Gourds, Chayote			
Dacus smieroides	N/A	Tropical	Luffa			
Dacus solomonensis	N/A	Tropical	Cucumber, Pumpkin			egg = 2 days larva = 12 days pupa = 9 days preovi. = 16 days Life cycle = 39 days
Dacus telfaireae	N/A	Tropical	Gourds, Oysternut			
Dacus vertebratus (Oakley, 1950)	Adult	Tropical to Temperate	Watermelon, Cantaloupe, cucumber, Squash, Granadilla			egg = 2-5 days larva = 15-18 days pupa = 14 days or less in summer egg to adult = 31-37 days or less Adult life span = 1-9 months
Dirioxa pornia (Oakley, 1950)	?	Tropical to Temperate	Star apple, Citrus, Quince, Persimmon, Apples, Mango, Mulberry, Passion fruit, Plums, Peach, Pears,			egg = 2 days larva = 14-18 days pupa = 10-28 days preovi. unknown egg to adult = 26-58 days
Epochra canadensis (Jones, 1937; Christenson & Foote, 1960)	Pupal Stage	Temperate to Cold Temperate	Currants, Gooseberries			egg = 6-8 days larva = 15 days pupa =10 months Life Cycle = one generation/year?

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species (continued)

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Monacrosthcius citricola	N/A	Tropical	Lime, Lemon, Pummelo			
Myiopardalis pardalina (Christensen & Foote, 1960; Narayanan & Batra, 1960)	Pupal Stage in soil	Tropical to Cold Temperate	Watermelon, Melon, Cucumber			egg = 2-3 days in summer larva = 8-18 days pupa overwinters over 6 months or = 13-20 days+ Life Cycle = 23-41 days normally Adults = 3-4 weeks
Rhagoletis cerasi (Smyth, 1960)	Pupal Stage in top 3" soil	Temperate	Honeysuckle, Berbers, Barbary, Cherries, Bilberry	Nondispersive movement = 350 meters if hosts are present.	In soil = 41^{0}F In air = 17.4^{0}F	Life cycle = 1-3 years = 430 DD (Post diapause) One complete Life cycle DD accumulated via air temperatures = 550 DD Mandatory diapause 1-3 winters dependent on DD accumulation
Rhagoletis cingulata	Pupal Stage in soil.	Temperate to Cold Temperate	Cherries			eggs = 1 week larvae = 11 days each of 3 instar pupae = overwinter preovi. = 5-10 days Life cycle = 1 year
Rhagoletis completa (Christensen & Foote, 1960)	Pupal Stage	Tropical to Temperate	Walnuts, Peaches			eggs = 5 days larva = @ 45-104^{o}F (mean 64^{o}F) = 36.8 days 67-90^{o}F (mean 82^{0}F) = 27.9 days pupa = 291-328 days Mandatory diapause
Rhagoletis conversa	?	Tropical to Temperate	Husk-tomato, Nightshades			

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species (continued)

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Rhagoletis fausta	Pupal stage in soil.	Temperate to Cold Temperate	Cherries			eggs = 1 week larvae = 11 days each of 3 instar pupae = overwinter preovi. = 5-10 days Life cycle = 1 year
Rhagoletis indifferens	?	Temperate to Cold Temperate	Cherries, Plums, Chokecherries			
Rhagoletis juglandis	?	Tropical to Temperate	Walnuts			
Rhagoletis lycopersella	N/A	Tropical	Tomatoes	From host to host	?	egg + Larva = 16-18 days Pupa = 26-38 days estivated pupae = 3-8 months Normal life cycle = 55.5-69 days Estimated life cycle = 4-9months
Rhagoletis mendax (Pearson, et al, 1995; Meyer & Cline, 1997)	Pupa Stage 1" - 6" in soil	Temperate to Cold Temperate	Blueberries, Cranberries Huckleberries, Plums	Very active from May through July	?	egg = 5 days larva = 14 days pupa = overwinter 1, 2, 3 winters preovi. = 7-10 days in following summer Life cycle = 1 to 3 years, most in first year.
Rhagoletis nova	?	Temperate	Pepino			

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species (continued)

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Rhagoletis pomonella (Christensen & Foote, 1960; Howitt, 1993))	Obligate pupal diapause	Tropical to Cold Temperate	Hawthorns, Crabapples, Apples, Plums, Apricot, Cherries, Peaches, Pears, Roses	Move readily from tree to tree, but usually no more than 200-300 yards.	With 50^{0}F as a base: 900 DD = first adult emergence. 1,100 DD = first eggs laid 1,600 DD = peak adult emergence 1,750 DD = peak egg laying 2,800 DD = end of adult emergence * * Data from Michigan State PETE Model The lower DD threshold is **43.5^{0}F** (Univ. Calif., 1998)	eggs = 3-7 days. av. = 4.5 days @ mean temp. 75^{o}F. larva = 2 weeks in early apples = several months in winter apples = 20-22 days in summer; longer towards fall. pupa = obligate diapause = 1-4 winters. Time = 11 to 47 months adult preovi.= 8-10 days (following summer) Life cycle = 1-4 years
Rhagoletis ribicola	?	Temperate to Cold Temperate	Currents, Gooseberries,			
Rhagoletis striatella	?	Tropical to Cold Temperate	Ground-cherries Husk tomato			
Rhagoletis suavis	?	Temperate	Walnuts, Peaches			
Rhagoletis tabellaria	?	Temperate to Cold Temperate	Dogwoods, Cranberry			
Rhagoletis tomatis	?	Tropical to Temperate	Tomato			
Toxotrypana curvicauda (Selman, 1998)	N/A?	Tropical to Subtropical	Papaya, Mango	Poor fliers. Local flight only within a 2 mile radius ?		egg = 12 days larva = 15-16 days pupae = 2-6 weeks Adult = 5-7 days Estimated life cycle = 41 - 70 days
Trirhithromyia cyanescens	N/A	Tropical to Temperate (Etienne, 1973)	Peppers, Tomatoes, Eggplant, Nightshade			

TABLE 1-3: Known Life Cycle Biology of Various Tephritid Species (continued)

Species	Overwintering Stage	Tropical/ Temperate	Hosts	Flight Characteristics	Day Degree Thresholds	Life Cycles
Trirhithrum coffeae	N/A	Tropical	Coffee			
Trirhithrum nigerrimum	N/A	Tropical	Coffee, Coca, Surinam cherry			
Zonosemata electa	Pupae	Temperate to Cold Temperate	Peppers, Tomatoes, Nightshade, Eggplant			egg = 10 days larva = 18 days pupa = overwinter one generation per year

Program actions are governed in part by insect life cycle data. Control and/or eradication treatments, length of survey activities, and regulatory functions are affected primarily by the length of time it takes for the pest to complete its life cycle.

Temperature data are available from the National Oceanic and Atmospheric Administration, the U. S. Department of Commerce, private, State, university, or industry sources, or from remote weather monitoring stations run by any of the above. Unforeseen delays in completion of the life cycle must be anticipated.

2 Identification Procedures

Manual Name

Contents

Introduction

Correct and proper identification of the pest is the key to determining if an action program will be attempted, and if so, the extent, direction, and magnitude of the program, which must be cost effective and environmentally acceptable. Continued identification services during the course of a program will help determine program changes and program failures.

Identification Characteristics

Field personnel assigned to a program can sort. In general, they should prepare a description of the target species with pictures and drawings for the program. This should include distinguishing features which separate the target tephritid from indigenous species.

General Description of the Tephritidae

Eggs

Egg color is usually glistening white to creamy-yellow, becoming slightly darker towards the time of hatching. The shape and size vary according to species, but in the species covered by this document, the eggs are elongate and gently tapering. At the anterior end of each egg is a small micropyle which is obvious in most species.

Larvae

Larvae of Dacinae and Trypetinae (the subfamilies of the Tephritidae with which we are dealing with here) that develop in soft fruits are usually maggot-like, with abdominal segment 8 truncate and the rest of the body tapered to the anterior end.

Pupae

The fruit flies we are dealing with have exatate pupae, which is a pupa within the hardened case of the last larval instar. The puparia vary in color from white, through brown to black, although a black color in a species that normally has pale colored puparia is an indication of parasitism. The puparia tend to be rounded at the anterior end, have slightly out-curved lateral, dorsal and ventral surfaces, sometimes with distinct segmentation, and the posterior end may be rounded or flat.

Adult

Tephritids vary in wing length for about 2 mm to 25 mm and most species have patterned wings. While details of the taxonomy should be left to the taxonomist; tephritids are distinguished from other flies by a right angled bend of a vein in the front part of the wing, called the Sc vein just before it joins the costa (the leading edge of the wing).

Another feature is the presence of frontal setae. These setae are found right above the antennae, on each side between the eyes. (White & Elson-Harris, 1992)

There are other important features dealing chiefly with the head and wing veination, but again, these should be left to a competent taxonomist.

The larval forms of many tephritid species have been covered in some detail by Kandybina, 1987. Egg and pupal stages are also described. This work includes keys to Paleoarctic species, but many economic species are included therein. This study is in Russian, but has been translated into English. Again, a competent taxonomist would be needed to carry out reliable identifications.

Identification is primarily through the adult form, because there is not enough known about features of the other life stages for many species. This fact makes it necessary, in most cases, to rear out the adult. This causes a delay of 30 days or more.

Bad links, bad email address

Where advances in DNA identification of fruit flies makes it possible, the larvae may be employed to obtain a positive identification. Note that this requires knowledge of the DNA of the local native fruit flies as well as the invasive pest in order to make a distinction, but if this database is set up, can result in an identification in 1-3 days. Such a scheme was used in Australia to rapidly identify finds of the Asian Papaya fruit fly (*Bactocera papayae*) during an eradication program there in 1996-7 (Rogers, 1997). The Centre for Pest Information Technology and Transfer may be contacted for further information at the following: ~~www.cpitt.uq.edu.au/services~~ and e-mail ~~<enquires@cpitt.uq.edu.au>~~. Also, the Centre for Identification and Diagnostics, which is part of the overall structure, may be contacted at: ~~<www.cpitt.uq.edu.au/cid/cid.html>~~.

Another means of larval identification is through Cuticular Hydrocarbon Analysis. A discriminant model is designed, based on samples of larvae of the target fruit fly and that of other native fruit flies in the area under quarantine. The difference in the ratio of two components is sufficient t discriminate third instars. Accuracy in discrimination, utilization of specimens that are damaged, dried or otherwise unusable for morphometric isozyme, or DNA analysis, low cost per sample and automation of the process, all make CHC analysis a particularly effective solution for identification of species. So far, this has been tried only on *Ceratitis capitata* and *Anastrepha suspensa* larvae. (Sutton & Steck, 1994)

Collection of Specimens

Collect as many specimens as possible of the pest for screening/ identification by the local designated identifier. Field personnel may carry out initial or preliminary identification (see Chart).

Handling of Adults

Add graphics

Handle suspect adult specimens collected from sticky traps carefully. The following procedures are recommended to insure that specimens caught in sticky material can be identified accurately:

FIGURE 2-1

1. Ship entire trap. Pin the trap in a pinning box suitable for mailing. Place it in a second shipping box and put filler between the two boxes.

   OR

2. Cut out a portion of the insert or trap wall surrounding the specimen. This will leave you with the specimen imbedded in sticky material on a cardboard. Put an insect pin (number two size) through the cardboard and pin the cardboard (with specimen attached) in a pinning box suitable for mailing. To ship the pinning box for identification, place it inside a second shipping box and put filler between the two boxes.

Handling of Larvae

Kill suspect larvae by placing in water, bringing to the boiling point, cooling, and then preserved in 70-75% ethyl alcohol.

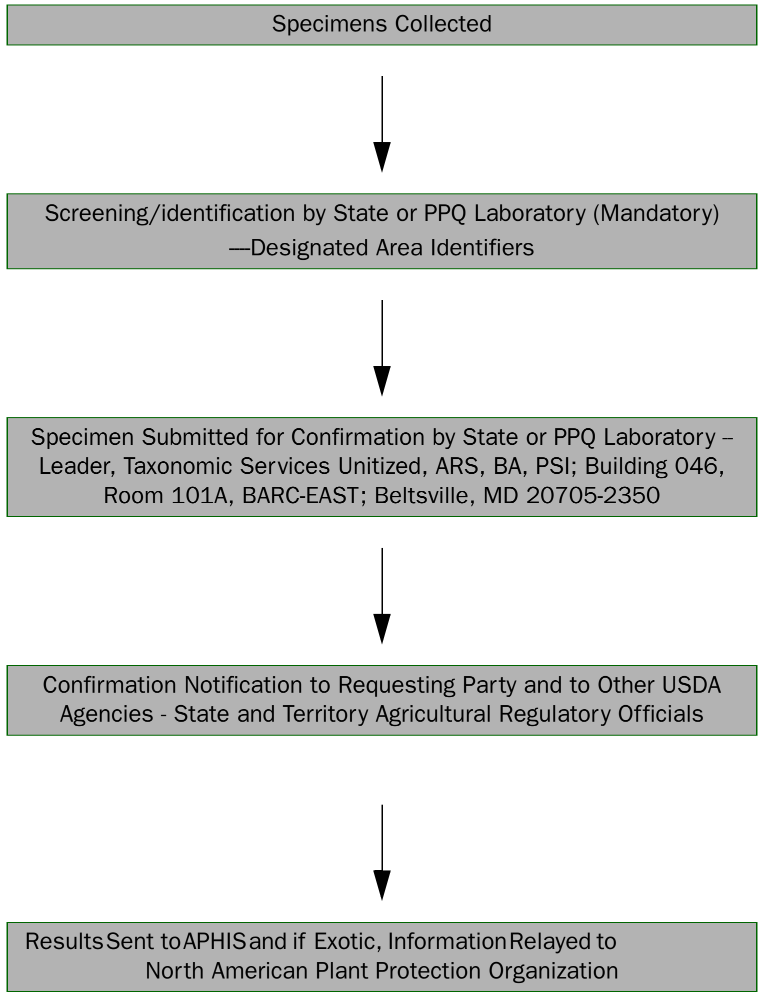
Shipping

Larvae and adult specimens should all be forwarded, along with any other insect stages that have been collected, for conformation to the designated area identifier (see following chart). All specimens must be accompanied by collection information.

- Collector's name
- Address
- Phone number
- Date collected
- Location
- A Pest Interception Form (PPQ Form 391) Marked "Urgent"

The identifier's office should be telephoned prior to shipping specimens to alert him/her of the shipment.

information Flow for the Identification of Specimens



3

Manual Name

Survey Procedures

Contents

Introduction

The survey effort is to determine the extent and means of pest spread. conversely, it is also used to determine pest-free areas. Human and other natural means of dispersal must also be considered. Such pathway dispersal must be factored into an active survey if it is not adequately covered under Section III. Regulatory Procedures.

Survey procedures will vary, depending on the Tephritid species involved and the availability of a pheromone. To help determine the outlines of a good survey system, a table listing known key trapping elements of many Tephritids, their pheromones (if available), and possible traps, trap arrays and specific information are given in Addendum D.4.

There are several primary survey systems for the Tephritidae: Trapping, Fruit Cutting, and Host Collecting. These systems complement each other. Soil screening is a rarely used supplemental option for certain species. Trapping is for the adult fly. fruit cutting, host collecting and soil screening are for primarily the larval and pupal stages, and to help confirm the presence of a breeding population of flies.

Any survey system should consider the existing survey system already in place (if present). These are usually the State or local systems set up to detect various species of fruit flies and which may in fact have detected the original find or finds. These systems may be upgraded, expanded and strengthened for program efforts. More informal types of surveys might also be in place, such as the systems run in Australia with grade school or high school students, called "Fruit Fly Fighters" (Anon., 2000b). While these may be important in making initial finds and should **not** be ignored, they may not be very helpful in determining trap locations or relied upon to make finds.

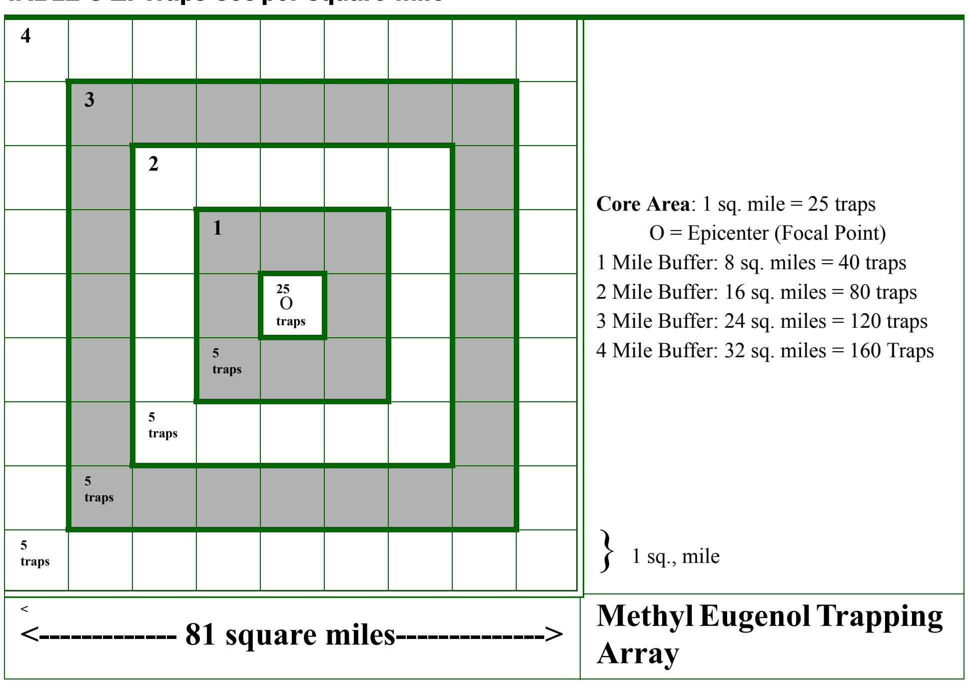
Delimiting Survey

When collecting one or more Tephritid species in an area, implement a delimiting survey immediately to determine the population distribution. Using the site of the detection as the epicenter (focal point), set out traps in a square mile (mi^2) trap array sequence. The trap array and type of traps are dependent on the Tephritid species involved and the kind of lures employed. Maintain traps through three generations after the last fly find.

Standard Methyl Eugunol Trapping Array

For Tephritid species attracted to Methyl Eugenol (ME), set out Jackson traps or their equivalent in a 25-5-5-5-5 per mi^2 trap array sequence (Stibick, 1988,1989). Use ME in the traps. Service the traps weekly.

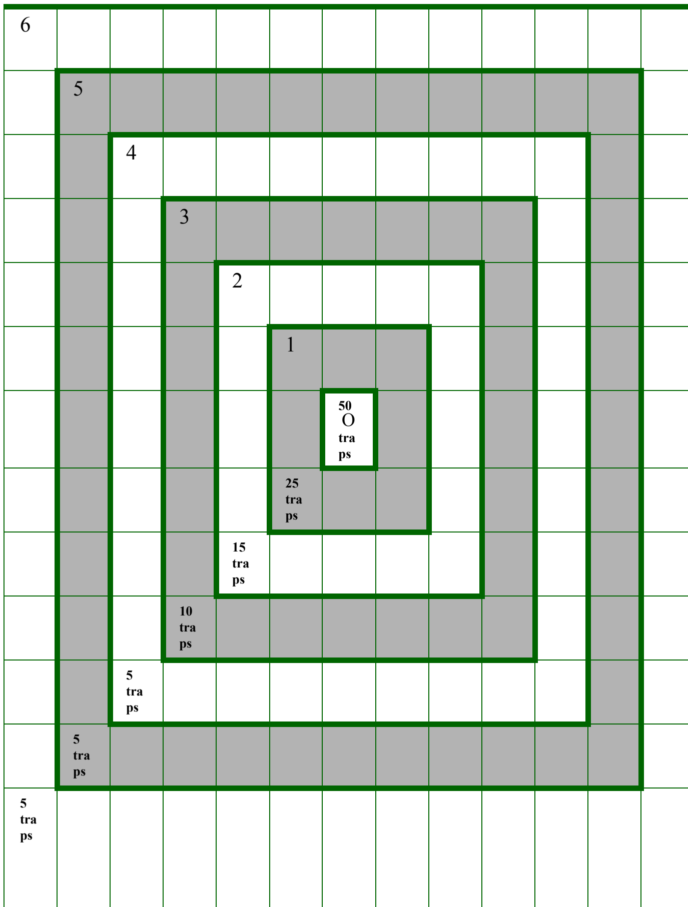
TABLE 3-1: Traps set per square mile



Standard Cuelure Trapping Array

For Tephritid species attracted to Cuelure (Cue), set out Jackson traps or their equivalent in a 50-25-15-10-5-5-5 per mi^2 trap array sequence (APHIS, 1984; Stibick, 1990). Use Cue in the traps. Service the traps daily during the initial 7-day period, then service weekly

TABLE 3-2: Traps set per square mile



Core Area: 1 sq. mile = 50 traps

O = Epicenter (Focal Point)

1 Mile Buffer: 8 sq. miles = 200 traps

2 Mile Buffer: 16 sq. miles = 240 traps

3 Mile Buffer: 24 sq. miles = 240 traps

4 Mile Buffer: 32 sq. miles = 160 traps

5 Mile Buffer: 40 sq. miles = 200 traps

6 Mile Buffer: 48 sq. miles = 240 traps

} 1 sq. mile

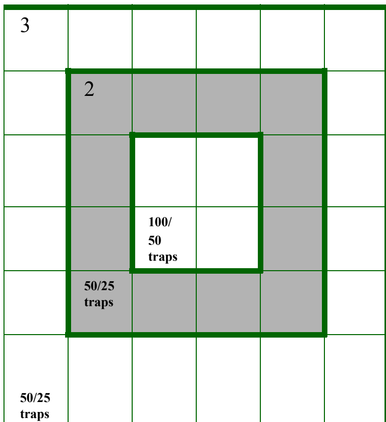
<------------------------169 square miles--------------------------->	**Curelure Trapping Array**

Standard Latilure Trapping Array

For Tephritid species attracted to Latilure (LTL), set out Jackson traps or their equivalent in a 100-50-50 per mi^2 trap array sequence (Stibick, 1993). Use LTL in the traps. Service the traps daily until treatment begins, then service weekly.

Also place McPhail traps in the core area and the first buffer at the rate of 50 in the core and 25 per mi^2 in the first and second buffer areas. Use McPhail traps in place of Jackson traps when sufficient latilure is not available.

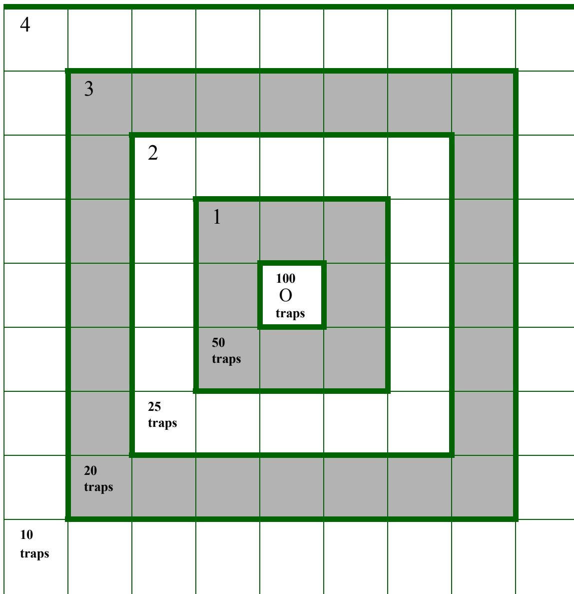
TABLE 3-3: Traps set per square mile

	**Core Area**: 4 sq. miles = 400 Jackson traps 200 McPhail traps Center of core (+) = Epicenter (Focal Point) 2 Mile Buffer: 12 sq. miles = 600 Jackson traps 300 McPhail traps 3 Mile Buffer: 20 sq. miles = 1000 Jackson traps 500 McPhail traps } 1 sq. mile
<—36 square miles—>	**Latilure Trapping Array**

Standard Trimedlure Trapping Array

For Tephritid species attracted to Trimedlure (TML), set out Jackson traps or their equivalent in a 100-50-25-20-10 per mi^2 trap array sequence (APHIS, 1982). Use TML in the traps. Service the traps daily until treatment begins, then service weekly

TABLE 3-4: Traps set per square mile



Core Area: 1 sq. mile = 100 traps

O = Epicenter (Focal Point)

1 Mile Buffer: 8 sq. miles = 400 traps

2 Mile Buffer: 16 sq. miles = 400 traps

3 Mile Buffer: 24 sq. miles = 480 traps

4 Mile Buffer: 32 sq. miles = 320 traps

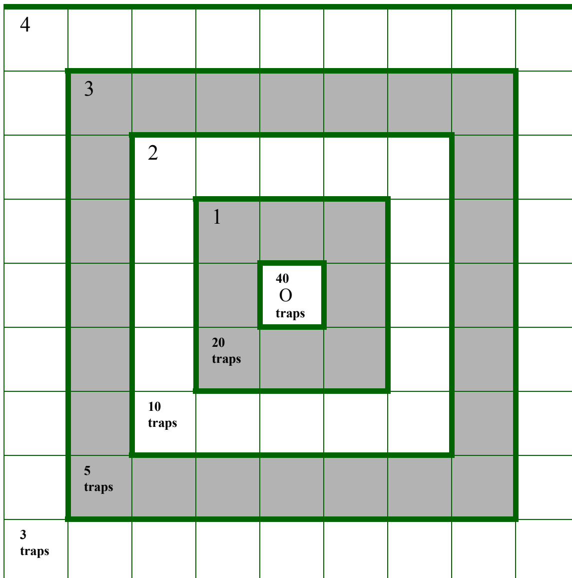
} 1 sq. mile

<——— 81 square miles———>	**Trimedlure Trapping Array**

Standard Olean Lure Trapping Array

For Tephritid species attracted to Olean Lure, set out Rebell traps or their equivalent in a 40-20-10-5-3 per mi^2 trap array sequence (Based on APHIS, 1982 and Bueno's 1986 ratios). Employ these traps at a rate of 259 traps per mi^2 in the core area (Bueno, 1986) as an alternate in the event the host(s) is very restricted and area very limited. Use Olean lure in the traps. Service the traps are daily until treatment begins, then service weekly.

TABLE 3-5: Traps set per square mile



:

Core Area: 1 sq. mile = 40 traps

O = Epicenter (Focal Point)

1 Mile Buffer: 8 sq. miles = 160 traps

2 Mile Buffer: 16 sq. miles = 320 traps

3 Mile Buffer: 24 sq. miles = 120 Traps

4 Mile Buffer: 32 sq. miles = 96 Traps

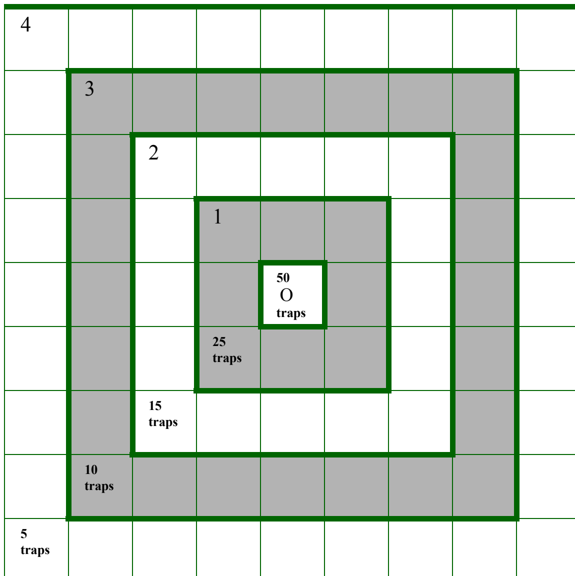
} 1 sq. mile

<—— 81 square miles————>	**Olean Lure Trapping Array**

Standard Carbonate Trapping Array

For Tephritid species attracted to visual/carbonate compounds, set out Rebell traps or their equivalent in a 50-25-15-10-5 per mi^2 trap array sequence. Use the carbonate lure in the traps. Service the traps daily until treatment begins, then service weekly.

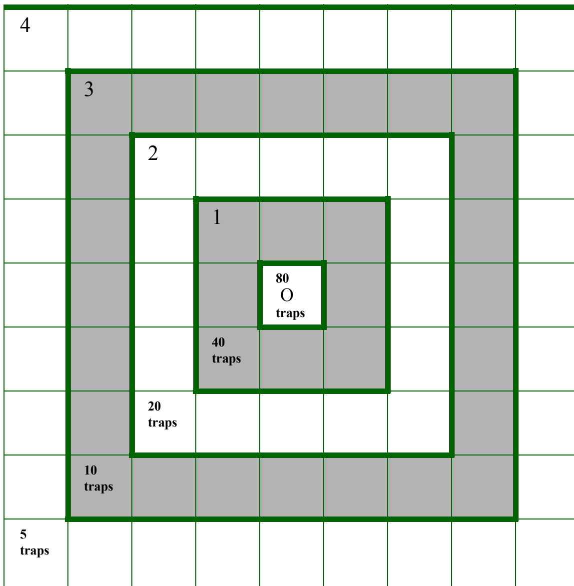
TABLE 3-6: Traps set per square mile

	**Core Area**: 1sq. mile = 80 traps O = Epicenter (Focal Point) 1 Mile Buffer: 8 sq. miles = 320 traps 2 Mile Buffer: 16 sq. miles = 320 traps 3 Mile Buffer: 24 sq. miles = 240 traps 4 Mile Buffer: 32 sq. miles = 160 traps } 1 sq. mile
<--------81 square miles------------->	**Carbonate Trapping Array**

Standard Food Trapping Array

For Tephritid species NOT attracted to any known pheromone or parapheromone, set out McPhail traps or their equivalent in a 80-40-20-10-5 per mi^2 trap array sequence (APHIS, 1982). If known, use an appropriate food lure in the traps, otherwise dissolve the standard six torula yeast pellets or a protein hydrolysate (PIB-7) in water in the trap. Service the traps weekly.

TABLE 3-7: Traps set per square mile



Core Area: 1 sq. mile = 80 traps
O = Epicenter (Focal Point)
1 Mile Buffer: 8 sq. miles = 320 traps
2 Mile Buffer: 16 sq. miles = 320 traps
3 Mile Buffer: 24 sq. miles = 240 traps
4 Mile Buffer: 32 square miles = 160 traps

} 1 sq. mile

<———81 square miles———> | **Food Trapping Array**

Monitoring/Evaluation Survey

Conduct a monitoring/evaluation survey in an area where eradication treatments are applied. Use the Jackson trap at a minimum rate of five per mi^2 to monitor the wild Target fruit fly population when full coverage protein bait sprays, male annihilation or other treatments are used. Use the traps to monitor the effectiveness of the treatments.

Where employing a sterile fly release project, substitute a dry-type trap (either a Steiner or a Nadel) for the Jackson trap and use at the rate of five traps per mi^2.

Fruit Cutting Survey

Cut and examine at the site preferred ripe or fallen host fruit within 1/4 mile (mi) of fly finds. If you find fruit fly larvae, take the infested fruits in a sealed container for identification by an authorized entomologist.

Soil Screening

Also use this procedure to supplement the survey. Take samples of soil from under suspect hosts within the infested area (usually within 656 feet of a larval find) and screen for larvae/pupae at a secure facility.

Host Collection and Holding

Collect fruit within 200 yards (yd.) of a larval detection and hold for at least one target fruit fly life cycle at optimum developmental temperatures and relative humidity for that species.

Security of the facility where the fruit is held must be equal to those established for a quarantine insect rearing facility in APHIS publication, series 81, number 61.

Detection Survey

Trap at a minimum rate of one trap per mi^2 in the area beyond the last buffer (up to the limit specified by protocol for the target fruit fly). Service traps weekly and rebait, depending on the lure used. Service the traps for three generations after the last fly find and are relocate at each servicing, depending on availability of preferred host.

Orientation of Survey Personnel

Experienced personnel will train the new personnel. Three working days will be necessary to teach the many facets of a fruit fly survey.

Survey Records

Maintain the records noting the area surveyed, sites trapped, dates, locations, and host in which detection were made.

For sterile release, a Cunningham Report (CR) will be completed. The CR is a square graph that charts trap sites and gives the weekly ratio of sterile (X) to wild finds (Y)

TABLE 3-8: Cunningham Report

X:Y	X:Y	X:Y
X:Y	X:Y	X:Y
X:Y	X:Y	X:Y

4

Manual Name

Regulatory Procedures

Contents

Instructions to Officers

Require regulatory actions until the pest is eradicated or declared established with no further suppression or control actions. A Scientific Advisory Committee will decide on the scope and extent of regulatory activity, if and when suppression and/or control actions are suspended or discontinued. Officers must follow instructions for regulatory treatments or other procedures when authorizing the movement of regulated articles.

Understanding the instructions and procedures will serve as a basis for explaining such procedures to persons interested in moving articles affected by the quarantine and regulations. Only authorized treatment procedures may be used.

You will find general instructions to be followed in regulatory treatments in Appendix D of these Guidelines, State regulatory manuals or in the Plant Protection and Quarantine, Animal and Plant Health Inspection Service, Treatment Manual. These may be helpful in formulating regulatory activities for a newly found pest.

Regulated Articles

A variety of articles may present direct or indirect risk of spreading exotic fruit flies. The movement of these articles will be regulated to prevent the infestation from spreading. Regulated articles include the following:

- Those fresh fruits and vegetables of hosts listed in **Appendix C** and any other plants discovered to be hosts which exist in the regulated area
- Cannery Waste
- Soil within the drip area of plants which produce the fruits, nuts, bolls, melons, vegetables and berries listed in Appendix C and another other plants deemed to be hosts which exist in the regulated area
- Since some species also oviposit in tender plant tissues such as terminals, unopened flowers, young stems, roots and seedlings, such plant parts as wilted runners, damaged buds, dead seedlings and other suspect plant parts are also regulated
- Any other product, article, or means of conveyance of any character whatsoever, when it is determined by an inspector that it presents a hazard of spread of a targeted fruit fly and the person in possession thereof has been so notified

Quarantine Actions

Regulatory action (see chart in **Appendix E**) will be required if there is a risk of artificial spread as determined by a risk assessment. If:

1. Two or more adults are found within a three mile radius within one estimated targeted fruit fly life cycle.

   or

   If ME is the attractant, 5 or more adult flies or an unmated female and a male are found in an area less than 1 mi^2 within one estimated targeted fruit fly life cycle.

   or

   If Cue lure is the attractant, 5 or more adult flies or an unmated female and a male are found in an area less than 169 mi^2 during a 30 day period or within one estimated life cycle of the targeted fruit fly.

   or

2. One mated female, or larva, or pupa are detected.

or

3. A single adult fly is found which is determined to be associated with a current eradication project.

When detections are made, the following steps should be taken:

Any Federal regulatory action requires a formal declaration in the Code of Federal Regulations (CFR). The states may issue regulations under less stringent requirements, but may have no authority to regulate interstate movement.

- **A.** State notifications are issued by state field personnel to the property owners or managers of all establishments within the regulated area that handles, moves, or processes host material which may include material and or conveyances capable of spreading the target fruit fly. Notifications will be issued pending authoritative confirmation and/or further instructions from the Head of the State Plant Protection Service and/or the Deputy Administrator, APHIS, PPQ.
- **B.** If necessary, the Deputy Administrator will issue a letter directing PPQ field offices to initiate specific emergency action under the Federal Plant Pest Act (7 U.S.C 150 dd) until emergency regulations can be published in the Federal Register. For information on other legal authorities, see Section II, Parts A and B of the APHIS Emergency Programs Manual (for plant pests).
- **C.** The Head of the State Plant Protection Service and/or the Deputy Administrator of APHIS will notify other State cooperators of the fruit fly detections, actions taken, and actions contemplated.
- **D.** A narrative description of the regulated area with supporting documents should be developed by State personnel. The regulated area, generally between 3 to 6.5 miles from a fly find (see chart, Appendix E), will normally be as determined by the species of fruit fly in question and the type and attractive power of the lure employed for its detection.
- **E.** The State may need to publish an interim rule covering the emergency regulations. The interim rule will announce a date for submitting written comments.
- **F.** After receipt of written comments, a final determination specifying the action decided upon will be published.

Regulated Establishments Trapping

Efforts to detect the pest within the regulated area will be made at establishments where regulated articles are sold, handled, processed, or moved. Establishments that might be involved include airports, landfill sites, fruit stands, grocery stores, farmer's markets, produce markets, flea markets, nurseries, and any other establishments that handle regulated articles. Survey personnel may place and service traps at regulated establishments which are considered a significant risk during the course of a program.

Use of Authorized Chemicals

The PPQ Treatment Manual and various individual Action Plans on Fruit Flies identify chemicals authorized for Fruit Fly control, methods and rates of application, and any special application instructions. the Invasive Species and Pest Management staff and applicable State staff must concur for the use of any other chemical or procedure for regulatory purposes. If treatments selected or proposed, including those listed in this Guidelines, do not comply with current pesticide labels, you will need to obtain emergency exemption under Section 18, or 24C, special local need (SLN) of FIFRA, as amended. For further instructions, see the Emergency Programs Manual, Section V. B. Regulated articles may be certified for movement after treatment.

Approved Regulatory Treatments

Soil Treatment

An approved insecticide applied to within the dripline of host plants.

Fumigation

The application of an approved fumigant (methyl bromide[1], Methyl Iodide[2]) as a treatment alone or in conjunction with cold treatment procedures.

Cold Treatment

The use of cold temperatures as a treatment on selected products, alone or in conjunction with fumigation.

Bait Spray

The application of approved ground or aerial proteinaceous bait spray to commercial host properties within the regulated area, as a condition for certification and movement.

1 Methyl bromide is banned from use as of 2002-05
2 Methyl Iodide is under investigation as a replacement. (Sharp & King, 1997), but has not been registered to date.

Principal Activities

The following identifies principal activities necessary for conducting a regulatory program to prevent the spread of the target fruit fly. The extent of regulatory activity required is dependant on the degree of infestation.

For example, to safeguard fruit stands through the entire regulated area when these stands are only engaged in local retail activity may not be necessary during a localized and light infestation. On the other hand, the judicious use of road patrols and roadblocks may be necessary where general or heavy infestations occur.

Principal regulatory activities include:

1. Contacting and advising regulated industry of regulations and required treatment procedures.
2. Issuing compliance agreements, certificates and permits.
3. Supervising, monitoring, and certifying treatments of regulated articles.
4. Conducting compliance inspections at regulated establishments such as:
   - **A.** Nurseries
   - **B.** Fruit stands and grocery stores
   - **C.** Landscape gardeners and lawn maintenance companies
   - **D.** Local growers and packers
   - **E.** Farmers, produce and flea markets
   - **F.** Commercial haulers of regulated articles
   - **G.** Public transportation
   - **H.** Post office contacts, and
   - **I.** Canneries and other processing establishments.
5. Monitoring the movement of waste material to landfills to ensure adequate disposal of regulated articles. This includes trapping and periodic inspections at landfills.
6. Monitoring the movement of regulated articles through airports and other transportation centers. Inspections must be carried out at local airports, bus stations, and train stations of all baggage being carried out of the regulated area.
7. Observing major highway and quarantine boundaries for movement of host materials. This is where road patrols and the use of established roadblocks occur. Roads leading into and out of the regulated area must be blocked and vehicles inspected to

prevent the movement of infested fruit out of the area. Operations at roadblocks are expensive, but usually prove their worth in preventing spread in instances of a heavy and persistent infestation. Chadwick, et al., 2000)

8. Notifying homeowners near detection sites of regulations.

Removing Areas from Quarantine

Areas placed under regulations may be removed from quarantine requirements after the targeted fruit fly has been declared eradicated. Program management will identify areas to be removed when the equivalent of three life cycles of the targeted fruit fly have been completed since the last specimen recovery in each of those areas. One life cycle must have elapsed since the cessation of control activities. A notice of Quarantine Revocation will need to be published when areas are removed from quarantine requirements.

Orientation of Regulatory Personnel

Only trained or experienced personnel, i.e., Rapid Response Team will be used initially. All personnel will receive adequate training in all program activities before deployment.

Regulatory Records

Maintain records as necessary to carry out an effective, efficient, and responsible regulatory program.

Records may include:

- Maps
- Chronology of events/action
- Personnel movement
- Treatment records of Geographic Areas such as DGPS files of Aerial Applications, if applicable
- Treatment records of Regulated Articles
- Regulatory activities
- Meeting notes
- Certification records

5

Manual Name

Control Procedures

Contents

Introduction

As control procedures are developed, they will be made available to the program. Any Federal participation in direct control programs will be at the discretion of the Agency concerned. If treatments selected or proposed are not in compliance with current pesticide labels, an emergency exemption will bee to be obtained under Section 18, or 24C, special local need (SLN) of FIFRA, as amended.

Eradication of a fruit fly infestation in the continental United States is often feasible and has been accomplished on numerous occasions. Improvements in methodology and ecologically friendly procedures have also helped spare the environment.

The following approved procedures available for use in most situations when a new pest has been detected. These procedures include biological, mechanical, and chemical controls. Local conditions will determine the most acceptable procedure or combination of procedures to achieve eradication, or failing that, suppression or control.

Recommended Pesticides

The treatments prescribed are predicated on an adequate survey. At the initiation of a program, an evaluation will be made of available insecticides for use on program operations.

Selection of Options

Program options may be selected through a decision-making process, such as embodied in the **Table 5-1**.

This decision table follows certain limited basic statements, and can be considered generally true in a biological sense, provided no other factors intervene. There are some underlying assumptions. For example, assume that the fruit fly in question will be able to survive in the same ecological and environmental circumstances as its host(s).

TABLE 5-1: Tephritidae Decision Table

<table>
<tr><th>If the finds are:</th><th>And the Pest Population appears to be:</th><th>And the Hosts are:</th><th>Then the Option is:</th></tr>
<tr><td rowspan="4">Established in a large, contiguous Area</td><td rowspan="2">In a marginal habitat</td><td>Limited and/or only in well defined areas</td><td>Control, Suppression and/or Eradication</td></tr>
<tr><td>Numerous and/or over an extensive area</td><td>Suppression, Cultural and Biological Controls</td></tr>
<tr><td rowspan="2">In a good habitat</td><td>Very limited and/or only in well defined areas</td><td>Control, Suppression, and/or Eradication</td></tr>
<tr><td>Numerous and/or over an extensive area</td><td rowspan="3">Biological and cultural controls</td></tr>
<tr><td rowspan="2">Present in a number of widely separate and discrete areas</td><td>Well established, as measured by: population estimate, competition, environment, and/or climatological considerations</td><td>→</td></tr>
<tr><td rowspan="3">Not well established and/or population estimates felt to be due to recent (within one year) establishment</td><td>Large number of hosts over an extensive area</td></tr>
<tr><td>Established in a small contiguous area</td><td>Moderate number of hosts over a well-defined area</td><td rowspan="2">Control, Suppression, and/or eradication</td></tr>
<tr><td>Present in only one or a few closely separate areas</td><td>Confined to a limited number of hosts and/or in a well-defined area</td></tr>
</table>

No Eradicative or Control Actions

Factors involved in arriving at a decision of “Biological and/or Cultural Controls only” include the following:

That the fruit fly species in question has firmly established itself in the the infested area and that;

1. No reasonable effort will be successful in eradicating it (vs. a reasonable effort may be successful);

or

2. Regulatory and/or suppressive measures will not be worth the cost, since the area involved and/or the rate of spread is too great (vs. affordable measures);

or

3. On the basis of measurable ecological factors, that the fruit fly will not be present in sufficient numbers in the environment to warrant control or suppression efforts (vs. a serious threat);

or

4. Control of the fruit fly is best left to normal means of control (such as host treatment) and other regulatory resources utilized to find ways to controlling the spread and effects of the pest (vs. an urgent need to augment natural controls).

If any of these statements are not true, then a decision to implement only Biological and Cultural controls should be carefully evaluated.

Approved Eradication/Suppression/Control Options

Various combinations of treatments to achieve a predetermined goal for a specific program may be for either eradication, suppression, or control. This goal, and the strategies useful for eradication, containment or control, will be determined by State, local and Federal personnel and/or their Scientific Advisory Committees or equivalent advisory boards, i.e., New Pest Advisory group.

The following table lists those triggers for known Tephritid species and the control options suggested as the minimum recommended response to the criteria. These triggers and options were taken from the various Action Plans designed by APHIS, with some additional species by CDFA.

Additional treatment options can be applied if mutually agreed upon by cooperating agencies. Eradication or control measures will continue for at least two target fruit fly generations. Trapping to verify that eradication or control has been accomplished will continue for three target fruit fly life cycles after the last fly find.

TABLE 5-2: Triggers for Known Tephritid Species

Fruit Fly Species	Triggers	Minimum Recommended Response
Anastrepha fraterculus[1]	1 unmated female	Treatment not required.
	1 mated female or 2 or more unmated females	Urban/residential Area ◆ Aerial or ground bait spray, soil treatment, fruit stripping. Commercial Area ◆ As above, plus aerial application of bait spray required; fruit stripping not required.
Anastrepha ludens[2]	One male	Treatment not required
	Two flies within 3 mi radius and within life cycle 1 mated female Larvae or pupaey	◆ Bait sprays by ground or air ◆ Sterile Release ◆ Soil Drenches ◆ Fruit Stripping ◆ Fumigation
Anastrepha suspensa[2]	One male	Treatment not required
	Two flies within 3 mi radius and within life cycle 1 mated female Larvae or pupaey	◆ Bait sprays by ground or air ◆ Sterile Release ◆ Soil Drenches ◆ Fruit Stripping ◆ Fumigation
Bactrocera cucurbitae[1]	1 adult male or 1 unmated adult female	Treatment not required
	1 mated female, a larval detection, a pupal detection or up to five adults i n area less than 7.4 sq. mi	In urban/residential area: ◆ Ground applied male annihilation (preferred) or cordelitos and soil treatment with addition of ground applied bait spray In commercial area: ◆ Add aerial applications of bait spray
	1 mated female, a larval detection, a pupal detection, or up to five adults or 5 detections of any combination in an area more than 7.4 sq. mi	In urban/residential area ◆ bait spray, ground application of male annihilation or cordelitos and soil treatment In commercial area ◆ Add aerial applications of bait spray.

TABLE 5-2: Triggers for Known Tephritid Species (continued)

Fruit Fly Species	Triggers	Minimum Recommended Response
Bactrocera dorsalis[1]	2 adult flies other than mated females within 3.5 mi radius and within 1 life cycle	Ground applied male annihilation treatments
	More than 5 adult flies or an unmated female and a male; or one mated female, larva, pupa; within 1 estimated life cycle or a single fly associated with a current eradication project	In urban/residential area: ◆ Male annihilation applications, soil treatment, and host stripping In commercial area: ◆ Add ground or aerial application of bait spray or Sterile Insect Release
Bactrocera latifrons[1]	2 or more adults within a 3 mi radius within 1 life cycle or 1 mated female, or larva or pupa or a single fly found associated with a current eradication project	◆ Ground applied Bait spray ◆ Aerial applied Bait spray ◆ Soil treatment ◆ Fruit stripping ◆ Plowing
Bactrocera tryoni[1]	2-4 Immature/unmated adults in area less than 1 sq. mile	◆ Ground-applied male annihilation ◆ Bait spray
	1 mated female, one larva, one pupa, or 5+ or more adults found in 169 sq. mile area in one life cycle in urban/residential area	◆ Ground-applied male annihilation ◆ Soil treatment ◆ Host stripping ◆ Ground application of bait spray
	As above, commercial area	As above, with aerial bait spray, SIT may be employed
Bactrocera zonata[1]	2 adult flies other than mated females within a 3-mi radius, within 1 life cycle	Ground applied male annihilation treatments
	5+ adult flies or an unmated female + male within an area less than 1 mi2 within 1 life cycle or 1 mated female, or larva, or pupa or a single adult fly associated with a current eradication project	In urban/residential area: ◆ Male annihilation applications, soil treatment, and fruit stripping In commercial area: ◆ Add ground or aerial application of bait spray or Sterile Insect Release

TABLE 5-2: Triggers for Known Tephritid Species (continued)

Fruit Fly Species	Triggers	Minimum Recommended Response
Ceratitis capitata[1]	1 adult male or unmated female	Intensified Trapping and fruit cutting of highly preferred hosts.
	unmated female or 2 adult males within 1 life cycle in an area of less than 5 mi^2	In urban/residential areas: ◆ Ground bait spray, soil treatment, fruit stripping ◆ Optional: Aerial bait spray, SIT or bisexual annihilation In commercial areas: ◆ Ground bait spray, soil treatment ◆ Optional: Fruit stripping, aerial bait spray, SIT, bisexual annihilation *Pesticide applications in core area mandatory
Ceratitis capitata[1]	1 mated female or one larva or pupa or more than two males within 1 life cycle in an area of less than 5 sq. mi^2	In urban/residential areas: ◆ Ground bait spray, soil treatment, aerial bait spray Optional: SIT or bisexual annihilation * Pesticide application in core mandatory In commercial areas: ◆ Ground bait spray, soil treatment, aerial bait spray ◆ Optional: fruit stripping
Rhagoletus cerasi[1]	1 adult male or unmated female	Treatment not required
	Mated female, numerous flies. immature stages	In urban/residential areas ◆ Aerial or ground application of bait, soil treatment and fruit stripping In commercial areas: ◆ Aerial bait applications, ground bait applications, soil Treatment, and destruction and removal of honeysuckle hosts only.

1 Sources: APHIS

2 Sources: CDFA

Approved Treatments

The following is a list of suggested treatments that may be applicable under certain conditions. The treatments selected will be determined by State and local personnel concerned with a given program and their Scientific Advisory Committees or equivalent Advisory Boards. Addendum F lists certain additional treatments which may be available.

Biological and cultural controls should play as large a role in program efforts as possible. It is worth noting that mortality of larvae in high populations due to parasitization or predation may be high. This effect can be enhanced or augmented with other available means such as biopesticides, mating disruption or mass trapping, utilizing strategies such as listed below and in Appendix F.

NOTICE

For fruit flies, augmentation of natural enemies has been tried only in a few cases.

Insecticides

Information on the available insecticides are given in Tables A through F in Appendix F. These tables, and those that follow, are designed to allow comparisons between different fruit fly species. This arrangement should facilitate decision-making and help in the selection of the best combination of available or known tools.

Biological Insecticides

Table F-1 in Appendix F charts the use of microorganisms against the Tephritidae. These include the following categories:

Bacteria—Ground Applied Proteinaceous Bait Spray with metabolites of Saccharopolyspora spinosa is currently the only practical biological insecticide application for fruit flies.

Application of protein bait spray should be initiated as soon as an eradication or control project is began. All host plants or trees of the target fruit fly within 400 yards (yd.) of the detection site will be sprayed at the prescribed intervals. Ground spraying may be discontinued after an estimated two generations of negative trapping or after the initiation of aerial bait spray treatments. See **Appendix F** for further details.

- Viruses
- Protozoa
- Nematodes
- Fungi

Chemical Insecticides

Insect Growth Regulators/Juvenile Hormones—Insect Growth Regulators (IGR) and Juvenile Hormones (JH) have sometimes been successfully employed to combat insect pests. This has not yet been employed for fruit flies.

Table B in Appendix F is reserved for Insect Growth Regulators and Juvenile Hormones.

Plant Extracts

Plant extracts have also been successfully used in some cases against a variety of insect pests. There has been very little research in this area for the Tephritidae.

Table F-4 in Appendix F lists efforts to date.

Chemical Control

Pure chemical control has not been carried out for the control of fruit flies for many years for environmental and health reasons. The procedure has been replaced by other, much more ecologically friendly techniques.

Behavioral Manipulation

The use of pheromone sprays, large numbers of traps, bait spots, or cordelitoes dropped from the air or tied to hosts (or any support) has been applied against the Tephritidae at various times. Table C in Addendum F gives those known pheromones in mating disruption programs for the Tephritidae, with such details as are known.

Ground Applied Proteinaceous Bait Spray

Application of protein bait spray should be initiated as soon as an eradication or control project is began. All host plants or trees of the target fruit fly within 400 yards (yd.) of the detection site will be sprayed at the prescribed intervals. Ground spraying may be discontinued after an estimated two generations of negative trapping or after the initiation of aerial bait spray treatments. See Appendix F.4.b.(1) for further details.

Aerial Proteinaceous Bait Spray

Full coverage bait spray should be applied on a 7 to 10 day schedule. The area of full coverage bait spray will extend a minimum of 1–1/2 sq. mi beyond any known fly detection. Spray operations may be discontinued after an estimated two generations of negative trapping. See **Appendix F** for further details.

Soil Treatment

Treatment applied to the soil under host plants within 200 yards of infested properties to interdict and destroy any larvae and/or pupae of the target fruit fly that may exist or enter the soil there. The applications must be tailored made for the species involved, but normally an interval of two weeks is necessary between applications on an indefinite basis until eradication is declared or the program ends. Weather cold enough to stop the accumulation of Day Degrees also mean the applications may stop. See **Appendix F** for further details.

Toxic Male Lure Bait

The application of a lure combined with an insecticide to attract and kill the male of the target fruit fly. This requires the field placement of many bait spots, up to 1.5 miles beyond any known target fruit fly detection, with a frequency dependent on the lure used and the response of the male to the lure. See **Appendix F** for further details.

Bisexual Annihilation

The destruction of both males and females through the application of food bait and/or a pheromone to lure them within range of a trap or device equipped with either a glue or an insecticide. See **Appendix F** for further details.

Foliage Baiting

The application of a male bait lure to the leaves of a host to attract and kill the male of the target fruit fly with an insecticide, up to 1.5 miles beyond any known target fruit fly detection. See **Appendix F** for further details.

Cordelitos

The application of a cord of cotton soaked in a male lure bait to a host, either loose or tied loosely to the host or scattered loosely in an area up to 1.5 miles beyond any known target fruit fly detection. See **Appendix F** for details.

Blocking

The application of blocks of Caneite material, either nailed or fastened to a host or scattered over an area up to 1.5 miles beyond any known target fruit fly detection. See **Appendix F** for details.

Biological Control

Most of the following items are covered in a separate document, *Natural enemies of True Fruit Flies* (NETFF).

Introduction of Exotic Natural Enemies

This technique is carried out by USDA, ARS and other agencies and institutions. APHIS, PPQ is active in implementing classical biological control. The objective is to find and establish exotic natural enemies to help suppress the target pest.

Possible parasites and/or predators, Microorganisms and Microbial toxins, whose efficacy would need to be tested against a target fruit fly are listed in the NETFF, in Tables 1 and 2, by host.

Conservation of Parasites/ Predators

This treatment refers to the conservation of natural enemies, native or introduced, through integrated procedures with highly selective predator/parasite friendly insecticides or techniques, biological insecticides, and cultural practices favoring predators and parasites.

Details covering several conservational techniques are given in the NETFF, under Conservation (and see 5 this section under Other Control Options).

Augmentation of Predators/ Parasites in Infested Area(s)

This technique is applied by mass raring of efficient parasites or predators for mass release in infected areas. The use of Beneficial Insect Planes (BIP), a type of model airplane controlled by radio, may be utilized to release parasites with less mortality than with conventional airplanes. Such craft can cover a 50 acre area in 6-7 minutes (Anon., 1993).

This approach has been used successfully in some instances. See NETFF under Augmentation and Table 3‘.

Enablement of Parasites/ Predators

This treatment refers to augmenting the ability of predators and parasites to attack the host with greater efficiency or to be more tolerant of insecticides or other practices through selective breeding of the most efficient predators and parasites. Gene manipulation may also be involved (Hoy, 1990a, 1990b; Caprio, et al., 1991).

Autocidal Control Options

Sterile Insect Technique (SIT)

SIT involves the release of large numbers of sterilized males. This technique has proved very successful against a number of serious fruit fly species. The downside to this option is that a rearing and irradiation facility has to be available to produce sterilized pupae in the numbers needed to make the program a success and the infrastructure on site to disseminate the pupae by several means throughout the infected area, as well as an identification process to sort out wild flies from sterile flies so that progress can be measured in terms of reduction of the wild population.

Details covering SIT programs are given in Addendum F.5.

Genetic Manipulation

The genetic manipulation of several species of fruit flies has been attempted on the experimental level. Medfly, *Ceratitis Capitata,* has been successfully tested with a transposable element from the Cabbage looper, *Trichoplusiani.* This makes it possible to have Medfly with colored eyes. Effective gene transfer systems would enable the creation of strains allowing genetic sexing and male sterilization and their use in sterile release programs without having to irradiate the pupae (Handler, et al., 1998).

Other Control Options

The following options, which include Environmental, Cultural, and Physical Control measures, are meant to enhance any efforts at control. Because some of these are more general biological control measures they appear here as well as in NETFF.

Predation

Natural predation, aside from micro-organisms, consists of birds, small animals and various invertebrates. While such predation is unlikely to influence outbreak populations of a fruit fly, there is accumulating evidence that birds, ants, small mammals and other generalist predators are very important in suppressing Tephritid populations when the latter are already scarce.

Bird Predation—Should it develop that a resident bird population will effectively reduce the numbers of a targeted pest, then the bird population in question should be disturbed as little as possible. If it is felt desirable, the birds can be encouraged to increase in numbers through provision of food during winter months, the protection of nesting sites, and the discouragement of various bird predators or possibly, control of diseases.

Small Mammal Predation—Small mammals frequently prey on late instars and pupae and can remove large proportions of these individuals from a population. Pupae at or near the ground tend to suffer greater losses.

Small mammals which are known or observed to feed on fruit fly life stages can be protected by not destroying their habitat or reducing their numbers through hunting. See Addendum F.5.c.

Insect Predation—There is apparently an inverse relationship between vertebrate and invertebrate predation levels. Pupal predation by vertebrates increases as small mammal density increases, but invertebrate predation decreases (Cook, et al., 1995).

See Thomas (1995), who stated that ants, rove beetles, and spiders were found to prey on Mexican fruit fly larvae which have left the host fruit and have not reached the shelter of a pupariation site. The predation rate was estimated to be 1-5%. Honey ants were recorded as being incidental predators. Rove beetles were deliberate predators during summer months.

However, pupae and emerging adults were subject to attack by salticid spiders, an insectivorous ant, *Pheidole* sp. and especially exotic fire ants, *Solenopsis invicta*, which were effective predators. Approximately 29.5% of the fruit fly population was destroyed (70.5% survival). This factor was most effective in the summer.

Ants may attack fruit fly last instar larvae on the ground as the latter look for a place to pupate. Ant numbers may be increased by spraying hosts with sucrose; by encouraging benign (to hosts), host dwelling honey-dew producing aphids; by providing food for ants during fruit fly off season periods, or even by transporting ant nests into an area on a small scale (Weseloh, 1994).

Similar results are known for other species of fruit fly. Ants (unspecified spp.) are responsible for 10% of the mortality of the soil-inhabiting stages of *Bactrocera tryoni* in Australia (Bateman, 1968). In Hawaii, *Pheidole megacephala* attacks *Bactrocera dorsalis* larvae in fallen fruit, causing 36% mortality (Newell and Haramoto, 1968).

The interaction of ant species and prey may be summarized by stating that ant species occurring in an area are important agents in the regulation of pests and the rate of control varies spatially (ground, bush, tree) and temporally (winter, spring, summer, fall) within that area, depending on which species of ant is dominant. The dominance pattern is typically a mosaic of territories, as ant colonies partition the area in accordance with habitat requirements and competitive abilities (generalized from Thomas, 1995). Ant colonies may be encouraged in commercial areas by as little use of insecticides as is possible and covering the soil in a grass sward (Bateman, 1968).

Spiders are another group of generalist predators that often consume the most abundant and most easily captured prey in their habitat.

Encouragement of spider populations at present consist of not disturbing them; or of observing which species may feed on the larvae and bringing in more of these spiders from elsewhere to feed on the target fruit flies.

Patch Complex —A variation of the above, involves the employment of patch complexes, in which a number of areas are set up inside the entire control area to promote certain ecological situations advantageous for control within the economic constraints of a program. Inside the patch (or area), a complex of increased natural diversity is encouraged. Methods include the introduction of understory trees or bushes to increase the provision of nesting sites for birds, the encouragement/ introduction of ant colonies, and so forth.

Host Plant Resistance—The modification or transformation of selected hosts to reduce larval feeding, including host destruction.

- Breeding and Hybridization

  These older methods require time to develop and are difficult to apply in practice over whole ecosystems.

- Transgenetic Engineering

  This area is receiving some attention. Hybrid plants with an engineered gene such as a Bacillis thuringiensis d-Endotoxin Gene may provide some protection.

Cultural Control

Host Destruction—In situations with a very limited infested area or extreme environmental sensitivity and when the hosts are all herbaceous, vinelike and/or decumbent, consideration may be given to host destruction. See also **Appendix F**.

Sanitation—Sanitation in nurseries, farms, gardens, and other establishments where hosts are present will be carried out within the core and buffer areas. See also **Appendix F**.

Host Cleaning—It may be advisable to clear the undergrowth from hosts. See **Appendix F**.

Bagging—Of use where the numbers of hosts are limited and where the fruit can easily be bagged. See **Appendix F**.

Plowing—Plowing fields of annual or perennial hosts within 200 yd. of a confirmed larval find may be able to destroy any life stages present in the soil. See **Appendix F**.

Pruning—With few hosts or a small area, pruning to make fruiting hosts unavailable to the pest may be an option. See **Appendix F**.

Interruption of Cropping—In a small area or with only a few cultivated hosts, crops need not be grown for a determined period of time. See **Appendix F**.

Small Mammal Preservation—Schedule certain activities to prevent displacing the small mammals which may feed on life stages of the target pest. See **Appendix F**.

Genetic Resistance—Certain hosts may be grown with genetic Resistance to infestation to the target pest. See **Appendix F**.

Vehicle/Outdoor Inspection

Vehicles, trucks, wagons and containers with host material or used in host fields, stands, orchards, etc., within the regulated area, must be inspected to ensure that accidental movement of life stages does not occur.

Orientation of Eradication/Control Personnel

Only trained and experienced personnel will be utilized initially. Replacement personnel will be trained by the individual being replaced.

Eradication/Control Records

Records noting the locations, dates, number, treatments, and Control formulations used will be maintained for all treated areas.

Monitoring

An effective monitoring program should be implemented to aid in the evaluation of program efforts and environmental impact. The application of pesticides will be assessed through the use of appropriate monitoring program criteria. The evaluation must effectively address Agency, Cooperator, and public concerns. Special techniques for monitoring the effect of insecticides on any forest fauna will likely be applicable.

The monitoring plan should include at least the following elements:

1. Determine the efficacy of any pesticide used against the target pest.
2. Monitor aerial applications, using dye cards to determine;
   - **A.** Droplet size
   - **B.** Droplet distribution
   - **C.** Identification of drift components
   - **D.** Verification of spray block boundaries
   - **E.** Identification of skips
3. Sampling to evaluate the effect of a tephritid program on the environment will be conducted in accordance with an Environmental Monitoring Plan. Samples in pre and post application sampling and observations will help determine the impact on soil, waster, vegetation, and non-target species. Carcass searches are a part of this monitoring.

6

Manual Name

Contacts

Introduction

When a fruit fly program is implemented, its success will depend on the cooperation, assistance, and understanding of many involved groups. The following groups should be continually informed of all operational phases of an emergency program.

- Other Federal, state, county, and municipal agricultural officials
- Grower groups
- Commercial interests
- Universities
- State and local law enforcement officials
- Public health
- Environmental groups
- State natural heritage programs
- Foreign agricultural interests
- National, State, and local news media
- The general public

7

Manual Name

Pathway Evaluation

Contents

Natural Means

In general, although many species are strong fliers, fruit flies do not qualify as long range migrants, as competition, predation, and parasitism all play a role, as does the availability of hosts. Barriers, such as bodies of water or mountains and deserts seem to be important factors.

Adult Dispersal

However, adults are highly mobile and some species can move considerable distances up to more than three miles in a day, and up to 40 miles in two weeks. Such movement is usually dictated by the comparative lack of food, but in some species may be dictated by an obligatory migratory phrase of up to 38 miles in spite of sufficient resources nearby.

Prevailing winds seem not to be a factor, but the presence of host is a strong influence.

Larval Dispersal

Natural spread by larvae is limited to the host, the ground beneath the canopy, and fallen fruit which may roll away from the source, unless picked up and carried. The larvae cannot move any distance by themselves, except, when leaving the fruit, to search within a limited range to pupate, usually within suitable soil.

Travel and Commerce

The greatest danger from fruit flies lies in the transport of infested fruit with eggs or larvae over long distances.

In years past, shipping was the primary means of travel between distant ports. Travel by ship has been particularly effective for spread of various fruit flies, especially since the end of the 19th century when powered ships could travel 350 miles per day (WWW.carambolafly, 2000). a

On land, the stagecoach and car, bus or train meant that persons carrying personal belongings, including fruit for the trip or even to plant at the end of their journey could go many miles, and the eggs and larvae in the fruit got a free ride. These means of travel were, however, time consuming and it could take still take days or weeks of travel.

The advent of air travel in the 20th century, meant that infested fruit can arrive in a country via a shipment of fruit, or more seriously, in uncontrolled passenger luggage, within days at the most. This has resulted in numerous invasions of fruit flies in many countries.

For this reason, fruit flies rank as a serious and very important invasive group of plant pests. The situation has resulted in the imposition of various quarantines throughout the world with consequent limitations on world trade and personal movement of fruit.

Invasion

Carey (1991, 1993) has divided the invasion process of Tephritid fruit flies into four different steps or phases.

1. Introduction

A Fruit fly introduction is the first phase of an invasion and consists of the arrival of one or more live individuals from a source region through an introductory process. The introduction must consist of either a mated, fertile female or at least one individual of each sex for it to be potentially viable. However, a minimally viable introduction usually consists of at least a dozen or more individuals (Soule, 1987).

The fact of arrival itself, however, does not necessarily constitute invasion because the individual(s) arriving can die without reproducing, thus ending the invasion process at that particular time and place.

There are many factors that influence the successful completion of the first stage of invasion. The most immediate of these factors are climatic constraints on the ability of the fruit fly to survive: temperature, humidity, intensity and length of daylight, and perhaps others. Biotic factors include the ability to find suitable food to sustain survival through any life stages or maturity processes to and through reproduction.

At the next level of organization are population-level concerns. Examples of these include: the size of the initial introduction, the timing of the introduction, the availability of resources needed for reproduction such as nesting sites, hosts, breeding sites, etc.

The advantages held by new populations, once the conditions above are met, however, are powerful. As is often the case, if the fruit fly arrives without its own host of biotic mortality factors, a new territory offers freedom from these natural enemies, competitors, and diseases that keep populations down in its native areas. With some readjustment in physiology or behavior or both, the fruit fly can find itself in an environment of limitless resources.

2. Successful Reproduction Or Colonization

The second step in the invasion process involves successful reproduction or colonization. Once the introduced individuals complete one reproductive cycle, the process of invasion can be said to be in the colonization phase. A colony is a small group of interbreeding individuals over a contiguous and circumscribed area and represents the basic unit of expansion.

3. Secondary Colonization

Secondary colonization (Phase III) occurs when a small number of colonies are created from a parent colony. These secondary colonizations are similar to phase I with the exceptions that distances involved are usually smaller and the individuals may have become acclimatized or naturalized to local conditions.

4. Establishment

Establishment is the final (Phase IV) step. It can be said to occur when the secondary colonies expand and create their own new colonies. A newly established population consists of a large number of well-entrenched colonies which may or may not be permanently established.

Extinction

With each step in the invasion process, the likelihood of extinction decreases. (WWW.carambolafly, 2000)

A

Manual Name

Appendix A

Definitions

Aerial Proteinaceous Bait Treatment — Applying a chemical or biological insecticide and a protein hydrolysate bait by aircraft over a treatment area.

Aerial Sterile Release — Releasing sterile Target Fruit Flies over a designated area.

Aerial Release Area — The core area and all peripheral areas a designated distance beyond the nearest known infestation, or to a suitable natural barrier within the designated peripheral area.

Array — The trapping pattern (array) in the delimiting survey area located around a detection.

Array Sequence — The intensity of traps within an array, beginning with the core area and continuing outward through each buffer area, ending with the outer buffer area.

Attractant (Lure) — An attractive bait to attract either male or female or both to a trap.

Autocidal Control — Self-destroying. The use of sterilized males (and/or females) of a pest species to eradicate or otherwise reduce a population of a species through swamping the wild population with sterile individuals, usually at ratios of ten steriles to one wild, as measured roughly by monitoring traps.

Augmentation — The intentional addition of natural enemies by mass release in areas where these enemies are absent, occur too late in the season or pest life cycle, or are in ineffective numbers.

Bait — An attractant and food source mixed with an insecticide for treating fruit fly infestations.

Behavioral Manipulation — The employment of pheromones, parapheromones, and/or food baits to reduce or eliminate a pest population through the use of chemicals which control behavior and another agent (chemical or biological) to kill or infect attracted individuals.

Biological Control — The development and use of natural means of control through parasites, predators, pathogens and biological tactics to suppress a pest population density below a level that would not occur in their absence, either for a given period of time, or permanently.

Biological Tactics — The use of any natural or derived product or technique utilizing biological applications such as gene transfer, genetic manipulation, pheromone attractants, host substitution or other biological tactics to suppress a pest population density below a level that would not occur in their absence, either for a given period of time, or permanently.

Biometric Survey — A survey on an organism which combines valid statistical procedures with known biological information. For the Tephritidae, APHIS uses statistics and biological information on ecology and life cycle characteristics to develop surveys to determine the presence or absence of a fruit fly and/or damage caused by the fruit fly.

Bisexual Annihilation — An eradication procedure that is designed to kill both male and female adults of the Target Fruit Fly species through intensive trapping at very high density.

Buffer Area — The area extending a prescribed distance beyond the boundary of the core, those buffers given for the target fruit fly in question, designated as 1-, 2-, 3- 4-, 5-, or 6- mi buffers, depending on the species of fruit fly and the drawing power of the associated attractant(s).

Cultural Control — The use of natural, non-chemical means of reducing a pest population by means of eliminating or denying those things that support that population, i.e., hosts or parts of hosts and/or direct mechanical destruction of a susceptible life stage

Chemical Integration — The direct application of selected chemicals to the host which are nontoxic or relatively nontoxic to selected parasites or predators.

Classical Biological Control — The introduction of exotic natural enemies from the region of origin to provide a permanent, self-sustaining suppression of a pest population density below a level that would not occur in their absence.

Cold Treatment — The use of cold temperatures as a treatment on selected products, alone or in conjunction with fumigation procedures

Commercial Production Area — An area where host material is grown for wholesale or retail markets.

Confirmed Detection — A positive laboratory identification of a submitted life form (specimen) as an exotic fruit fly.

Core Area — The area determined to be the core area for the Target Fruit Fly species, that encompasses the confirmed detection and where all elements of a detection, survey, regulatory, and control program are carried out.

Core Area (Regulatory) — The area in the CFR for the purpose of determining where treatments may be conducted.

Cultural Control — The intentional use of simple practices or mechanical measures which may be available to control a pest population.

Day Degrees — An accumulation of heat units above a specified developmental temperature threshold during a life stage.

Delimiting Survey — Determining whether an infestation exists and if so, the extent of the infestation in an area where the target fruit fly has been detected.

Detection — The collection of any life stage of the Target Fruit Fly.

Detection Survey — An activity to determine the presence of the target fruit fly, conducted in a susceptible area not known to be infested.

Developmental Threshold — The minimum (or maximum) temperature below (or above) which physiological development stops (peaks).

Diapause — An obligatory arrestment of development in any of the immature stages, depending on the species involved.

Enablement — To enhance the ability of predators and/or parasites to attack a host with greater efficiency or to be more tolerant of insecticides or other control practices through selective breeding and/or gene manipulation.

Epicenter/Focal Point — The initial site of an infestation.

Eradication — The confirmed removal of all target fruit fly life forms in a specified geographical area, as determined by a negative survey for the equivalent of three life cycles.

Exotic Fruit Fly — A species of fruit fly not native to or nonindigenous in a area. In this Guidelines, a non-native fruit fly of the family Tephritidae.

Fruit Collection Survey — The collection of fruit to determine the extent and nature of an infestation.

Fruit Cutting Survey — Cutting fruit and examining for larvae.

Fruit Stripping — The removal and proper disposal of all host fruit of the Target Fruit Fly from a designated area.

Fumigation — The application of an approved fumigant (ethylene dibromide, Methyl Bromide, Phostoxin(R)) as a treatment alone or in conjunction with cold treatment procedures.

Generation (Life Cycle) — The period of time required for the pest to complete all stages of development predicted on day degrees or on the basis of other biological information.

Ground Proteinaceous Bait Spray — Using ground equipment to spray host vegetation in a target fruit fly infested area with an insecticide or biological insecticide and a protein hydrolysate bait.

Host — A plant species capable of supporting target fruit fly reproduction.

Host Collection/ Holding	The gathering of host material and its containment in a secure facility to determine the extent and nature of an infestation.
Host Cutting Survey	A survey conducted in the core and buffer areas by cutting fruit and examining for larvae.
Host Stripping	The removal and proper disposal of all host fruit of the target fruit fly from a designated area.
Infestation	The collection of a larva, pupa, mated female, or two or more target fruit fly adults within on estimated life cycle and within a determined radius for that specific target fruit fly, or the detection of a single adult determined to be associated with current infestation -- Generally, any evidence of a reproductive population.
Infested Area	A distance of 1 1/2 to 4 1/2 miles from all detection sites depending on the target fruit fly species involved, unless biological factors indicate the need for more or less area -- Generally, an area where a reproducing population exists.
Inoculative Augmentation	Flooding a chosen area with large numbers of one or more natural enemies at the time a pest occurs or is expected to occur in an area, with the intention of having established populations of these enemies through subsequent generations for pest control.
Inundated Augmentation	Flooding a chosen area with large numbers of one or more natural enemies to exert rapid control of a pest in the present generation in order to prevent or decrease possible damaging host losses.
Lure	The synthetic food and/or sex lure used to attract the male and/or the female of the Target Fruit Fly
Male Annihilation Procedure	An eradication procedure that is designed to kill the adult Target Fruit Fly male. Bait spots or traps which consist of a male lure, thickening agent, and an insecticide are ground applied.
Monitoring/ Evaluation Survey	Using interdependent visual and trapping surveys in an area where a biological or chemical treatment is in progress to evaluate the effectiveness of the application.
Parapheromone	An attractant for either the male or female of a fruit fly species, that is not a natural sex attractant.
Parasite/ Predator Conservation	The conservation of natural enemies through integrated procedures, highly selective predator/parasite friendly insecticides or techniques, biological insecticides, or cultural practices favoring parasites/predators.
Pheromone	A natural sex attractant, a chemical substance, usually a glandular secretion, which is use in communication within a species, such that one individual releases the material as a signal and another responds after sensing it.

PPQ-APHIS-USDA Plant Protection and Quarantine, Animal and Plant Health Inspection Service, U. S. Department of Agriculture.

Regulated Area An area that extends at least 3 to 6.5 miles in all directions from an infected property, depending on the target fruit fly species.

Regulated Articles All known or suspected hosts of the target fruit fly, also cannery waste, soil under host, and any other suspected product or article which present a high risk for the artificial movement of a target fruit fly species (as listed in the CFR or EAN).

Regulatory Survey Trapping conducted around establishments where regulated articles are sold, handled, processed, or moved.

Roving Sterile Release The release of sterile fruit flies of the Target Fruit Fly species in an area from a motor vehicle.

Sex Pheromone A pheromone which will attract the male (or female) of a given fruit fly.

Soil Screening The passing of soil through a screen for the detection of pupae.

Soil Treatment The application of an approved insecticide to the soil of nursery stock and/or within the drip line of host plants.

Static Release Placing Pupae of the Target Fruit Fly species in protective stations for emergence of sterile fruit flies of that species.

Sterile Release Releasing sterile adults of the Target Fruit Fly in an area as a method of eradication or control or as one of several methods in an integrated eradication or control program.

Tephritidae The Scientific name for the family of true fruit flies. Specific genera and species are given in the text.

Trap Array The trapping pattern in a designated 1-mi^2 area.

Ultralow-Volume Bait Spray A mixture of small amounts of an insecticide with protein hydrolysate. This mixture is applied as droplets by aircraft, using 2.4 oz. ai malathion and 9.6 oz. of protein hydrolysate per acre.

Urban/ Residential Area An area containing multiple- or single-family dwellings, and /or commercial and industrial facilities.

Vapor Heat Treatment The use of heated air saturated with water vapor to raise the temperature of the commodity to a required point

Visual Survey Examining fruit for signs of fruit fly damage, life stages during fruit cutting and collecting surveys.

B

Manual Name

Appendix B

Safety

General Information

Personnel and public safety must be a prime consideration at all times. Safety practices should be stressed in preprogram planning. Supervisors must enforce on-the-job safety procedures.

Pesticides authorized for use vary in toxicity. When used in accordance with label instructions, materials do not constitute a threat to people, wildlife, bees, etc. Specific safety precautions for each pesticide are listed on the label. In addition, any special precautions listed in this or specific manuals shall be observed.

Keep pesticides in closed, properly labeled containers in a dry place. Store them where will not contaminate food, feed, or bait and where children and animals cannot reach them.

When handling a pesticide, follow all precautionary labeling.

Should there be contact through spillage or otherwise, wash immediately with soap and water. Should clothing become contaminated, launder before wearing again or destroy if necessary. If a pesticide has spilled into the environment and may create a hazard, then appropriate emergency and cleanup procedures must be instituted. The Assistant Regional Director and the National Monitoring Coordinator must be notified of all pesticide incidents. Refer to the PPQ Treatment Manual for additional information.

Empty pesticide containers should be disposed of in an approved sanitary landfill, by incinerator, or by other satisfactory methods approved by the Federal Environmental Protection Agency, whereby they will not present a hazard or problem. Arrangements for disposal if such containers should be completed and thoroughly understood by all parties directly involved with a program prior to the actual start of operations. PPQ Regional Offices and the National Monitoring Coordinator should be consulted for pertinent information in States where operations are conducted.

When applying a pesticide, consider the potential impact of the pesticide on all components of the total environment, including humans, crops, livestock, wildlife, aquatic life, nontarget insect species, and domesticated honey bees. Avoid contamination of lakes streams, ponds, or watersheds.

Ultraviolet Light

In instances where employees are exposed to ultraviolet light while sorting dye marked sterile flies from wild flies, the following applies:

- Wear UV protective goggles/eyeshields when the UV lights are in use. Assign protective equipment individually.
- Cover exposed skin surfaces that receive an irradiance greater that 1 mW/cm^2. This primarily refers to the skin of the hands and forearms.
- Increase background visible light in the room to reduce eye strain during evaluations.
- Consider exposure of photosensitive individuals or individuals on medications which induce photosensitivity on a case by case basis after consultation with the employee's personal physician.
- PPQ management should be aware of any improvements in fly marking which would reduce or eliminate the need for UV marking.

First Aid Suggestions

In case of accidental poisoning or as soon as any person shows symptoms of having been affected by any pesticide, do the following:

1. Remove the person to a place where there will be no further contact with the pesticide.
2. Have the person lie down and keep quiet.
3. Call a physician and provide the name and formulation of the pesticide in use and for aid given.
4. Call Chemtrex on toll free Area Code (800 424-9300) for additional assistance in the event of spills, leaks, fires, exposures, accidents, or other chemical emergencies.

Keep the local Poison Control Center telephone number posted where pesticides are stored and used. The number may also be found on the inside front cover of the telephone directory.

Managing/Monitoring Pesticide Spills

Supervisors involved in pesticide applications must have available and be familiar with *Guidelines for Managing and Monitoring Pesticide Spills*, dated March 1981. In addition, the following pesticide spill safety and cleanup equipment must be present at all job sites where pesticides are stored or used.

Safety Equipment

- First Aid Kit—Bus and Truck Kit, GSA 66545-00-644-5312 (or equivalent
- Fire Extinguisher—5lb. size for Class A, B, C fires
- Portable Eye Wash Kit

Cleanup Equipment

- Shovel, Square-point, “D” handle
- Large heavy duty plastic bags with ties (23)
- Rubber boots (2 pairs)
- Disposable coveralls (4 pairs)
- 5 gallons of water
- Rubber gloves (4 pairs)
- Respirators and pesticide cartridges (2 sets)
- Broom
- Dust pan
- Liquid detergent (1 pint bottle)/paper towels
- Scrub brushes (2)
- Plastic cover or tarpaulin to cover dry spills (10’ x 12’)
- Absorbent material to absorb liquid spills (sand, sawdust, vermiculite, “Kitty Litter,” etc.)
- Portable light source

C

Manual Name

Appendix C

Hosts

Introduction

This host list is only intended as a guide to known hosts. It is as complete as a reasonable search of the literature could be within a given timetable. Changes in what are presumed to be known hosts and the discovery of previously unknown Tephritid species and hosts make it necessary to use this list with care. The latest information on any Tephritid pest under consideration for a program must be used at the time of that program.

Hosts are listed in alphabetical order by Scientific Name. For some species with very long host lists, a short program list of useful commercial hosts is given instead, and references provided for publicly available host lists of the known economic Tephritid species. For the most part, the hosts given here are from White & Elson-Harris, 1992 and Drew & Hancock, 1994. Any additional hosts are cited by source.

Host List

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
Anastrepha antunesi	*Doryvalis hebecarpa*	Ketembilla
	Genipa americana	Maramalade-box
	Manikara zapota	Sapodilla
	Spondias mombin	Hog-plum
	Spondias purpurea	Red mombin
Anastrepha bistrigata	*Psidium guajava*	Common guava
	Psidium guineense	Brazilian guava
Anastrepha carambolae	*Anacardium occidenatale*	Cashew
	Arenga pinnata	Sugar plum
	Artocarpus altilis	Breadfruit
	Artocarpus elasticus	
	Artocarpus heterophyllus	Jackfruit
	Averrhoa carambola	carambola
	Averrhoa bilimbi	Bilimbi
	Baccaurea motleyana	Rambai
	Capsicum, annum	chilli pepper
damaged fruit only	*Chrsyophyllum cainito*	Star-apple

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
Probably only damaged fruit	*Citrus x paradisi*	Grapefruit
Probably only damaged fruit	*Citrus reticulata*	Tangerine
Probably only damaged fruit	*Citrus sinensis*	Sweet Orange
	Eugenia uniflora	Surinam cherry
	Lycopersicon esculentum	Tomato
	Malpighia glabra	Huesito
	Mangifera indica	Mango
	Manikara zapota	Sapodilla
	Musax paradisiaca	Banana
	Psidium guajava	Common guava
	Solanum ferox	
	Syzygium aqueum	Waterly rose-apple
	Syzygium jambos	Rose-apple
	Syzygium malaccense	Malay-apple
	Terminalia catappa	Tropical almond
	Ziziphus jujube	Common jujube
	Lepisanthes fruticosa	Luna nut
	Wild Hosts	
	This species has been recorded from wild species of the following host families:	
	Clusiaceae	Euphorbiaceae
	Meliaceae	Moraceae
	Myrtaceae	Olacaceae
	Rhizophoraceae	Rutaceae
	Symplocaceae	
Anastrepha distincta	# from Oakley, 1950.	
	Chrysophyllum cainito	Star-apple
	Eugenia nesiotica	—
	Inga edulis	Ice cream bean
	# *Inga feuilei*	—
	# *Inga goldmanii*	—
	# *Inga hayesii*	—
	Inga inicuil	—
	Inga laurina	Caspirol
	# *Inga lushnathiana*	—
	# *Inga panamensis*	—
	Inga paterna	Paterna
	# *Inga punctata*	—
	# *Inga setifera*	—
	# *Inga spuria*	—

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Inga spp.	
	Mangifera indica	Mango
Anastrepha fraterculus	Commercial Hosts	
	* Eskafi & Cunningham, 1987	
	+(Uchoa-Fernandes, 2002)	
	Anacardium occidentale	Cashew
	Annona cherimola	Cherimoya
	Annona muricata	Soursop
	Annona squamosa	Sugar-apple
	Averrhoa carambola	Carambola
	Citrus aurantium	Sour Orange
	Citrus limetta	Sweet lime
	Citrus maxima	Pummelo
	Citrus medica	Citron
	Citrus x paradisi	Grapefruit
	Citrus reticulata	Tangerine
	Citrus sinensis	Sweet orange
	Coffea arabica	Arabica coffee
	Coffea liberica	Liberica coffee
	Cydonia oblonga	Quince
	Diospyros kaki	Japanese persimmon
	Dovyalis hebecarpa	Ketembilla
	Eriobotrya japonica	Loquat
	Eugenia brasiliensis	Brazil cherry
	Eugenia uniflora	Surinam cherry
	Feijoa sellowiana	Feijoa
	Ficus carica	Common fig
	Fortunellal japonica	Round kumquat
	Fragaria vesca	Strawberry
	Inga edulis	Ice cream bean
	**Inga micheliana*	Cushin
	**Inga paterna*	Paterna
	Jugans neotropica	Andrean walnut
	Juglans regia	English walnut
	Malus domestica	Apple
	Mangifera indica	Mango
	Manikara zapota	Sapodilla
	Persea americana	Avocado
	Pouteria obovata	Lucmo

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Prunus armeniaca	Apricot
	**Prunus capuli*	Capulin cherry
	Prunus domestica	Plum
	Prunus persica	Peach
	Psidium caudatum	––(Katiyar, et al., 2000)
	Psidium guajava	Common guava (Aguiar-Menezes & Menezes, 1997)
	Psidium guineense	Brazilian guava
	**Psidium littorale*	Strawberry guava
	+*Psidium* sp.	Araca
	Punica granatum	Pomegranate
	Pyrus communis	Pear
	Rubus glaucus	Andes berry
	Solanum quitoense	Naranjilla
	Spondias cytherea	Jew plum
	Spondias purpurea	Red mombin
	Spondias mombin	Hog-plum
	Syzgium jambos	Rose-apple
	Syzygium malaccense	Malay-apple
	Terminalia catappa	Tropical almond
	Theobroma cacao	Cocco
	Vitis vinifera	Wine grape
	Wild Hosts This species (Sensu Latus) has been recorded from numerous species of the following host families:	
	Annonacee	Euphorbiaceae
	Myrtaceae	Olacaeae
	Rosaceae	Sapotaceae
	Staphyleaceae	
Anastrepha grandis	*Citrullus lanatus*	Watermelon
	Cucumis sativus	Cucumber
	Cucurbita maxima	Pumpkin
	Cucurbita moschata	Pumpkin
	Cucurbita pepo	Pumpkin
	Lageneria siceraria	White-flowered gourd
	Passiflora alata (Oakley, 1950)	––
	Psidium guajava	Common guava
Anastrepha lepozona	*Chrysophyllum cainito*	Star-apple

Fruit Fly Species	HOST Scientific Name	Common Name
	Crataegus sp.	—
	Micropholis mexicana	
	Pouteria caimito	Abiu
	Pouteria campechiana	Egg-fruit tree
Anastrepha ludens	* Eskafi & Cunningham, 1987 # from Oakley, 1950	
	Anacardium occidentale	Cashew
	Annona cherimola	Cherimoya
	Annona muricata	Soursop
	Annona reticulata	Custard apple
	Annona squamosa	Sugar-apple
	Carica papaya	Papaya
	Casimiroa edulis	White sapote
	Casimiroa tetrameria	Yellow Sapote
	Citrus aurantiifolia	Lime
	Citrus aurantium	Sour orange
	**Citrus deliciosa*	Mediterranean tangerine
	# Citrus grandis	Pummelo
	Citrus limetta	Sweet lime
	Citrus maxima	Pummelo
	Citrus medica	Citron
	Citrus x paradisi	Grapefruit
	**Citrus reshni*	Cleopatra tangerine
	Citrus reticulata	Tangerine
	Citrus sinensis	Sweet orange
	Citrus x tangelo	Tangelo
	Coffea arabica	Arabica coffee
	Cydonia oblonga	Quince
	Diospyros kaki	Japanese persimmon
	Diospyros texana	Texas persimmon
	**Eugenia jambos*	Rose apple
	Feijoa sellowiana	Feijoa
	# Gurania suberosa	—
	# Inga inicuil	—
	**Inga micheliana*	Cushin
	# Malpighia mexicana	—
	Malus domestica	Apple
	# Malus sylvestris	Apple
	Malus pumila	Paradise apple

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Mammea americana	Mammy-apple
	Mangifera indica	Mango
	# Manilkara zapota	Sapodilla
	Passiflora edulis	Purple granadilla
	Persea americana	Avocado
	Pouteria sapota	Sapote
	Prunus domestica	Plum
	Prunus persica	Peach
	Psidium guajava	Common guava
	Psidium guineense	Brazilian guava
	Psidium littorale	Strawberry guava
	Pyrus communis	Pear
	Punica granatum	Pomegranate
	# Sargentia greggi	—
	Spondias purpurea	Red mombin
	Syzygium jambos	Rose-apple
Anastrepha macrura	*Chrysophyllum cainito*	Star-apple
	Pouteria lactescens	—
Anastrepha obliqua	* Eskafi & Cunningham, 1987 # Oakley, 1950 + Uchoa-Fernandes, 2002	
	Anacardium occidentale	Cashew
	# Annona hayesii	—
	Averrhoa carambola	Carambola
	Brosimum alicastrum	Ramon
	+Campomanesia sessiflora	Guavira
	Citrus aurantium	Sour orange
	# Citrus grandis	Pummelo
	Citrus limetta	Sweet lime
	Citrus x paradisi	Grapefruit
	Citrus sinensis	Sweet orange
	Coffee arabica	Arabica coffee
	Dovyalis hebecarpa	Ketembilla
	Diospyros digyna	Black sapote
	Eriobotrya japonica	Loquat
	+Eugenia dysinterica	Cagaita
	# Eugenia jambos	Rose apple
	# Eugenia malaccensis	Malay apple
	# Eugenia nesiotica	—

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	# Eugenia uniflora	Surinam cherry
	**Inga micheliana*	Cushin
	**Inga paterna*	Paterna
	Malpighia glabra	Huesito
	Mangifera indica	Mango
	Manikaara zapota	Sapodilla
	+Myrciaria jaboticaba	Jabuticaba
	Passiflora quadrangularis	Giant granadilla
	Pouteria sapota	Sapote
	Pouteria viridis	Green sapote
	# Prunus amygdalus	Almond
	**Prunus capuli*	Capulin cherry
	Prunus dulcis	Almond
	Prunus salicina	Japanese plum
	Psidium friedrichsthalianum	Wild guava (Katiyar, et al., 2000)
	Psidium guajava	common guava
	Psidium guineense	Brazilian guava (Katiyar, et al., 2000)
	Psidium littorale	Strawberry guava
	Pyrus communis	Pear
	# Spondias cirouella	——
	Spondias cytherea	Jew plum
	+Spondias lutea	Hog plum
	Spondias mombin	Hog-plum
	# Spondias nigrescens	——
	Spondias venulosa	Small hogplum (Aguiar-Menezes & Menezes, 1997)
	Spondias purpurea	Red mombin
	Syzygium jambos	Rose-apple
	Syzygium malaccense	Malay-apple
Anastrepha ocresia	*Citrus x paradisa (?)*	Grapefruit
	Manikara zapota	Sapodilla
	Psidium guajava	Common guava
Anastrepha ornata	*Psidium guajava*	Common guava
	Pyrus communis	Pear
Anastrepha pseudoparallela	*Mangifera indica*	Mango
	Passiflora alata	Maracuja grande
	Passiflora caerulea	Blue passion fruit

Fruit Fly Species	HOST Scientific Name	Common Name
	Passiflora edulis	Purple granadilla
	Passiflora ligularis	Sweet grandadilla
	Passiflora quadrangularis	Giant granadilla
Anastrepha serpentina	# from Oakley, 1950 +from Villachica,1996	
	Annona glabra	Pond-apple
	Brysonima crassifolia	Nance
	# Bumelia laetevirens	
	Chrysophyllum cainito	Star-apple
	# Chrysophyllum panamense	—–
	Citrofortunella x mitis	Panama orange
	Citrus auarantium	Sour orange
	Citrus x paradisi	Grapefruit
	Citrus maxima	Pummelo
	Citrus reticulata	Tangerine
	Citrus sinensis	Sweet orange
	Cydonia oblonga	Quince
	Diospryos digyna	Black sapote
	Dovyalis hebecarpa	Ketembilla
	# Ficus sp.	Fig
	# Labatia standleyana	—–
	# Lucuma obovata	—–
	# Lucuma salicifolia	—–
	Malus domestica	Apple
	Malus sylvestris	Apple
	Mammea americana	Mammy-apple
	Manilkara zapota	Sapodilla
	Mangifera indica	Mango
	# Mimusops coriacea	—–
	Persea americana	Avocado
	Pouteria caimito	Abiu
	Pouteria campechiana	Egg-fruit tree
	+Pouteria lucuma	Lucuma
	+Pouteria macrophylla	Lucma
	Pouteria mammose	Sapote (Eskafi & Cunningham, 1987)
	Pouteria obovata	Lucmo
	Pouteria sapota	Sapote
	Pouteria viridis	Green Sapote

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Prunus persica	Peach
	Psidium guajava	Common guava
	Pyrus communis	Pear
	# Sideroxylon tempisque	——
	Spondias mombin	Hog-plum
	Spondias purpurea	Red mombin
	# Zschokkea panamaensis	——
	Wild Hosts	
	This species has been recorded from several genera of:	
	Sapotaceae	
	plus single species of:	
	Apocynaceae	Moraceae
	Euphorbiaceae	
Anastrepha sororcula	*+ Uchoa-Fernandes, 2002*	
	+Campomanesia sessiflora	Guavira
	+Caryocar brasilense	Pequi
	Coffea arabica	Arabica coffee
	Eugenia brasiliensis	Brazilian cherry
	Eugenia uniflora	Surinam cherry
	+Myrciaria jaboticaba	Jabuticaba
	Pseidium guajava	Common guava
	+Psidium sp.	Araca
	+Spondias purpurea	Red mombim
	+Syzigium cumini	Jambolan plum
Anastrepha striata	*Annona muricata*	Soursop
	Calyptranthes tonduzii (Oakley, 1950)	——
	Chrysophyllum cainito	Star-apple
	Citrus sinensis	Sweet orange
	Diospyros digyna	Black sapote
	Mangifera indica	Mango
	Manihot esculenta	Cassava
	Persea americana	Avocado
	Pouteria viridis	Green sapote
	Prunus persica	Peach
	Psidium caudatum	—— (Katiyar, et al., 2000)
	Psidium friedrichsthalianum	Wild guava (Katiyar, et al., 2000)

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Psidium guajava	Common guava
	Psidium guineense	Brazilian guava
	Psidium littorale	Strawberry guava
	+*Psidium* sp.	Araca
	Solanum macranthum	Cuernavaca (Eskafi & Cunningham, 1987)
	Sponidias mombin	Hog-plum
	Spondias purpurea	Red mombin
	Syzygium jambos	Rose-apple
	Syzygium malaccense	Malay -apple
	Terminalia catappa	Tropical almond
	Wild Hosts This species has been recorded form several species of:	
	Myrtaceae	Sapotaceae
	Solanaceae	
Anastrepha suspensa	# from Oakley, 1950	
	# *Achras zapota*	Sapodilla
	Annona glabra	Pond-apple
	Annona reticulata	Custard-apple
	Annona squamosa	Sugar-apple
	Averrhoa carambola	Carambola
	Blighia sapida	Akee
	Canella winteriana	Cinnamon
	Capsicum annuum	Bell pepper
	Carica papaya	Papaya
	Carissa macrocarpa	Natal Plum
	Casimiroa edulis	White sapote
	Chrysobalanus icaco	Coccoplum
	Chrysophyllum cainito	Star-apple
	Chrysophyllum olivforme	Satinleaf
	Citrofortunella x mitis	Panama orange
	Citrus aurantiifolia	Lime
	Citrus aurantium	Sour orange
	# *Citrus grandis*	Pummelo
	Citrus limetta	Sweet lime
	Citrus x limonia	Lemandarin
	Citrus maxima	Pummelo
	Citrus x paradisi	Grapefruit
	Citrus reticulata	Tangerine

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Citrus sinesis	Sweet orange
	Citrus x tangelo	Tangelo
	Clausena lansium	Wampi
	Coccoloba uvifera	Seagrape
	Diospyros blancoi	Velvet apple
	Diospyros kaki	Japanese persimmon
	Diospyros virginiana	Common persimmon
	Dovyalis caffra	Kei apple
	Eriobotrya japonica	Loquat
	Dovyalis hebecarpa	Ketembilla
	Eugenia aggregata	Rio Grande cherry
	Eugenia brasiliensis	Brazil cherry
	# Eugenia jambos	Rose apple
	# Eugenia malaccensis	Malay apple
	Eugenia uniflora	Surinam cherry
	Ficus carica	Common fig
	Flacourtia indica	Governor's plum
	Fortunella x crassifolia	Meiwa kumquat
	Fortunella margarita	Oval kumquat
	Garcinia livingstonei	Imbe
	Litchi chinensis	Lychee
	Lycopersicon esculentum	Tomato
	Malpighia glabra	Huesito
	Malus domestica	Apple
	Mangifera indica	Mango
	Manikara zapota	Sapodilla
	Momordica balsamina	Balsam-apple
	Momordica charantia	Bitter gourd
	Muntingia calabura	Calabur
	Murraya paniculata	Orange jessamine
	Myrciaria caulifora	Jaboticaba
	Persea americana	Avocado
	Phoenix dactylifera	Date palm
	Pimenta dioica	Allspice
	Pouteria campechiana	Egg-fruit tree
	Prunus persica	Peach
	# Psidium cattleianum	Strawberry guava
	Psidium friedrichsthalianum	Wild guava
	# Psidium guajava	Guava

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Psidium guineense	Brazilian guava
	Psidium littorale	Strawberry guava
	Punica granatum	Pomegranate
	Pyrus communis	Pear
	Pyrus pyrifolia	Sand pear
	Spondias cytherea	Jew plum
	Spondias mombin	Hog-plum
	Sunsepalum dulcificum	Miraculous berry
	Syzygium cumini	Java plum
	Syzygium jambos	Rose-apple
	Syzygium malaccense	Malay-apple
	Syzygium samarangense	Water apple
	# Terminalia catappa	Tropical almond
	Triphasia trifolia	Limeberry
	Wild Hosts	
	Recorded from hosts in several unrelated families:	
	Araliaceae	Clusiaceae
	Combretaceae	Euphorbiaceae
	Moraceae	Myrtaceae
	Rosaceae	Rutaceae
	Sapotaceae	
Bactrocera albistrigata	*Psidium guajava (Ranganath & Veenakumari, 1996)*	Guava
	Syzygium aqueum	Watery rose-apple
	Syzygium malaccense	Malay-apple
	Syzygium samarangense	water apple
	Terminalia catappa	Tropical almond
Bactrocera aquilonis	*Anacardium occidentale*	Cashew
	Annona muricata	Soursop
	Annona reticulata	Custard apple
	Annona squamosa	Sugar-apple
	Averrhoa carambola	Carambola
	Blighia sapida	Akee
	Capsicum annuum	Bell pepper
	Chrysophyllum cainito	Star-apple
	Citrus limon	Lemon
	Citrus maxima	Pummelo
	Citrus x paradisi	Grapefruit
	Citrus reticulata	Tangerine

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Eriobotrya joponica	Loquat
	Eugenia uniflora	Surinam cherry
	Flacourtia jangomas	Indian plum
	Flaucourtia rukam	Indian prune
	Fortunella x crassifolia	Meiwa kumquat
	Lycopersicon esculentum	Tomato
	Malpighia glabra	Huesito
	Malus domestica	Apple
	Mangifera indica	Mango
	Manikara zapota	Sapodilla
	Musa acuminata	Dwarf banana
	Persea americana	Avocado
	Phyllanthus acidus	Otaheite gooseberry tree
	Prunus persica	Peach
	Psidium littorale	Strawberry guava
	Psidium guajava	Common guava
	Rollinia mucosa	Wild sweetsop
	Rollinia pulchrinervis	Biriba
	Spondias cytherea	Jew plum
	Syzygium aqueum	Watery rose-apple
	Syzygium jambos	Rose-apple
	Syzygium malaccense	Malay-apple
	Terminalia catappa	Tropical almond
	Ziziphus mauritiana	Jujube
	Wild Hosts	
	This species has been recorded from species of:	
	Annonaceae	Apocynaceae
	Arecaceae	Chrysobalanaceae
	Combretaceae	Ebenaceae
	Elaeocarpaceae	Euphorbiaceae
	Lauraceae	Meliaceae
	Myrtaceae	Rosaceae
	Rubiaceae	Rutaceae
Bactrocera atrisetosa	*Aglaia sapindina*	
	Citrullus lanatus	Watermelon
	Cucumis sativus	Cucumber
	Cucurbita pepo	Pumpkin
	Lycopersicon esculentum	Tomato

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
Bactrocera carambolae	*“Host Range somewhat unstable” (CFFP, 2000)*	
	** From Miller, 1940, hosts recorded from”Chaetodacus ferrugineus”, which may or may not be B. carambolae*	
	Anacardium occidentale	Cashew
	Arenga pinnata	Sugar plum
	Artocarpus altilis	Breadfruit
	Artocarpus elasticus	——
	Artocarpus heterophyllus	Jackfruit
	Averrhoa bilimbi	Bilimbi
	Averrhoa carambola	Carambola
	Baccaurea motleyana	Rambai
	Capsicum annuum	Chilli pepper
	** Carica papaya*	Papaya
	Chrysoplyllum cainito	Star-apple
	** Citrus limettioides*	Sweet lime
	Citrus x paradisi	Grapefruit
	Citrus sinensis	Sweet orange
	Citrus reticulata	Tangerine
	** Eugenia aquea*	——
	Eugenia uniflora	Surinam cherry
	** Gossypium sp.*	Cotton
	Lepisanthes fruticosa	Luna nut
	** Luffa aegyptiaca*	Loofah
	Lycopersicon esculentum	Tomato
	Malpighia glabra	Huesito
	Malpighia punicifolia (CFFP, 2000)	West Indian cherry
	Mangifera indica	Mango
	Manilkara zapota	Sapodilla
	** Nephelium lappaceum*	Rambutan
	Psidium guajava	Common guava
	Solanum ferox	——
	** Solanum verbascifolium*	Potato tree
	Syzygium aqueum	Watery rose-apple
	Syzygium jambos	Rose-apple
	Syzygium malaccense	Malay-apple
	Syzygium samarangense	Water apple
	Terminalia catappa	Tropical almond

Fruit Fly Species	HOST Scientific Name	Common Name
	Ziziphus jujube	Common jujube
		Wild Hosts
	Recorded from wild species of:	
	Clusiaceae	Euphorbiaceae
	Meliaceae	Moraceae
	Myrtaceae	Olacaceae
	Rhizophoraceae	Rutaceae
	Symplocaceae	
Bactrocera caryeae	*Aegle marmelos*	——
	Artocarpus heterophyllus	Jackfruit
	Artocarpus integer	Chempedak
	Callocarpum sapote	——
	Careya arborea	Patana oak
	Citrus spp.	Citrus species generally
	(?) Coffea canephora	Robusta coffee
	(?) Ficus sp.	——
	Mangifera indica	Mango
	(?) Prunus dosmestica	Plum
	Psidium guajava	Common guava
	Solanum auriculatum	Bug tree
	Solanum verbascifolium	——
	Terminalia (?) catappa	Tropical almond
Bactrocera caudata	*# from Oakley, 1950.*	
	(?) Benincasa hispida	Wax gourd
	# (?) Bryonopsis laciniosa	
	(?) Capsicum annuum	Chili pepper
	# (?) Citrullus lanatus	Watermelon
	(?)Citrus aurantium	Sour orange
	(?)Citrus maxima	Pummelo
	# (?) Citrus paradisi	Grapefruit
	# (?) Cucumis melo	Melon
	(?) Cucumis sativus	Cucumber
	(?) Cucurbita pepo	Bitter pumpkin
Only confirmed host. All other records are unconfirmed (White & Elston-harris, 1992)	*Cucurbita spp.*	Pumpkin
	# (?) Eugenia sp.	——
	# (?) Garcinia zanthochymus	——

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	(?) Lagenaria siceraria	White-flowered gourd
# Reared from this host (Oakley, 1950)	*Lycopersicon esculentum*	Tomato
	(?)Luffa acutangula	Angled luffa
	(?) Luffa aegyptiaca	Luffa
	(?) Mainkara zapota	Sapodilla
	(?) Momordica charantia	Gourd
	# (?) Morus sp.	Mulberry
	(?) Prunus persica	Peach
	(?) Psidium guajava	Common guava
	(?) Syzygium samarangense	Water apple
	# (?) Trichosanthes anguina	Serpant cucumber
	# (?) Trichosanthes cordata	—
	(?) Trichosanthes cucumerina	Snakegourd
Bactrocera correcta	Those hosts marked with an asterick (*) are listed in Tigvattananont, 1986.	
	Aegle marmelos	India bael
	Carissa carandas	Karanda
	Citrus sp.	Orange
	Coffea canephora	Robusta coffee
	**Elaeocarpus hygrophilus*	—
	**Eugenia javanica*	Java apple
	Eugenia uniflora	Surinam cherry
	**Garcinia dulcis*	—
	Mangifera indica	Mango
	Manikara zapota	Sapodilla
	**Polyathia longifolia*	—
	**Prunus ceracus*	Sour cherry
	Prunus persica	Peach
	Psidium guajava	Guava
	Ricinus communis	Caster-oil plant
	Santalum album	Sandalwood
	Syzygium jambos	Rose-apple
	Terminalia catappa	Tropical almond
	Ziziphus jujube	Common jujube
	** Zizyhhus mauritiana*	Indian jujube

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
Bactrocerus cucumis	*Bryonopsis laciniosa (Fitt, 1980)*	———
	Carica papaya	Papaya
	Cucumis melo	Rockmelon
	Cucumis sativus	Cucumber
	Cucurbita pepo	Marrow Pumpkin & Squash
	Diplocyclos palmatus	———
	Glochidion harveyanum	———
	Luffa aegyptiaca	Luffa
	Lycopersicon esculentum	Tomato
	Momordica charantia	Bitter gourd
	Passiflora edulis	Purple granadilla
	Trichosanthes cucumerina	Snakegourd
Bactrocera cucurbitae	Generally, a very serious pest of curcubit crops, it has been recorded from hosts of many other plant families as well. Over 125 hosts are known or listed. Of these, only those hosts listed in BASS, 1986 as "Superior" or "Satisfactory" are given here for program purposes.	
	Annona muricata	Soursop
	Benincasa hispida	Wax gourd
	Capsicum annuum var.annuum gp. grossum	Bell pepper
	Capsicum annuum var.annuum gp. longum	Chili pepper
	Capsicum frutescens	Tobasco pepper
	Carica papaya	Papaya
	Citrullus colocynthis	Colocynth
	Citrullus lanatus	Watermelon
	Citrus reticulata	Mandarin orange
	Citrus sinesis	Sweet orange
This host is fron the Pacific Fruit Fly Web <www.pacificfly.org/ Species_profiles>	** Coccinia grandis*	Ivy gourd
	Cucumis melo	Melon
	Cucumis melo var. conomon	Oriental pickling melon
	Cucumis sativus	Cucumber
	Cucurbita maxima	Squash
	Cucurbita moschata	Pumpkin
	Cucurbita pepo	Pumpkin

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Cucurbita spp.	———
	Cyphomandra betaceae	Tree tomato
	Ficus carica	Common fig
	Fragaria chiloensis	Strawberry
	Garcinia sp.	———
	Hibiscus esculentus	Okra
	Lageneria siceraria	Bottle gourd
	Luffa acutangula	Angled luffa
	Luffa aegyptiaca	Luffa
	Lycopersion esculentum	Tomato
	Malus sylvestris	Apple
	Mangifera indica	Mango
	Momordica sp.	Bitter melon
	Momordica balsaminia	Balsam-apple
	Momordica charantia	Bitter gourd
	Momordica cochinchiensis	Kakari
	Passiflora spp.	Water lemon
	Passiflora edulis	Purple granadilla
	Passiflora foetida	Running pop
	Passifloria quadrangula	Giant granadilla
	Passiflora seemanni	——
	Persea americana	Avocado
	Phaseolus lunatus	Lima bean
	Phaseolus radiatus	Mung bean
	Phaseolus vulgaris	String bean
	Phoenix dactylifera	Date palm
	Prunus persica	Peach
	Psidium guajava	Common guava
	Sechium edule	Chayote
	Sicyos sp.	Bur cucumber
	Solanum melongena	Eggplant
	Trichosanthes anguina	Serpent cucumber
	Trichosanthes cucumerina	Snakegourd
	Triochosanthes cucumeriodes	Snake gourd
	Trichosanthes dioica	Pointed gourd
	Triphasia tufolia	Limeberry
	Vigna unguiculata	Cowpea

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
Bactrocera curvipennis	*The following host list is from the Pacific Fruit Fly Web at <www.pacificfly.org/Species_profiles>*	
	Anacardium occidentale	Cashew
	Annoa reticulata	Bullock's heart
	Calophyllum inophyllum	Indian laural
	Capsicum annuum	Bell pepper
	Citrus maxima	Pomelo
	Citrus reticulata	Mandarin orange
	Citrus x paradisa	Grapefruit
	Coffea arabica	Coffee
	Diospyros macrocarpa	——
	Eugenia uniflora	Surinam cherry
	Mangifera indica	Mango
	Malpighia glabra	Acerola
	(?) Musa x paradisiaca	Banana (But this may be in error (White & Elston-Harris, 1992).
	Passiflora foetida	Wild passionfruit
	Prunus persica	Peach
	Psidium cattleianum	Strawberry guava
	Psidium guajava	Guava
	Syzyium jambos	Rose apple
	Syzyium malaccense	Mountain apple
	Terminalia catappa	Tropical almond
	Vitis vinifera	Grape
Bactrocera decipiens	*Cucurbita pepo*	Pumpkin
Bactrocera depressa	*Citrullus lanatus*	Watermelon
	Cucumis metuliferus	African horned cucumber
	Cucumis sativus	Cucumber
	Cucurbita moschata	Pumpkin
	Lagenaria siceraria	White-flowered gourd
	(?) Lycopersicon esculentum	Tomato
Bactrocera distincta	** (from the Pacific Fruit Fly Web at <www.pacificfly.org/Species_profiles* ***(from Laiti, et al., 2002)*	
	Anacardium occidentale	Cashew
	** Burkella richii*	——
	Chrysophyllum cainito	Star-apple
	***Eugenia brasiliensis*	Brazil cherry
	Hibiscus tiliaceus	Sea hibiscus

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	** Manilkara zapota*	Sapodilla
	Pometia pinnata	Pacific lychee
Bactrocera diversa	** (from Syed, 1970)* *# (from Kapoor, 1993)*	
	#Benincasa hispida	White gourd
	**Cerebera mangyas*	Honde fruit
	Citrus aurantium	Sour orange
	***Coccinia grandis*	Ivy gourd
	Cucurbita maxima	Pumpkin
	Cucurbita pepo	Pumpkin
	**Eugenia jambolana*	Rose apple
	Lagenaria siceraria	White-flowered gourd
	Luffa acutangula	Angled luff
	Luffa aegyptiaca	Luffa
	Mangifera indica	Mango
	Musa x paradisiaca	Banana
	**Musa sapientum*	Banana
	#Muristica beddomei	Wild nutmeg
	Myristica sp.	Nutmeg
	Prunus domestica	Plum (Grewal & Kapoor, 1986)
	Psidium guajava	Common guava
	Pyrus communis	Pear (Grewal & Kapoor, 1986)
	#Solanum erianthum	Mullein Nightshade
	**Solanum verbascifolium*	Mullein Nightshade
	Syzygium cumini	Java plum
Bactrocerus dorsalis	*A very serious pest of hosts in many different plant families. There are over 239 different hosts. Of these, only those given as “Superior” in BASS, 1983 are listed here. Reference to the complete list will be necessary for program purposes.* ** (from the Pacific Fruit Fly Web at <www.pacificfly.org/Species_profiles*	
	Annacardium occidentale	Cashew
	Annona muricata	Soursop
	Annona reticulata	Custard apple
	Annona cherimola	Cheremoya
	Artocarpus altilis	Breadfruit
	Averrhoa carambola	Country gooseberry

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Cananga odorata	Ylang-ylang
	Capsicum frutescens longum	Chilli
	Carica papaya	Papaya
	Carissa grandiflora	Natal plum
	Casimiroa edulis	White sapote
	Chrysophyllum cainito	Star-apple
	Chrysophyllum oliviforme	Damson plum
	Diospyros discolor	Velvet apple
	Citrus aurantifolia	Lime
	Citrus japonica hazara	Chinese orange
	* *Citrus maxima*	Pomelo
	Citrus nobilis	King orange
	Citrus unshu	Unshu orange
	Citrus mitis	——
	Citrus paradisi	Grapefruit
	Citrus reticulata	Mandarin orange
	Citrus sinensis	Sweet orange
	Diospryos discolor	Mabola persimm
	Diospyros kaki	Japanese persimmon
	Dracena draco	Dragon tree
	Eriobotrya japonica	Loquat
	Eugena sp.	——
	Eugenia jambos	Malabar plum
	Eugenia malaccenis	Malay apple
	Eugenia uniflora	Surinam cherry
	Ficus carica	Fig
	Fortunella japonica	Round kumquat
	Fragaria sp.	——
	* *Inocarpus fagifer*	Tahitain chestnut
	Jubaea spectabilis	Syrup palm
	Lucuma nervosa	Canistel
	Malpighia punicifolia	Barbados cherry
	Malus sylvestris	Common apple
	Mangifera indica	Mango
	Manilkara zapota	Sapodilla
	Mimusops elengi	Spanish cherry
	Murraya exotica	China box
	Musa paradisiaca	Common banana
	* *Ochrosia sp.*	——

Fruit Fly Species	HOST	
	Scientific Name	**Common Name**
	** Persea americana*	Avocado
	Prunus americana	American plum
	Prunus armeniaca	Apricots
	Prunus ilicifolia	Catalina cherry
	Prunus persica	Peach
	Prunus persica var. nucipersica	Nectarine
	Psidium cattleianum lucidum	Yellow Strawberry guava
	Psidium cattleianum littorale	Red strawberry guava
	Psidium guajava	Guava
	Pyrus communis	Pear
	Sandoricum koetjape	Santol
	Solanum pseudocapsicum	Jerusalem cherry
	Spondias cytherea	Golden apple
	Spondias tuberosa	Imbu
	Terminalia catappa	Tropical almond
	Terminalia chebula	———
	Thevetia peruviana	Yellow oleander
	Vitis spp.	Grape
Bactocera facialis	** (from the Pacific Fruit Fly Web at <www.pacificfly.org/Species_profiles>*	
	Anacardium occidentale	Cashew
	Ananas comosus	Pineapple
	Artocarpus altilis	Breadfruit
	Capsicum annuum	Bell pepper
	Capsicum frutescens	Tabasco pepper
	** Carica papaya*	Papaya
	** Cerbera manghas*	——
	Citrus limon	Lemon
	Citrus x paradisi	Grapefruit
	Citrus maxima	Pummelo
	Citrus reticulata	Mandarin
	Citrus sinesis	Sweet orange
	Eugenia uniflora	Surinam cherry
	Hibiscus tiliaceus	Sea hibiscus
	** Gardenia tahitensis*	——
	Inocarpus fagifer	Tahiti chestnut
	Lycopersicon esculentum	Tomato

Fruit Fly Species	HOST Scientific Name	HOST Common Name
	Mangifera indica	Mango
	* *Micromelum minutum*	——
	* *Ochrosia oppositifolia*	——
	Passiflora quadrangularis	Giant granadilla
	* *Persea americana*	Avocado
	* *Phaleria disperma*	——
	Pometia pinnata	Pacific lychee
	Prunus americana	Avocado
	Prunus persica	Peach
	Psidium guajava	Common guava
	Syzygium jambos	Rose-apple
	Syzygium malaccense	Malay-apple
	* *Syzygium neurocalyx*	——
	Terminalia catappa	Tropical almond
	* *Vavaea amicorum*	——
Bactrocera frauenfeldi	* (from the Pacific Fruit Fly Web at <www.pacificfly.org/Species_profiles # from Oakley, 1950	
	* *Anacardium occidentale*	Cashew
	* *Annona glabra*	Pond apple
	* *Annona muricata*	Soursop
	* *Areca catechu*	Betel nut (ripe)
	Artocarpus altilis	Breadfruit
	**Artocarpus heterophyllus*	Jackfruit
	* *Averrhoa carambola*	Carambola
	* *Barringtonia edulis*	——
	* *Broussonetia papyrifera*	Paper mulberry
	* *Calophyllum inophyllum*	Indian laurel
	* *Calophyllum kajewskii*	——
	Carica papaya	Papaya
	* *Cerbera manghas*	——
	* *Chrysophyllum cainito*	Star apple
	* *Citrus aurantium*	Sour orange
	* *Citrus maxima*	Pomelo
	* *Citrus x paradisi*	Grapefruit
	* *Citrus reticulata*	Mandarin
	* *Citrus sinensis*	Orange

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Diospyros digyna (Vagalo, et al, 1997)	Black Sapote
	* *Diospyros hebecarpa*	—
	# *Eugenia jambos*	Rose apple
	# *Eugenia malaccensis*	Malay apple
	* *Eugenia uniflora*	Surinam cherry
	* *Ficus sp.*	—
	* *Fortunella japonica*	Kumquat
	* *Guettarda speciosa*	—
	* *Inocarpus fagifer*	Tahiti chestnut
	* *Malpighia glabra*	Acerola
	* *Mammea odorata*	—
	Mangifera indica	Mango
	* *Mangifera minor*	Mango
	Manilkara kauki	Sauh
	* *Manikara zapota*	Sapodilla
	Musa x paradisiaca	Banana
	* *Neonauclea forsteri*	—
	* *Ochrosia oppositifolia*	—
	# *Pepisala sp.*	—
	* *Persea americana*	Avocado
	* *Pometia pinnata*	Pacific lychee
	* *Pouteria campechiana*	Canistel
	Psidium guajava	Common guava
	* *Scaveola tacadda*	Govugovu
	* *Spondias cytherea*	Golden apple
	* *Syzygium aqueum*	Water apple
	Syzygium jambos	Rose-apple
	* *Syzygium javanicum*	—
	Syzygium malaccense	Malay-apple
	* *Terminalia carolinensis*	—
	Terminalia catappa	Tropical almond
	* *Terminalia kaernbachii*	Okari nut
	* *Terminalia samoensis*	—
	* *Terminalia whitmorae*	—
	* *Trichosanthes cucumerina*	Snake gourd
Bactrocera jarvisi	*Annona muricata*	Soursop
	Averrhoa bilimbi	Bilimbi
	Carica papaya	Papaya

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Citrus x paradisi	Grapefruit
	Citrus sinensis	Sweet orange
	Cydonia oblonga	Quince
	Diospryos kaki	Japanese persimmon
	Lycopersicon esculentum	Tomato
	Malus spp.	Apple
	Mangifera indica	Mango
	Musa acuminata	Dwarf banana
	Musa sp.	Cavendish banana
	Planchonia careya = Careya australis	Cockatoo Apple “A wild host”. Preferred over cultivated hosts. And see Jarvis, 1925.
	Prunus armeniaca	Apricot
	Prinus persica	Peach
	Psidium guajava	Common guava
	Psidium littorale	Strawberry guava
	Punica granatum	Pomegranate
	Pyrus communis	Pear
	Spondiaas cytherea	Jew plum
	Syzygium malaccense	Malay-apple
	Terminalia catappa	Tropical almond
		Wild Hosts
	The following families of wild hosts are known:	
	Anacardicaceae	Barringtoniaceae
	Chrysobalanaceae	Combretaceae
	Combretaceae	Cucurbitaceae
	Lecythidaceae	Meliaceae
	Myrtaceae	Oleaceae
	Sapotaceae	
Bactrocera kandiensis	*(?) Citrus x paradisi*	Grapefruit
	Garcinia sp.	Mangosteen
	Mangifera indica	Mango
	(?) Solanum melongena	Eggplant
Bactocera kirki	** (from the Pacific Fruit Fly Web at <www.pacificfly.org/Species_profiles* ***(from Laiti, et al., 2002)*	
	Ananas comosus	Pineapple
	** Annona muricata*	Soursop
	** Annona reticulata*	Bullock’s heart

Fruit Fly Species	HOST Scientific Name	HOST Common Name
	Averrhoa carambola	Carambola
	***Calophyllum inophyllum*	Indian laurel
	* *Canarium vulgare*	—
	Capsicum annuum	Bell pepper
	Capsicum frutescens	Tabasco pepper
	* *Carica papaya*	Papaya (ripe)
	* *Chrysophyllum cainito*	Star apple
	Citrus aurantiifolia	Lime
	* *Citrus maxima*	Pomelo
	Citrus reticulata	Mandarin
	Citrus sinensis	Sweet orange
	* *Cucurbita pepo*	Pumpkin
	***Elaeocarpus tonganus*	—
	**Eryobotria japonica*	Loquat
	***Eugenia braxiliensis*	Brazil cherry
	Eugenia uniflora	Surinam cherry
	Hibiscus tiliaceus	Sea hibiscus
	Inocarpus fagifer	Tahiti chestnut
	Mangifera indica	Mango
	* *Morinda citrifolia*	Noni
	* *Musa sp.*	Bananas
	Ochrosia oppositifolia	Fao
	Passiflora edulis	Purple granadilla
	* *Passiflora quadrangularis*	Giant granadilla
	* *Persea americana*	Avocado
	* *Pometia pinnata*	Pacific lychee
	***Pouteria cainito*	Abiu
	Prunus persica	Peach
	* *Psidium cattleianum*	Strawberry guava
	Psidium guajava	Common guava
	* *Solanum melongena*	Eggplant
	* *Spondias cytherea*	Golden apple
	* *Spondias mombin*	Hog-plum
	***Syzygium aqueum*	Water apple
	* *Syzygium corynocarpum*	—
	* *Syzygium deleatum*	—
	Syzygium jambos	Rose-apple

Fruit Fly Species	HOST Scientific Name	HOST Common Name
	Syzygium malaccense	Malay-apple
	** Syzygium richii*	—
	Terminalia catappa	Tropical almond
Bactrocera latifrons	*The following host list is from Table 4, (Liquido, et al, 1994) with host records questioned by Dr. Drew indicated by (?)*	
	(?) Averrhoa carambola	Carambola
	Baccairea motleyana	Rambai
	Benincasa hispida	Tunka
	Capsicum annuum	Chili pepper
	Capsicum frutescens	Tabasco pepper
	(?) Citrus limon	Lemon
	(?) Citrus sinensis	Sweet orange
	Coccinea grandis	Ivy gourd
	(?) Coffea sp.	Coffee
	Cucumis sativus	Cucumber
	Cucumis melo	Melon
	Cucurbita maxima	Pumpkin
	Lagenaria siceraria	Ipu
	Litchi chinensis	Lychee
	Lycopersicon lycopersicum	Common Tomato
	Lycopersicon pimpinellifolium	Currant tomato
	Malus domestica	Common apple
	(?) Mangifera indica	Mango
	Momordica charatia	Balsam-apple
	(?) Musa x paradisiaca	Banana
	Physalis peruviana	Poha
	(?) Psidium guajava	Guava
	Solanum aculeatissimum	Soda -apple
	Solanum incanum	——
	Solanum indicum	——
	Solanum melongena	Common eggplant
	Solanum nigrum	Popolo
	Solanum pseudocapsicum	Jersalem cherry
	Solanum sarmentosum	——
	Solanum sisymbriifolium	Sticky nightshade
	Solanum sodomeum	Sodom apple
	Solanum torvum	Turkey berry

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Solanum trilobatum	———
	Solanum verbascifolium	———
	Solanum viarum	———
	Solanum virginianum	———
	Trichosanthes anguina	Snake gourd
	Ziziphus jujuba	Chinese jujube
Bactrocera melanota	* (from the Pacific Fruit Fly Web at <www.pacificfly.org/Species_profiles. Note: puboished hosts only. This species attacks 36 hosts in 29 genera and 19 families.	
	* *Carica papaya*	Papaya
	Citrus aurantium	Sour orange
	* *Citrus maxima*	Pomelo
	* *Citrus reticulata*	Mandarin
	* *Citrus sinensis*	Orange
	* *Citrus x paradisi*	Grapefruit
	* *Inocarpus fagifer*	Tahiti chestnut
	Mangifera indica	Mango
	* *Persea americana*	Avocado
	Psidium guajava	Common guava
	* *Syzygium malaccense*	Mountain apple
	* *Terminalia catappa*	Tropical almond
Bactrocera minax	*Citrus aurantium*	Sour orange
	Citrus limon	Lemon
	Citrus medica	Citron
	Citrus maxima	Pummelo
	Citrus reticulata	Tangerine
	Citrus sinensis	Sweet orange
	Citrus tangerina	Tangerine
	Fortunella x crassifolia	Meiwa kumquat
Bactrocera musae	* *from Smith, 1977*	
	**Capparis licida*	bush shrub
	**Capsicum annuum*	birds-eye chillies
	Carica papaya	Papaya
	**Lycopersicum esculentum*	Tomato
	Musa acuminata	Dwarf banana
	Musa banksii	———
	Musa x paradisiaca	Banana
	Psidium guajava	Common guava

Fruit Fly Species	HOST Scientific Name	HOST Common Name
		Wild Hosts
	Recorded from species of:	
	Capparidaceae	Myrtaceae
Bactrocerus neohumeralis	*Annona squamosa*	Sugar-apple
	Cananga odorata	Ylang-ylang
	Casimiroa edulis	White sapote
	Citrus limon	Lemon
	Citrus maxima	Pummelo
	Citrus x parasisi	Grepefruit
	Citrus reticulata	Mandarin
	Citrus sinensis	Sweet orange
	Coffea arabica	Arabica coffee
	Crateva religiosa	Sacred garlic-pear
	Cyphomandra betacea	Tree tomato
	Eriobotrya japonica	Loquat
	Eugenia uniflora	Surinam cherry
	Feijoa sellowiana	Feijoa
	Ficus benjamini	Weeping fig
	Fortunella japonica	Round kumquat
	Fragaria sp.	Strawberry
	Lycopersicon esculentum	Tomato
	Malus domestica	Apple
	Mangifera indica	Mango
	Morus nigra	Black mulberry
	Passiflora suberosa	Corky-stem passionflower
	Phoenix dactylifera	Date palm
	Prunus armeniaca	Apricot
	Prunus domestica	Plum
	Prunus persica	Peach
	Psidium guajava	Common guava
	Psidium littorale	Strawberry guava
	Pyrus communis	Pear
	Rubus rosifolius	Mauritius raspberry
	Solanum laciniatum	Kangaroo apple
	Solanum seaforthianum	———
	Spondias cytherea	Jew plum
	Syzygium aqueum	Watery rose-apple
	Terminalia catappa	Tropical almond
	Vitis labrusca	Fox grape

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
		Wild Hosts
	Wild hosts recorded from the following plant families:	
	Annonaceae	Capparidaceae
	Celastraceae	Combrataceae
	Euphorbiaceae	Lauraaceae
	Oleaceae	Passifloraceae
	Naucleaceae	Rutaceae
	Sapindaceae	Sapotaceae
	Solancaeae	
Bactrocerus occipitalis	*Mangifera indica*	Mango
	Psidium guajava	Guava
Bactrocerus oleae	# from Oakley, 1950	
	# *Olea chrysophylla*	——
	Olea europaea	Olive
	Olea europaea africana	Wild olive
	# *Olea foveolata*	——
	# *Olea laurifolia*	——
	# *Olea verrucosa*	——
	# *Olea woodiana*	——
Bactrocera papayae	*Annona glabra*	Pond-apple
	Annona muricata	Soursop
	Arenga pinnata	Sugar plum
	Artocarpus dadah	——
	Artocarpus heterophyllus	Jackfruit
	Artocarpus integer	——
	Artocarpus rigidus	Monkey-jack
	Averrhoa carambola	Carambola
	Baccaurea motleyana	Rambai
	Capsicum annuum	Chilli pepper
	Capiscum frutescens	Tabasco pepper
	Carica papaya	Papaya
	Citrus sinensis	Sweet orange
	Diospyros blancoi	Velvet apple
	Eugenia uniflora	Surinam cherry
	Garcinia hombroniana	Seashore mangosteen
	Lansium domesticum	Langsat
	Mangifera indica	Mango
	Momordica charantia	Bitter gourd
	Manikara zapota	Sapodilla

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Mussa x paradisiaca	Banana
	Nephelium lappaceum	Rambutan
	Passiflora edulis	Purple granadila
	Psidium guava	Common guava
	Sandoricum koetjape	———
	Solanum ferox	———
	Solanum torvum	Terongan
	Spondias cytherea	Jew plum
	Syzygium aqueum	Watery rose-apple
	Syzygium jambos	Rose-apple
	Syzygium malaccense	Malay-apple
	Syzygium samaranganse	Wax-apple
	Terminalia sp.	———
	Ziziphus mauritiana	Indian jujube
	Wild Hosts Recorded from wild hosts in the following families:	
	Clusiaceae	Moraceae
	Rutaceae	Sapindaceae
Bacterocera passiflorae	* (from the Pacific Fruit Fly Web at <www.pacificfly.org/Species_profiles # from Oakley, 1950 ** From Simmons, 1935	
	** Amaroria soulameides*	—–
	Anacardium occidentale	Cashew
	Artocarpus altilis	Breadfruit
	# Artocarpus heterophyllus	
	** Barringtonia edulis*	—–
	# Barringtonia speciosa	
	# Capsicum frutescens grossum	Capsicum
	# Capsicum frutescens longum	
	Carica papaya	Papaya
	** Cerbera manghas*	—–
	** Chrysobalanus icaco*	—–
	** Chrysophyllum cainito*	Star apple
	Citrus aurantiifolia	Lime
	** Citrus aurantium*	Sour orange
	# Citrus grandis	Pommelo

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	** Citrus maxima*	Pomelo
	# Citrus paradisi	Grapefruit
	Citrus reticulata	Mandarin
	** Citrus sinensis*	Orange
	** Citrus x paradisi*	Grapefruit
	Coffea sp.	Coffees
	# Coffea arabica	Arabian coffee
	** Coffea liberica*	Coffee
	# Cucumis melo	Canteloupe
	# Cucumis sativus	Cucumber
	** Dracontomelon sylvestre*	—
	# Eugenia brasilienis	Brazil cherry
	# Eugenia malaccensis	Malay apple
	# Eugenia uniflora	Surinam cherry
	** Fortunella japonica*	Kumquat
	***Gossyhium barbadense*	Cotton bolls
	# Gossypium spp.	Cotton
	** Inocarpus fagifer*	Tahiti chestnut
	Mangifera indica	Mango
	** Neuburgia corynocarpa*	—
	Ochrosia oppositifolia	Fao
	Passiflora edulis	Purple granadilla
	Passiflora quadrangularis	Giant granadilla
	Persea americana	Avocado
	Pometia pinnata	Pacific lychee
	** Psidium cattleianum*	Strawberry guava
	Psidium guajava	Common guava
	Psidium littorale	Strawberry guava
	** Santalum yasi*	Sandalwood
	Solanum melongena	Eggplant
	** Syzygium jambos*	Rose apple
	Syzygium malaccense	Malay-apple
	** Terminalia catappa*	Tropical almond
	** Terminalia litoralis*	—
	Theobroma cacao	Cocoa
Bactrocera philippinensis	*Artocarpus altilis*	Breadfruit
	Artocarpus communis	Camansi
	Carica papaya	Papaya

Fruit Fly Species	HOST Scientific Name	Common Name
	Mangifera indica	Mango
	Pouteria duklitan	—
	Syzygium malaccensis	Malay-apple
Bactrocera psidii	* (from the Pacific Fruit Fly Web at <www.pacificfly.org/Species_profiles>) # from Oakley, 1950.	
	* *Anacardium occidentale*	Cashew
	* *Aleurites moluccana*	—
	* *Annona reticulata*	Bullock's heart
	* *Carophillus* sp.	—
	* *Citrus maxima*	Pomelo
	Citrus sp.	
	* *Diospyros macrocarpa*	—
	* *Eugenia uniflora*	Surinam cherry
	* *Ficus sp.*	fFigs
	# *Ficus stephanocarpa*	Wild black fig
	# *Inocarpus fagiferus*	Tahitian chestnut
	Mangifera indica	Mango
	# *Musa sp. (Mature)*	Banana
	# *Nephelium* sp.	Rambutan
	Passiflora quadrangularis	Giant granadilla
	# *Persea americana*	Avocado
	* *Prunus domestica*	Plum
	* *Prunus persica*	Peach
	* *Psidium cattleianum*	Strawberry guava
	Psidium guajava	Common guava
	Psidium littorale	Strawberry guava
	# *Schizomeria ovata*	White ash
	# *Sideroxylon australe*	Native plum
	* *Syzygium jambos*	Rose apple
	* *Syzygium malaccense*	Malay apple
	Terminalia catappa	Tropical almond
	Vitis vinifera	Grape
Bactrocera pyrifoliae	*Baccaurea ramiflora*	——
	Prunus persica	Peach
	Psidium guajava	Common guava
	Pyrus pyrifolia	Sand pear

Fruit Fly Species	HOST Scientific Name	Common Name
Bactrocera tau	* (from Tigvattananont, 1986) ** (from Kapoor, 1993) + (from Grewal & Kapoor, 1986)	
	***Benincasa hispida*	White gourd
	Citrullus lanatus	Watermelon
	***Citrus maxima*	Pummelo
	**Coccinia grandis*	Ivy gourd
	Cucumis sativus	Cucumber
	Cucurbita maxima	Pumpkin
	***Lagenaria siceraria*	Bottle gourd
	Luffa acutangula	Angled luffa
	**Luffa cylindrica = aegyptiaca*	Luffa
	Mangifera foetida	Bachang
	Momordica charantia	Bitter gourd
	Morus sp.	Mulberry
	Muntingia calabura	Calabur
	+Pyrus communis	Pear
	Syzygium malaccense	Malay-apple
Bactrocera tau (continued)	***Trichosanthes anguina*	Snake gourd
	Note: Numerous unconfirmed records exist of other possible hosts. Kapoor, 1993, lists some of these hosts. The ones listed here are hosts from which this species has been verified.	
Bactrocera trilineola	All hosts from: * (from the Pacific Fruit Fly Web at <www.pacificfly.org/Species_profiles>)	
	* *Anacardium occidentale*	Cashew
	* *Annona muricata*	Soursop
	* *Artocarpus altilis*	Breadfruit
	* *Averrhoa carambola*	Carambola
	* *Carica papaya*	Papaya
	* *Citrus limon*	Lemon (smooth)
	* *Citrus maxima*	Pomelo
	* *Citrus sinensis*	Orange
	* *Eugenia uniflora*	Surinam cherry
	* *Fortunella japonica*	Kumquat
	* *Inocarpus fagifer*	Tahiti chestnut
	* *Mangifera indica*	Mango
	* *Musa x paradisiaca*	Plantain
	* *Persea americana*	Avocado

Fruit Fly Species	HOST Scientific Name	Common Name
	** Pometia pinnata*	Pacific lychee
	** Psidium guajava*	Guava
	** Syzygium elusiifolium*	—
	** Syzygium jambos*	Rose-apple
	** Syzygium malaccense*	Mountain apple*
	** Terminalia catappa*	Tropical almond
Bactrocera trivialis	* (from the Pacific Fruit Fly Web at <www.pacificfly.org/Species_profiles>)	
	Capsicum frutescens	Tabasco pepper
	** Citrus x paradisi*	Grapefruit
	** Mangifera indica*	Mango
	Prunus persica	Peach
	Psidium guajava	Common guava
Bactrocerus tryoni	A very serious pest ot hosts in many different plant families. There are over 150-200 hosts. Only those given as "Superior" in BASS (undated (a))are listed here. Reference to the complete list will be necessary for program purposes. See also the Pacific Fruit Fly Web at <www.pacificfly.org/Species_profiles>) for a host list of South Pacific hosts.	
	Citrus aurantium	Sour Orange
	Citrus limon	Lemon
	Citrus paradisi	Grapefruit
	Citrus reticulata	Mandarin Orange
	Citrus sinensis	Sweet Orange
	Cydonia oblonga	Common quince
	Diospyros kaki	Persimmon
	Eriobotrya japonica	Loquat
	Eugenia spp.	Eugenia
	Eugenia uniflora	Brazilian cherry
	Feijoa sellowiana	Feijoa
	Fortunella japonica	Kumquat
	Glochidion ferdinandii	Garden plum
	Juglans regia	Walnut
	Lycopersicon esculentum	Tomato
	Mangifera indica	Mango
	Malus sylvestrus	Apple
	Morus alba	White mulberry
	Morus nigra	Black mulberry
	Passiflora quadrangularis	Granadilla

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Phoenix dactylifera	Date palm
	Prunus armeniaca	Apricot
	Prunus avium	Cherry
	Prunus domestica	Plum
	Prunus persica	Peach
	Prunus persica var. nectaarina	Nectarine
	Psidium cattleianum	Cherry guava
	Psidium granatum	Pomegranate
	Pyrus communis	Pear
	Rauwenhoffa leichhardtii	Bluebelly sapsucker
	Rubus fruticosus	Blackberry
	Sideroxylon australe	Black apple
	Terminalia catappa	Tropical almond
	Terminalia melanocarpa	Myrobalan
	Terminalia muelleri	Myrobalan
	Zizyphus mauritiana	Chinese apple
	Recorded from 60 wild hosts belonging to 25 different plant families. This very wide host range enables the species to build up large populations in forested areas, which are thus reservoirs for attacking commercial or garden crops.	
Bactrocera tsuneonis	*Citrus aurantium*	Sour orange
	Citrus kinokuni (Oakley, 1950)	—–
	Citrus paradisi (Oakley, 1950)	Grapefruit
	Citrus reticulata	Tangerine
	Citrus sinensis	Sweet orange
	Citrus tangerina	Tangerine
	Fortunella x crassifolia	Meiwa kumquat
	Fortunella japonica	Round kumquat
	Fortunella margarita	Oval kumquat
Bactrocera tuberculata	*Mangifera indica*	Mango
	Prunus persica	Prunus persica
Bactrocera umbrosa	*Artocarpus altilis*	Breadfruit
	Artocarpus heterophyllus	Jackfruit
	* *Artocarpus odoratissima* (Tigvattananont, 1986)	—–
	Artocarpus integer	Chempedak

Fruit Fly Species	HOST Scientific Name	HOST Common Name
	Artocarpus polyphemus (Oakley, 1950)	——
	Citrus aurantium	Sour orange
	Citrus maxima	Pummelo
	Citrus paradisi (Oakley, 1950)	Pomelo
	Citrus sinensis (Oakley, 1950)	Orange
	Momordica charantia	Bitter gourd
	Passiflora quadrangularis	Giant granadilla
	** Polycias sp. (Vagalo, et al, 1997)*	——
Bactrocera xanthodes	* (from the Pacific Fruit Fly Web at www.pacificfly.org/Species_profiles **(from Simmons, 1935) + (from Laiti, et al., 2002)	
	+Annona reticulata	Soursop
	***Anona sativus*	Cucumber??
	Ananas comosus	Pineapple
	Artocarpus altilis	Breadfruit
	** Artocarpus heterophyllus*	Jackfruit
	** Barringtonia edulis*	——
	** Burckella richii*	——
	Capsicum annuum	Bell pepper
	Carica papaya	Papaya
	Citrullus lanatus	Watermelon
	***Citrus decumara*	
	Citrus grandis (Oakley, 1950)	Pummelo
	** Citrus maxima*	Pomelo
	Citrus paradisi (Oakley, 1950)	Grapefruit
	Citrus reticulata	Mandarin
	** Excoecaria agallocha*	——
	Hibiscus tiliaceus	Sea hibiscus
	Lycopersicon esculentum	Tomato
	Mammea americana	Manny-apple
	Mangifera indica	Mango
	** Ochrosia oppositifolia*	——
	Passiflora quadrangularis	Giant granadilla

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Persea americana (Oakley, 1950)	Avocado
	Pometia pinnata	Lychee
	+Pouteria cainito	Abiu
	Psidium guajava	Guava
	+Terminalia catappa	Tropical almond
	Wild Hosts Hosts have been recorded in the following plant families:	
	Apocynaceae	Euphorbiaceae
	Sapotaceae	
Bactocera zonata	*Abelmoschus esculentus*	Okra
	Aegle marmelos	Indian bael
	Annona squamosa	Sugar-apple
	Carica papaya	Papaya
	Citrullus lanatus	Watermelon
	Citrus sinensis	Sweet orange
	Cucumis melo	Melon
	Cydonia oblonga	Quince
	Ficus carica	Common fig
	Grewia asiatica	Phalsa
	Lagenaria siceraria	White-flowered gourd
	Luffa sp.	——
	Lycopersicon esculentum	Tomato
	Malus domestica	Apple
	Malus pumila	Paradise apple
	Mangifera indica	Mango
	Manikara zapota	Sapodilla
	Momordica charantia	Bitter gourd
	Phoenix dactylifera	Date palm
	Prunus domestica	Plum (Grewal & Kapoor, 1986)
	Prunus persica	Peach
	Psidium guajava	Common guava
	Punica granatum	Pomegranate
	Pyrus communis	Pear (Grewal & Kapoor, 1986)
	Solanum melongena	Eggplant
	Terminalia catappa	Tropical almond

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Ziziphus jujube	Common jujube
Capparimyia savastani	*Capparis spinosa*	Caper
Carpomya incompleta	*Ziziphus jujube*	Common jujube
	Ziziphus lotus	Lotus
	Ziziphus sativus	——
	Ziziphus spina-christi	Christ's thorn
Carpomya vesuviana	*(?) Psidium guajava*	Common guava
	Ziziphus jujube	Common jujube
	Ziziphus mauritiana	Indian jujube
	Ziziphus nummularia	——
	Ziziphus rotundifolius	——
	Ziziphus sativus	——
Ceratitis anonae	# from Oakley, 1950	
	# Anisophyllea laurina	——
	Annona muricata	Soursop
	Coffea canephora	Robusta coffee
	# Cola sp.	——
	# Conopharyngia sp.	——
	Mangifera indica	Mango
	# Myrianthus arboreus	——
	Persea americana	Avocado
	Persea littorale	Strawberry guava
	# Psidium cattleianum	Strawberry guava
	Psidium guajava	Common guava
	# Spondias mombin	Yellow mombin
	Terminalia catappa	Tropical almond
	# Theobroma cacao	Cacao
Ceratitis capitata	This species has the greatest host range of any of the Tephritidae, owing, in part to its presence in many parts of the world and the invasion of many other areas. There are over 400 known hosts. Of these, only those hosts listed in BASS, 1985 as "Superior" are given here for program purposes. A complete host list is given in Liquido, et al., 1991). Recently, it was revealed that Medfly develops enormous populations in Argan Forests in the Middle East, from which it probably evolved and from which it spreads to citrus and other hosts in the area (Debouzie & Mazih, 1999). +Uchoa-Fernandes, 2002. Included because it is from Brazil and involves some hosts not otnerwise reported.	
	Argania spinosa	Argan tree

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Blighia sapida	Akee
	Calophyllum inophyllum	Indian laurel
	+Campomanesia sessiflora	Guavria
	Carica quercifolia	Dwarf papaya
	Casimiroa edulis	White sapote
	Chrysophyllum cainito	Star apple
	Chrysophyllum oliviforme	Satin leaf
	Chrysophyllum polynesicium	Chrysophyllum
	Citrus aurantium	Sour orange
	Citrus grandis	Pommelo
	Citrus limettioides	Sweet lime
	Citrus limon	Lemon
	Citrus limonia	Oataheite orange
	Citrus meyeri	Meyer lemon
	Citrus paradisi	Grapefruit
	Citrus reticulata	Tangerine
	Citrus reticulata x Citrus sinensis	King orange
	Citrus reticulata x Fortunella sp.	Calamondin orange
	Citrus sinensis	Sweet orange
	Coffea canephora	Robusta coffee
	Coffea liberica	Liberian coffee
	Cydonia oblonga	Common quince
	Diospryos decandra	Persimmon
	Diospryos kaki	Japanese persimmon
	Dovyalis caffra	Kei-apple
	Eriobotrya japnoica	Loquat
	Eugenia dombeyi	Spanish cherry
	Eugenia uniflora	Surinam cherry
	Feijoa sellowiana	Feijoa
	Ficus carica	Common fig
	Fortunella japonica	Kumquat
	Geoffroea decorticans	Chanar
	+Inga laurina	Inga
	Juglans spp.	Walnut
	Malpighia glabra	Barbados cherry
	Malus sylvestris	Apple

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Mangifera indica	Mango
	Mespilus germanica	Medlar
	Micropholis mexicana	Baricoco
	Mimusops elengi	Spanish cherry
	Murray paniculata	Orange jasmine
	Persea americana	Avocado
	Prunus americana	American plum
	Prunus armeniaca	Apricot
	Prunus domestica	Common plum
	Prunus domestica var. *insitita*	Damson plum
	Prunus persica	Peach
	Prunus persica var. *nectarina*	Nectarine
	Psidium cattleianum	Strawberry guava
	Psidium guajava	Common guava
	Pyrus communis	Pear
	Strychnos spinosa * (Dubois, 1965)	——
	Syzygium jambos	Rose apple
	Syzygium malaccense	Malay apple
	Terminalia catappa	Tropical almond
	Terminalia chebula	Black myrobalan
Ceratitis catoirii	# from Oakley, 1950	
	Annona reticulata	Custard-apple
	Averrhoa carambola	Carambola
	Capsicum annuum	Bell pepper
	# Capsicum frutescens	Chili pepper
	Carica papaya	Papaya
	# Citrus aurantifolia	Lime
	# Citrus grandis	Pummelo
	(?) Citrus maxima	Pummello
	# Citrus medica	Citron
	Citrus reticulata	Tangerine
	# Citrus sinensis	Sweet orange
	Eriobotrya japonica	Loquat
	# Eugenia aquea	——
	# Eugenia jambos	Malabar plum
	Eugenia uniflora	Surinam cherry
	(?) Fllacourtia indica	Governer's plum

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Lycopersicon esculentum	Tomato
	Mangifera indica	Mango
	Manikara zapota	Sapodilla
	# Passiflora quadrangularis	Giant granadilla
	Persea americana	Avocado
	Prunus persica	Peach
	Prunus persica nectarina	Nectarine
	Psidium cattleyanum	Strawberry guava (Etienne, 1973)
	Psidium guajava	Common guava
	Psidium littorale	Strawberry guava
	Punica granatum	Pomegranate
	(?) Spondias cumini	Java plum
	(?) Spondias dulcis	Jew plum
	Syzygium aqueum	Rose-apple
	Terminalia catappa	Tropical almond
	Ziziphus jujube	Common jujube
Ceratitis colae	# from Oakley, 1950. Notes: Chiefly a pest of Kola fruit. Guava heavily infested some years. Slight infestation in oranges.	
	# Chrysophyllum albidum	–––
	# Citrus sinensis	Oranges
	# Coffea arabica	Arabian coffee
	Cola acuminata	Abata cola
	# Dovyalis caffra	Key-apple
	# Eriobotrya japonica	Loquat
	# Eugenia jambos	Rose apple
	# Myrianthus arboreus	–––
	# Podocarpus gracilior	–––
	# Prunus persica	Peach
	# Psidium cattleianum	Strawberry guava
	# Psidium guajava	Guava
	# Rawsonia usambarensis	–––
	# Rubus spp.	Blackberry
	# Sersalisia usambarensis	–––

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
Ceratitis cosyra	# From Oakley, 1950 ## From Steck, 2000 * From Dubois, 1965	
	# *Acokanthera longiflora*	——
	## *Anisopyllea laurina*	——
	## *Annona cherimola*	Cherimoya
	## *Annona reticulata*	Custard apple
	Annona senegalensis	Wild custard-apple
	## *Chrysolbalanus* sp.	
	Citrus aurantium	Sour orange
	# *Conopharyngia penduliflora*	——
	# *Cordyla africana*	——
	## *Diospyros mespiliformis*	
	## *Dovyalis caffra*	Kei apple
	* *Fortunella margarita*	Kumquat
	Landophia sp.	
	Mangifera indica	Mango
	# *Nauclea esculenta*	——
	## *Nauclea latifolia*	
	## *Parinari mobola*	
	Persea americana	Avocado
	* *Poupartia caffra*	——
	Prunus persica	Peach
	Psidium guajava	Common guava
	Rollinia sieberi	
	Saba senegalensis	
	## *Sarcocephalus esculentus*	
	Sclerocarya birrea	Maroola plum
	# *Sclerocarya caffra*	——
	# *Sersalisia usambarensis*	——
	* *Spondias cythera*	Otaheite apple
	## *Uapaca kirkiana*	
	# *Warburgia ugandensis*	——
		Wild Hosts
	A highly polyphagous species recorded from: wild species of:	

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Apocynaceae	Canellaceae
	Chrysobalanaceae	Ebenaceae
	Euphorbiaceae	Fabaceae
Ceratitis malgassa	*Citrus* sp.	Orange
	Citrus reticulata	Mandarin orange
	Eugenia malaccensis *(Dubois, 1965)	Malay apple
	Eugenia jambos * (Dubois, 1965)	Rose apple
	Malus domestica	Apple
	Myristica fragrans	Nutmeg
	*Nephelium lappaceum * (Dubois, 1965)*	Rambutan
	Persea gratissima (Dubois, 1965)*	Aguacate
	*Prunus domestica * (Dubois, 1965)*	Plum
	Prunus persica	Peach
	*Psidium cattleianum * (Dubois, 1965)*	Strawberry guava
	Psidium guava	Common guava
	*Pyrus communis * (Dubois, 1965)*	Pear
	*Poupartia caffra * (Dubois, 1965)*	—
	Sclerocarya birrea	Maroola plum
	*Strychnos spinosa * (Dubois, 1965)*	—
Ceratitis pedestris	*Lycopersicon esculentum*	Tomato
	Strychnos spp.	——
Ceratitis punctata	# from Oakley, 1950.	
	Chrysophyllum albidum	White star-apple
	# Chrysophyllum pruniforme	——
	Coffea arabica	Arabica coffee
	# *Conopharyngia* sp.	——
	Cucumis melo	Melon
	# *Landolphia* sp.	——
	Mangifera indica	Mango
	# Napoleona imperailis	—
	Passiflora sp.	Granadilla

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	# Passiflora edulis	Passion-fruit
	# Persea americana	Avocado
	# Plumeria longifolia	——
	Psidium guajava	Common guava
	# Sersalisia usambarensis	——
	Theobroma cacao (Gowdey, 1913)	Cocoa
	Wild Hosts Recorded from some wild species of:	
	Apocynaceae	Passifloraceae
Ceratitis quinaria	*Citrus* spp.	Citrus
	Ficus sp.	Fig
	Prunus armenicaca	Apricot
	Prusus persica	Peach
	Psidium guajava	Common guava
	Ziziphus spina-christi	Christ's thorn
Ceratitis rosa	# from Oakley, 1950	
	Annona muricata	Soursop
	Annona reticulata	Custard-apple
	Averrhoa carambola	Carambola
	Capsicum frutescens	Tabasco pepper
	Carica papaya	Papaya
	Carissa macrocarpa	Natal plum
	Chrysophyllum albidum	White star-apple
	Citrus aurantium	Sour orange
	Citrus x paradisi	Grapefruit
	Citrus reticulata	Tangerine
	Citrus sinensis	Valencia oranges
	Coffea arabica	Arabica coffee
	Cydonia oblonga	Quince
	Diospyros virginiana	Common persimmon
	Dovyalis caffra	Kei apple
	Eriobotrya japonica	Loquat
	# Eugenia cordata	——
	Eugenia uniflora	Surinam cherry
	Ficus carica	Common fig
	Garcinia livingstonei	Imbe
	Garcinia mangostana	Mangosteen
	Litchi chinensis	Lychee

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Lycopersicon esculentum	Tomato
	Malus domestica	Apple
	# Malus sylvestris	Crabapple
	Mangifera indica	Mango
	Manilkara jujuba	Sapodilla
	(?) Musa nana or Musa x paradisiaca	Banana
	Opuntia ficus-indica	Indian fig prickly pear
	Opuntia tuna	Elephant-ear prickly pear
	(?) Persea gratissima or *Persea americana*	Aguacate or Avocado
	Prunus armeniaca	Apricot
	Prunus domestica	Plum
	Prunus persica	Peach
	# Prunus persica var. nucipersica	Nectarine
	Psidium guajava	Common guava
	Psidium littorale	Strawberry guava
	Pyrus communis	Pear
	Rubus fruticosa	Blackberry
	Solanum auriculatum	Bug tree
	# Solanum giganteum	——
	Syzygium aqueum	Watery rose-apple
	Syzygium cumini	Java plum
	Syzygium jambos	Rose-apple
	Syzygium malaccense	Malay-apple
	Terminalia catappa	Tropical almond
	Theobroma cacao	Cocoa
	Vitis vinifera	Wine grape
	Ziziphus jujuba	Common jujube
		Wild Hosts
	This species has been recorded from wild species of:	
	Cecropiaceae	Euphorbiaceae
	Flacourtiaceae	Loganiaceae
	Myrtaceae	Podocarpaceae
	Rubiaceae	Rutaceae
	Sapotaceae	
Ceratitis rubivora	# Oakley, 1950. Note: White & Elston-Harris, 1992 state that records not from Rubus spp. may have been based on misidentifications.‘	
	(?) Chrysophyllum cainito	Star-apple

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	# Coffea arabica	Arabian Coffee
	# Deinbollia sp.	——
	# Myrianthus arbovorus	——
	# Persea americana	Avocado
	# Prunus persica	Peach
	# Psidium guajava	Guava
	# Rawsonia usambarensis	——
	Rubus flagellaris x R. loganobaccus	Youngberry
	Rubus fruticosa	Blackberry
	Rubus idaeus	Raspberry
	Rubus loganobaccus	Loganberry
Dacus axanus	*Luffa aegyptiaca*	Luffa
	Trichosanthes cucumerina	Snakegourd
Dacus bivittatus	# from Oakley, 1950.	
	# (?) Adenia sp.	——
	Carica papaya	Papaya
	Citrullus lanatus	Watermelon
	# Citrus limon	Lemon
	# Coccinia palmata	——
	Coffea sp.	Coffee
	Cucumeropsis mannii	White egusi
	Cucumis melo	Canterloupe
	Cucumis metuliferus	African horned cucumber
	Cucumis sativus	Cucumber
	Cucurbita maxima	Squash
	Cucurbita pepo	Pumpkin
	# Dioscorea macroura	A Yam
	Lagenaria siceraria	White-flowered gourd
	Luffa aegyptiaca	Luffa
	Lycopersicon esculentum	Tomato
	# Mangifera indica	Mango
	Momordica charantia	Bitter gourd
	# Momordica involucrata	——
	Passiflora quadrangularis	Giant granadilla
	# Peponium sp.	——
	# Peponium mackenii	——
	# Peponium vogelii	——

Fruit Fly Species	HOST Scientific Name	Common Name
	Sechium edule	Chayote
	# Sphaerosicyos sphaericus	—–
	Telfairea pedata	Oysternut
	# Vitex sp.	—–
		Wild Hosts
	Many species of Cucurbitaceae, such as:	
	Momordica spp.	*Peppmium* spp.
Dacus ciliatus	# from Oakley, 1950 * from BASS, undated (b)	
	Abelmoschus esculentus	Okra
	** Asclep8as syriaca*	Common milkweed
	** Benincasa hispida*	Wax gourd
	** Capsicum annuum*	Capsicum pepper
	Capsicum sp.	A pepper
	Citrullus colocynthis	Colocynth
	Citrullus lanatus	Watermelon
	# Citrus aurantium	Sour orange
	# Citrus paradisi	Grapefruit
	# Citrus reticulata	Mandarin
	# Citrus sinensis	Orange
	# Coccinia adoensis	—–
	# Coccinia cordifolia	—–
	# Coccinia palmata	—–
	# Coccinia quinqueloba	—–
	# Cucumis africanus	—–
	** Cucumis anguria*	West Indian gherhin
	** Cucumis lanatus*	Round melon
	Cucumis melo	Cantaloupe
	Cucumis melo	Melon
	Cucumis metuliferus	African horned cucumber
	# Cucumis myriocarpus	—–
	Cucumis sativus	Cucumber
	** Cucumis utilissimus*	Long melon
	Cucurbita maxima	Squash
	Cucurbita maxima	Pumpkin
	** Cucubita mixta*	Pumpkin
	# Cucurbita moschata	Pumpkin
	Cucurbita pepo	Squash

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Cucurbita pepo ovifera	Yellow-flowered gourd
	** Gliricidia septium*	Madre
	** Gossypium hirsutum*	Cotton
	Gossypium sp.	Cotton
	Horedum vulgare	Barley
	Lagenaria siceraria	White-flowered gourd
	Luffa acutangula	Angled luffa
	Luffa aegyptiaca	Luffa
	Lycopersicon esculentum	Tomato
	** Malus sylvestris*	Apple
	Momordica balsamina	Balsam apple
	Momordica charantia	Bitter gourd
	# Momordica involucrata	——
	# Momordica schimperiana	——
	** Olea europaea*	Olive
	# Passiflora caerulea	Blue passionflower
	Phaseolus spp.	Beans
	# Phaseolus vulgaris	String Bean
	Sechium edule	Chayote
	# Trichosanthes anguina	Serpant cucumber
	** Trichosanthes anguina*	Snakegourd
	Trichosanthes cucumerina	Snakegourd
	Triticum aestivum	Wheat
	Many species of Cucurbitaceae	Wild Hosts
Dacus demmerezi	*Citrullus lanatus*	Watermelon
	Cucumis melo	Melon
	Cucumis sativus	Cucumber
	Cucurbita maxima	Pumpkin, squashes
	Cucurbita pepo	Pumpkin
	Lagenaria siceraria	White-flowered gourd
	Luffa acutangula	Luffa
	Melothria sp.	——
	Momordica charatia	Bitter gourd
	Sechium edule	Chayote
	# Trichosanthes anguina (Oakley, 1950)	Serpant cucumber
	Trichosanthes cucumerina	Snakegourd

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
Dacus frontalis	All cultivated curcurbits are attacked (Steffens, 1983)	
	Citrullus colocynthis	Colocynth
	Citrullus lanatus	Watermelon
	Coccinia sp.	A gourd
	Cucumiz anguaria (Steffens, 1983)	West Indian Gerkin
	Cucumis melo	Sweet melon
	Cucumis sativus	Cucumber
	Cucurbita pepo	Pumpkin
Dacus lounsburyii	*Citrullus lanatus*	Watermelon
	Cucumis melo	Melon
	Cucurbita pepo	Pumpkin
Dacus punctatifrons	*Cucumis sativus*	Cucumber
	Cucurbita pepo	Pumpkin
	Gloriosa sp.	——
	Momordica charantia	Bitter gourd
	Passiflora foetida	Watermelon
	Sechium edule	Chayote
		Wild Hosts
	Bryanopsis spp.	*Melothria* spp.
	Momordica spp.	*Peponium* spp.
Dacus smieroides	*Luffa acutangula*	Angled luffa
Dacus solomonensis	* (from the Pacific Fruit Fly Web at www.pacificfly.org/Species_profiles	
	** Calophyllum inophyllum*	Indian laurel
	Cucumis sativus	Cucumber
	Cucurbita pepo	Pumpkin
	** Trichosanthes cucumerina*	Snake gourd
Dacus telfaireae	*(?) Lagenaria*	A Gourd
	Telfairea pedata	Oysternut
Dacus vertebratus	*Citrullus lanatus*	Watermelon
	Citrullus vulgaris (Oakley, 1950)	Watermelon
	Coccinia spp. (Oakley, 1950)	Gourds
	Cucumeropsis mannii	White egusi
	Cucumis melo	Cantaloupe
	Cucumis myriocarpus (Oakley, 1950)	——

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Cucumis sativus	Cucumber
	Cucurbita maxima	Squash
	Cucurbita pepo var. *(Oakley, 1950)*	Pumpkin & marrows, Kaffir melon, and gourds.
	Passiflora spp.	Granadilla
	Momordica spp.	——
Dirioxa pornia	*Chrysophyllum cainito*	Star apple
	Chrysophyllum pruniferum	———
	x Citroncirus webberi	Citrange
	Citrus sp.	Orange
	Citrus limon	Lemon
	Citrus maxima	Pummelo
	Citrus reticulata	Mandarin orange
	Cydonia oblonga	Quince
	Diospyros sp.	Persimmon
	Feijoa sellowiana	Feijoa
	Malus domestica	Apple
	Mangifera indica	Mango
	Morus sp.	Mulberry
	Passiflora sp.	Passion fruit
	Planchonella australis	———
	Poncirus trifoliata	Trifoliate orange
	Prunus domestica	Plum
	Prunus persica	Peach
	Pyrus communis	Pear
	Pyrus pyrifolia	Sand pear
	Sideroxylon sp.	———
Wild Hosts Wild species found in the following plant families:		
	Fabaceae	Lauraceae
	Sapotaceae	
Epochra canadensis	*Ribes spp.*	Currants
	Ribes aureum	Golden currant
	Ribes nigrum	Blackcurrant
	Ribes rubrum	Redcurrant
	Ribes uva-crispa	Gooseberry
Monacrostichus citricola	*Citrus limetta*	Lime
	Citrus limon	Lemon
	Citrus maxima	Pummelo
Myiopardalis pardalina	*Citrullus lanatus*	Watermelon

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
	Cucumis melo	Melon
	Cucumis sativus	Cucumber
	Ecballium elaterium	Squirting cucumber
	Prunus persica	Peach
Rhagoletis cerasi	*(?) Berberis vulgaris*	Berberis
	Lonicera spp.	Wild honeysuckle
	(?) Lycium barbarum	Barbary matrimony vine
	Prunus spp.	Wild cherries
	Prunus avium	Sweet cherry
	Prunus cerasus	Sour cherry
	Prunus mahaleb	Mahaleb cherry
	Prunus serotina	Black cherry
	(?) Vaccinium myrtillus	Bilberry
Rhagoletis cingulata	*Prunus avium*	Sweet cherry
	Prunus cerasus	Sour cherry
	Prunus mahaleb	Mahaleb cherry
	Prunus serotina	Black cherry
	Prunus pensylvanica	Pin cherry
	Prunus virginiana	Chokecherry
Rhagoletis completa	*Juglans californica*	California walnut
	Juglans hindsii	Hind’s walnut
	Juglans nigra	Black walnut
	Juglans regia	English walnut
	Prunus persica	Peach
Rhagoletis conversa	*Physalis philadelphica*	Husk-tomato
	Solanum nigrum	Black nightshade
	Solanum tomatillo	Tomatill
Rhagoletis fausta	*Prunus avium*	Sweet cherry
	Prunus cerasus	Sour cherry
	Prunus pensylvanica	Pin cherry
	Prunus serotina	Black cherry
	Prunus virginiana	Chokecherry
Rhagoletis indifferens	*Prunus avium*	Sweet cherry
	Prunus cerasus	Sour cherry
	Prunus salicina	Japanese plum
	Prunus subcordata	Klamath plum
	Prunus virginiana	Chokecherry
Rhagoletis juglandis	*Juglans major*	Arizona walnut
	Juglans regia	English walnut

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
Rhagoletis lycopersella	*Lycopersicon esculentum*	Tomato
	Lycopersicon pimpinellifolium	Currant tomato
Rhagoletis mendax	* from *Geddes*, et al., 1987	
	**Amelanchier bartramiana*	Dwarf serviceberry
	**Cornus canadensis*	Bunchberry
	Gaultheria procumbens	Wintergreen
	Gaylussacia baccata	Black huckleberry
	Gaylussacia dumosa	Dwarf huckleberry
	Gaylussacia frondosa	Dangleberry
	Prunus sp.	Wild plum
	**Pyrus melanocarpa*	Chokeberry
	Vaccinium angustifolium	Lowbush blueberry
	Vaccinium corymbosum	Highbush blueberry
	Vaccinium macrocarpon	Cranberry
	Vaccinium myrtilloides	Sourtop blueberry
	**Vaccinium vaccilans*	Early sweet blueberry
	Vaccinium vitis-idaea	Mountain cranberry
Rhagoletis nova	*Solanum muricatum*	Sweet cucumber
Rhagoletis pomonella	*Crataegus* sp.	Ornamental hawthorns
(Kroening, et al, 1989)	*Crataegus rivularis*	Hawthorn
	Malus baccata	Siberian Crabapple
	Malus domestica	Apple
	Prunus angustifolia	Chickasaw plum
	Prunus armeniaca	Apricot
	Prunus avium	Sweet cherry
	Prunus cerasus	Sour cherry
	Prunus persica	Peach
	Pyrus communis	Pear
	Rosa carolina	Pasture rose
	Rosa rugosa	Japanese rose
	Sorbus aucupaira	Rowan
	Wild hosts in Rosaceae:	Wild Hosts
	Amelanchier spp.	*Aronia* spp.
	Cotoneaster spp.	
Rhagoletis ribicola	*Ribes aureum*	Golden currant
	Ribes rubrum	Redcurrant
	Ribes uva-crispa	European gooseberry

	HOST	
Fruit Fly Species	**Scientific Name**	**Common Name**
Rhagoletis striatella	*Physalis lanceolata*	Long leaf ground-cherry
	Physalis philadelphica	Husk tomato
Rhagoletis suavis	*Juglans ailantifolia*	Japanese walnut
	Juglans cinerea	Butternut
	Juglans nigra	Black walnut
	Juglans regia	English walnut
	Prunus persica	Peach
Rhagoletis tabellaria	*Cornus amomum*	Silky dogwood
	Cornus stolonifera	red-osier dogwood
	Vaccinium macrocarpon	Cranberry
Rhagoletis tomatis	*Lycopersicon esculentum*	Tomato
Toxotrypana curvicauda	*Carica papaya*	Papaya
	** Gonolobus erianthus (Landolt, 1994)*	Talayote
	** Gonolobus sorodius Landolt, 1994)*	A Milkweed
	(?) Mangifera indica	Mango
	** Morrenia odorata (Landolt, 1994)*	A Milkweed
Trirhithromyia cyanescens	*Capsicum annuum*	Bell pepper
	Capsicum frutescens	Tabasco pepper
	Eriobotrya japonica	Loquat
	Lycopersicon esculentum	Tomato
	Solanum auriculatum	—
	Solanum erythracanthum	—
	Solanum melongena	Eggplant
	Solanum nigrum	Black nightshade
Trirhithrum coffeae	*Coffea arabica*	Arabica coffee
	Coffea canephora	Robusta coffee
Trirhithrum nigerrimum	*Coffea arabica*	Arabica coffee
	Coffea canephora	Robusta coffee
	(?) Erythroxylum coca	Coca
	(?) Eugenia uniflora	Surinam cherry
Zonosemata electa	*Capsicum annuum*	Bell pepper
	Capsicum frutescens	Tabasco pepper
	Lycopersicon esculentum	Tomato
	Solanum aculeatissimum	Soda-apple nightshade
	Solanum carolinense	Horsenettle
	Solanum elaeagnifolium	Silverleaf nightshade
	Solanum melongena	Eggplant

D

Manual Name

Appendix D

Technical Survey Information

Cross Transit Survey

Draw two straight lines on a map that will intersect each other and run through:

- High Risk suburban/urban areas whose residents are likely to travel to Tephritid-infested areas.
- Host Production Areas.
- Areas where hosts are in abundance (Backyards, etc.).
- Coastal areas where hosts are available.

The lines should both bisect the area under survey. They do not need to be perpendicular to each other, but should both run through the most suitable local sites that have been identified.

Survey Procedures

For fruit flies, survey systems consist of trapping, fruit collection, fruit cutting and soil screening. The greatest effort goes into trapping of adults. During winter months, the effort may shift to fruit collection (if available) and soil screening, generally to hunt for the overwintering stage of the target fruit fly.

Inspection Procedures

Trappers will make routine inspections of traps for the target fruit fly and be familiar with the appearance of the adult stage. While in the field, properly store and label suspect specimens, then take in for identification.

For egg and larval stages, take samples in this order:

- from fallen fruit
- overripe fruit
- ripe fruit or fruit at the right stage of development if the target fruit fly attacks green fruit
- nearby overripe fruit or (green) fruit with blemishes or stings

Any hard, mummified fruit must be collected, as trapped larvae can pupate within and come out only when they can escape, thus resulting in much delayed emergence.

For pupae, take soil samples from suspect hosts. Unless they can be identified, take eggs, larvae, and pupae into a quarantine lab for rearing and identification

Traps

The following table lists, as far as is known, the pheromone requirements of each species. Note that for many species an attractant is not known, and more reliance must be made on food type attractants and larval surveys.

For a complete list of fruit fly species that respond or do not respond to known attractants, refer to the FAO Action Plan for Peach Fruit Fly, Addendum I (Gomes, 2000) at:

http://www.iaea.org/programmes/nafa/d4/public/zonata-actionplan.pdf

All pheromones were taken from White & Elson-Harris, 1992 and Drew & Hancock, 1994, unless otherwise indicated.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Anastrepha antunesi		Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	1. 6 torula yeast pellets or PIB-7 + water 2. Place in a favored host.
Anastrepha bistrigata	**See Literature?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	1. 6 torula yeast pellets or PIB-7 + water 2. Place in a favored host.
Anastrepha distincta	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	1. 6 torula yeast pellets or PIB-7 + water 2. Place in a favored host.
Anastrepha fraterculus	**See Literature?	Males: Females Females	1.McPhail Trap (APHIS, 1982b) and orange panel @ 590 nm (Aluja, 1994)	80-40-20-10-5	1. 6 torula yeast pellets or PIB-7 + water 2. Place in a favored host.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Anastrepha grandis	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.
Anastrepha leptozona	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.
Anastrepha ludens	Mexican Fruit Fly Lure**!! (Weaver, 1998) Check re or fermented yellow chapote 3.6x more attractive than yeast (Aluja, 1994). or E802 Mazoferm Steepwater 4x ,more attractive than NuLure	Females Males: Females	orange panel @ 590 nm (Aluja, 1994) McPhail Trap (APHIS, 1982b)	80-40-25-10-5	? 6 torula yeast pellets or PIB-7 + water or Mexican Food Lure 5. Food Lures a.(6) Steepwater b. Mexican Food Lure) Place in a favored host., in filtered sunlight, in 1' to 1!/2' free space with foliage & fruit around, in upper 1/2 of canopy
Anastrepha macrura	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.
Anastrepha obliqua	Human urine 10x more effective than torula yeast (Aluja, 1994)	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.
Anastrepha ocresia	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.
Anastrepha ornata	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.
Anastrepha pseudoparallela	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.
Anastrepha serpentina	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Anastrepha striata	Human urine 10x more effective than torula yeast (Aluja, 1994)	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.
Anastrepha suspensa	**Check on this	Males: Females Females	McPhail Trap (APHIS, 1982b orange panel @ 590 nm (Aluja, 1994)) orange balls: diameter 20cm (Aluja, 1994)	80-40-20-10-5	6 torula yeast pellets or PIB-7 or bird dung* + water Place in a favored host. *See Epsky, et al., 1996
Bactrocera albistrigata	Cue lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with ripening fruit.
Bactrocera aquilonis	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with ripening fruit.
Bactrocera atrisetosa	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Bactrocera carambolae	Methyl Eugenol	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick, 1989)	25-5-5-5-5 and 25 Core - 5 1st Buffer	1. 1. 6 ml ME + 1% Naled 2. 5 Torula yeast tablets or Miller's NU-LURE + borax in 600 ml water 3. Place traps in areas with more than one host and in the center of orchards, in shade, especially bearing fruit.
Bactrocera caryeae	Methyl Eugenol	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick, 1989)	25-5-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml ME + 1% Naled 2. 5 Torula yeast tablets or Miller's NU-LURE + borax in 600 ml water 3. Place traps in areas with more than one host and in the center of orchards, in shade, especially bearing fruit.
Bactrocera caudata	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Bactrocera correcta	Methyl Eugenol	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick, 1989)	25-5-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml ME + 1% Naled 2. 5 Torula yeast tablets or Miller's NU-LURE + borax in 600 ml water 3. Place traps in areas with more than one host and in the center of orchards, in shade, especially bearing fruit.
Bactrocera cucumis	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Bactrocera cucurbitae	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water or 200ml of 2% SolBait (Fabre, et al., 2003) 3. Place traps in a shady areas near major hosts
Bactrocera curvipennis	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Bactrocera decipiens	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.
Bactrocera depressa	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.
Bactrocera distincta	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Bactrocera diversa	Methyl Eugenol	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick, 1989)	25-5-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml ME + 1% Naled 2. 5 Torula yeast tablets or Miller's NU-LURE + borax in 600 ml water 3. Place traps in areas with more than one host and in the center of orchards, in shade, especially bearing fruit.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Bactrocera dorsalis	Methyl Eugenol	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick, 1989) or Ladd Trap (Crnelius, et al., 1999)	25-5-5-5-5 and 25 Core - 5 1st Buffer one per orhard	1. 6 ml ME + 1% Naled 2. 5 Torula yeast tablets or Miller's NU-LURE + borax in 600 ml water 3. Place traps in areas with more than one host and in the center of orchards, in shade, especially bearing fruit. Optimum trap height 1 meter (Ali, et al., 1999 Place Ladd traps in the center of orchards)
Bactrocera facialis	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Bactrocera frauenfeldi	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Bactrocera jarvisi	Cue Lure	Males weakly attracted or no response Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1982b)	100-50-50 80-40-20-10-5	1. 6 ml Cue in a 8:1 ratio of lure to 91% malathion 2. 6 torula yeast pellets or PIB-7 + water Place in a favored host.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Bactrocera kandiensis	Methyl Eugenol	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick, 1989)	25-5-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml ME + 1% Naled 2. 5 Torula yeast tablets or Miller's NU-LURE + borax in 600 ml water 3. Place traps in areas with more than one host and in the center of orchards, in shade, especially bearing fruit.
Bactrocera kirki	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	◆ 6 ml Cue + 1% Dibrom ◆ Yeast tablets or PIB-7 in water ◆ Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Bactrocera latifrons	Latilure (LTL)** (Stibick, 1993) Malay Fruit Fly Lure (Wood, 1999)	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick 1993)	100-50-50 50-50-50	1. Latilure, contact ARS, Hawaii Malaysian Fruit Fly Lure, a combination of alpha-ionol and cade oil, contact ARS Hawaii 2. Torula yeast tablets or Miller's NU-LURE + borax in 600 ml water To be used in place of LTL when not available. NOTE: Traps shold be placed in preferred hosts and only in other hosts if the former are not fruiting or not available.
Bactrocera melanota	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in a shady areas near major hosts
Bactrocera minax	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Bactrocera musae	Methyl Eugenol	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick, 1989)	25-5-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml ME + 1% Naled 2. 5 Torula yeast tablets or Miller's NU-LURE + borax in 600 ml water 3. Place traps in areas with more than one host and in the center of orchards, in shade, especially bearing fruit.
Bactrocera neohumeralis	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Bactrocera occipitalis	Methyl Eugenol	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick, 1989)	25-5-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml ME + 1% Naled 2. 5 Torula yeast tablets or Miller's NU-LURE + borax in 600 ml water 3. Place traps in areas with more than one host and in the center of orchards, in shade, especially bearing fruit.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Bactrocera oleae	Olean Lure** (Bueno, 1986) male sex attractant+ female aggregation pheromone + 50 g food (Haniotakis, et al., 1991)	Male:Female 10:1 (Bueno, 1986) Fewer Males: More Females (Haniotakis, et al., 1991)	1. Rebell Trap (Jones, et al., 1983) and 2. McPhail Trap (Bueno, 1986)	40-20-10-5-3 or 259 per mi2 in Core only and 80-40-20-10-5-3	25 mg.Olean Lure in 4 ml polyethylene vial or 50mg of racemic 1,7 dioxaspiro[5.5]undecane + 50ml of g(AI)/Liter of 1 g Decis, 100 g sugar, 100 g glycerine in 1 gm polyethyline vial or Vioryl dispensers 2. NuLure at 9% in aqueous solution plus Borax at 3% (Katsoyannos & Papadopoulos, 2003)
Bactrocera papayae	Methyl Eugenol	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick, 1989)	25-5-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml ME + 1% Naled 2. 5 Torula yeast tablets or Miller's NU-LURE + borax in 600 ml water 3. Place traps in areas with more than one host and in the center of orchards, in shade, especially bearing fruit.
Bactrocera passiflorae	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Bactrocera philippinensis	Methyl Eugenol	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick, 1989)	25-5-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml ME + 1% Naled 2. 5 Torula yeast tablets or Miller's NU-LURE + borax in 600 ml water 3. Place traps in areas with more than one host and in the center of orchards, in shade, especially bearing fruit.
Bactrocera psidii	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Bactrocera pyrifoliae	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.
Bactrocera tau	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Bactrocera trilineola	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with ripening fruit.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Bactrocera trivialis	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with ripening fruit.
Bactrocera tryoni	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick, 1990)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue in a 8:1 ratio of lure to 91% malathion. 2.Ammonium chloride & Miller's NU-LURE in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Bactrocera tsuneonis	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.
Bactrocera tuberculata	Methyl Eugenol	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick, 1989)	25-5-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml ME + 1% Naled 2. 5 Torula yeast tablets or Miller's NU-LURE + borax in 600 ml water 3. Place traps in areas with more than one host and in the center of orchards, in shade, especially bearing fruit.
Bactrocera umbrosa	Methyl Eugenol	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick, 1989)	25-5-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml ME + 1% Naled 2. 5 Torula yeast tablets or Miller's NU-LURE + borax in 600 ml water 3. Place traps in areas with more than one host and in the center of orchards, in shade, especially bearing fruit.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Bactrocera xanthodes	Methyl Eugenol	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick, 1989)	25-5-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml ME + 1% Naled 2. 5 Torula yeast tablets or Miller's NU-LURE + borax in 600 ml water 3. Place traps in areas with more than one host and in the center of orchards, in shade, especially bearing fruit.
Bactrocera zonata	Methyl Eugenol	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (Stibick, 1989)	25-5-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml ME + 1% Naled 2. 5 Torula yeast tablets or Miller's NU-LURE + borax in 600 ml water 3. Place traps in areas with more than one host and at the edges of orchards, in shade, especially bearing fruit. Optimum trap height 1 meter (Ali, et al., 1999)
Capparimyia savastani	?	?			
Carpomya incompleta	?	?			
Carpomya vesuviana	?	Males: Females	1. McPhail Trap (APHIS, 1982a, draft, 1993, Permalloo, et al., 2002)	25 Core - 5 1st Buffer	1. 200 ml in water of: 5% Protein Hydrolsate: 12.5% neutralised brewery waste and 2% ammonium chloride 2. Place traps in partly shaded open area (including fruiting hosts) with nearby food source, such as orchard edges, so winds blow scent to hosts.
Ceratitis anonae	?	Males: Females	McPhail Trap (APHIS, 1982b)	25 Core - 5 1st Buffer	1. 5 torula yeast tablets or 9% Miller NU-LURE + 5% Borax in water 2. Place traps in partly shaded open area (including fruiting hosts) with nearby food source, such as orchard edges, so winds blow scent to hosts.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Ceratitis capitata	Trimedlure (TML) minus-ceralure Terpinyl Acetate	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1982a, draft, 1993) NOTE: Sensus Trap used in Africa at present	100-50-25-20-10 and 25 Core - 5 1st Buffer NOTE: Sensus traps: use same ratios as above if tried .	1. 2 ml of TML in liquid or solid form (plug) 2. 5 torula yeast tablets or 9% Miller NU-LURE + 5% Borax in water or Medfly food lure (5. Food lures d.) 3. Place traps in partly shaded open area (including fruiting hosts) with nearby food source, such as orchard edges, so winds blow scent to hosts NOTE: Sensus traps are serviced once per season..
Ceratitis catoirii	?	Males: Females	1. McPhail Trap (APHIS, 1982a, draft, 1993)	25 Core - 5 1st Buffer	1. 5 torula yeast tablets or 9% Miller NU-LURE + 5% Borax in water 2. Place traps in partly shaded open area (including fruiting hosts) with nearby food source, such as orchard edges, so winds blow scent to hosts.
Ceratitis colae	?	Males: Females	1. McPhail Trap (APHIS, 1982a, draft, 1993)	25 Core - 5 1st Buffer	1. 5 torula yeast tablets or 9% Miller NU-LURE + 5% Borax in water 2. Place traps in partly shaded open area (including fruiting hosts) with nearby food source, such as orchard edges, so winds blow scent to hosts.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Ceratitis cosyra	Terpinyl Acetate	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1982a, draft, 1993) NOTE: Sensus Trap used in Africa at present	100-50-25-20-10 and 25 Core - 5 1st Buffer NOTE: Sensus traps: use same ratios as above if tried .	1. 2 ml of Terpinyl Acetate 2. 5 torula yeast tablets or 9% Miller NU-LURE + 5% Borax in water 3. Place traps in partly shaded open area (including fruiting hosts) with nearby food source, such as orchard edges, so winds blow scent to hosts. NOTE: Sensus traps are serviced once per season..
Ceratitis malgassa	Trimedlure (TML) Angelica Oil (Dubois,1965)	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1982a, draft, 1993)	100-50-25-20-10 and 25 Core - 5 1st Buffer	1. 2 ml of TML in liquid or solid form (plug) 2. 5 torula yeast tablets or 9% Miller NU-LURE + 5% Borax in water 3. Place traps in partly shaded open area (including fruiting hosts) with nearby food source, such as orchard edges, so winds blow scent to hosts.
Ceratitis pedestris	Trimedlure Terpinyl Acetate	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1982a, draft, 1993)	100-50-25-20-10 and 25 Core - 5 1st Buffer	1. 2 ml of TML in liquid or solid form (plug) 2. 5 torula yeast tablets or 9% Miller NU-LURE + 5% Borax in water 3. Place traps in partly shaded open area (including fruiting hosts) with nearby food source, such as orchard edges, so winds blow scent to hosts.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Ceratitis punctata	Methyl Eugenol Terpinyl Acetate	Males Males: Females	1. Jackson Trap 2. McPhail Trap	100-50-25-20-10 and 25 Core - 5 1st Buffer	1. 2 ml of TML in liquid or solid form (plug) 2. 5 torula yeast tablets or 9% Miller NU-LURE + 5% Borax in water 3. Place traps in partly shaded open area (including fruiting hosts) with nearby food source, such as orchard edges, so winds blow scent to hosts.
Ceratitis quinaria	Terpinyl Acetate	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1982a, draft, 1993)	100-50-25-20-10 and 25 Core - 5 1st Buffer	1. 2 ml of TML in liquid or solid form (plug) 2. 5 torula yeast tablets or 9% Miller NU-LURE + 5% Borax in water 3. Place traps in partly shaded open area (including fruiting hosts) with nearby food source, such as orchard edges, so winds blow scent to hosts.
Ceratitis rosa	Trimedlure Terpinyl Acetate	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1982a, draft, 1993) NOTE: Sensus Trap used in Africa at present	100-50-25-20-10 and 25 Core - 5 1st Buffer NOTE: Sensus traps: use same ratios as above if tried .	1. 2 ml of TML in liquid or solid form (plug) 2. 5 torula yeast tablets or 9% Miller NU-LURE + 5% Borax in water 3. Place traps in partly shaded open area (including fruiting hosts) with nearby food source, such as orchard edges, so winds blow scent to hosts. NOTE: Sensus traps are serviced once per season..

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Ceratitis rubivora	Trimedlure Terpinyl Acetate	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1982a, draft, 1993)	100-50-25-20-10 and 25 Core - 5 1st Buffer	1. 2 ml of TML in liquid or solid form (plug) 2. 5 torula yeast tablets or 9% Miller NU-LURE + 5% Borax in water 3. Place traps in partly shaded open area (including fruiting hosts) with nearby food source, such as orchard edges, so winds blow scent to hosts.
Dacus axanus	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Dacus bivittatus	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Dacus ciliatus	Methanol extract of *Acorus calamus* attracted males/ females in lab only (Qureshi, et al., 1986)	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	6 torula yeast pellets or PIB-7 + water Place in a favored host.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Dacus demmerezi	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Dacus frontalis	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Dacus lounsburyii	?	Males: Females	McPhail Trap (APHIS, 1982b)	80-40-20-10-5	1. 6 torula yeast pellets or PIB-7 + water 2. Place in a favored host.
Dacus punctatifrons	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Dacus smieroides	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Dacus solomonensis	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Dacus telfaireae	Cue Lure	Males Males: Females	1. Jackson Trap and 2. McPhail Trap (APHIS, 1984a)	50-25-15-10-5-5-5 and 25 Core - 5 1st Buffer	1. 6 ml Cue + 1% Dibrom 2. Yeast tablets or PIB-7 in water 3. Place traps in partial shade on the windward side of host trees or broadleaf nonhost trees. If possible, select host trees with riening fruit.
Dacus vertebratus	Vert Lure**	Males			
Dirioxa pornia	?	?			
Epochra canadensis	?	?			
Monacrosthcius citricola	?	?			
Myiopardalis pardalina	?	?			
Rhagoletis cerasi	?	Males: Females	Rebell Trap (APHIS, 1984b)	80-40-20-10-5	1. ?Check literature. Use in combination with volatile cherry lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995)

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Rhagoletis cingulata	?	Males: Females	Rebell Trap (APHIS, 1984b)	80-40-20-10-5	1. ?Check literature. Use in combination with volatile cherry lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995)
Rhagoletis completa	?	Males: Females	Rebell Trap (APHIS, 1984b) 2. McPhail Trap)	80-40-20-10-5 80-40-20-10-5	1. ?Check literature. Use in combination with volatile cherry lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995)
Rhagoletis conversa	?	Males: Females	Rebell Trap (APHIS, 1984b)	80-40-20-10-5	1. ?Check literature. Use in combination with volatile cherry lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995)

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Rhagoletis fausta	?	Males: Females	Rebell Trap (APHIS, 1984b)	80-40-20-10-5	1. ?Check literature. Use in combination with volatile cherry lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995)
Rhagoletis indifferens	?	Males: Females	Rebell Trap (APHIS, 1984b)	80-40-20-10-5	1. ?Check literature. Use in combination with volatile cherry lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995)
Rhagoletis juglandis	?	Males: Females	Rebell Trap (APHIS, 1984b)	80-40-20-10-5	1. ?Check literature. Use in combination with volatile cherry lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995)

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Rhagoletis lycopersella	?	Males: Females	Rebell Trap (APHIS, 1984b)	80-40-20-10-5	1. ?Check literature. Use in combination with volatile cherry lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995)
Rhagoletis mendax	?	Males: Females	Rebell Trap (APHIS, 1984b)	80-40-20-10-5	1. ?Check literature. Use in combination with volatile cherry lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995)
Rhagoletis nova	?	Males: Females	Rebell Trap (APHIS, 1984b)	80-40-20-10-5	1. ?Check literature. Use in combination with volatile cherry lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995)

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Rhagoletis pomonella	?	Males: Females	Rebell Trap (APHIS, 1984b) or Ladd Trap (MacCollum, 1987; Rull, 2003)	80-40-20-10-5	1. Check literature. Use in combination with volatile apple or host lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995) or Ladd Trap in upper half of host canopy at one per center of every Orchid (Rull, 2003)
Rhagoletis ribicola	?	Males: Females	Rebell Trap (APHIS, 1984b)	80-40-20-10-5	1. ?Check literature. Use in combination with volatile cherry lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995)
Rhagoletis striatella	?	Males: Females	Rebell Trap (APHIS, 1984b)	80-40-20-10-5	1. ?Check literature. Use in combination with volatile cherry lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995)

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Rhagoletis suavis	?	Males: Females	Rebell Trap (APHIS, 1984b)	80-40-20-10-5	1. ?Check literature. Use in combination with volatile cherry lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995)
Rhagoletis tabellaria	?	Males: Females	Rebell Trap (APHIS, 1984b)	80-40-20-10-5	1. ?Check literature. Use in combination with volatile cherry lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995)
Rhagoletis tomatis	?	Males: Females	Rebell Trap (APHIS, 1984b)	80-40-20-10-5	1. ?Check literature. Use in combination with volatile tomato lures +ammonium acetate+protein hydrolysate (Hull, et al., 1995) 2. Place traps in or near host material, near edges and surrounded by fruit and foliage but not in touch, and in direct view about head height (Hull, et al., 1995)

TABLE D-1: Table of Key Trapping Elements for any Proposed Tephritid Survey Program (continued)

Species	Pheromone or Parapheromone	Sex Attracted	Trap Type	Trap Array	Specifics
Toxotrypana curvicauda	Papaya Fruit Fly Lure**	Females:Males	1, Green Sticky Paper Cylinder Trap 2. McPhail Trap (Heath, et al., 1996)	80-40-20-10-5 80-40-20-10-5	1. Check literature. Use unbaited trap if lure not available. (Heath, et al., 1996). 2. Use only if cylinder trap not available. (Heath, et al., 1996)
Trirhithromyia cyanescens	?	?			
Trirhithrum coffeae	?	?			
Trirhithrum nigerrimum	?	?			
Zonosemata electa	?	?			

The Jackson Trap

This trap has been the standard trap for years.

Assembly

Jackson traps come unassembled. Follow the steps to assemble each trap.

Liquid Lure—Install a Richmond dental wick capable of holding 6 ml of solution, 3/4 inch in diameter and 1 inch or 1 1/2 inch long in the trap. Bait the wick with a mixture of bait appropriate to the lure.

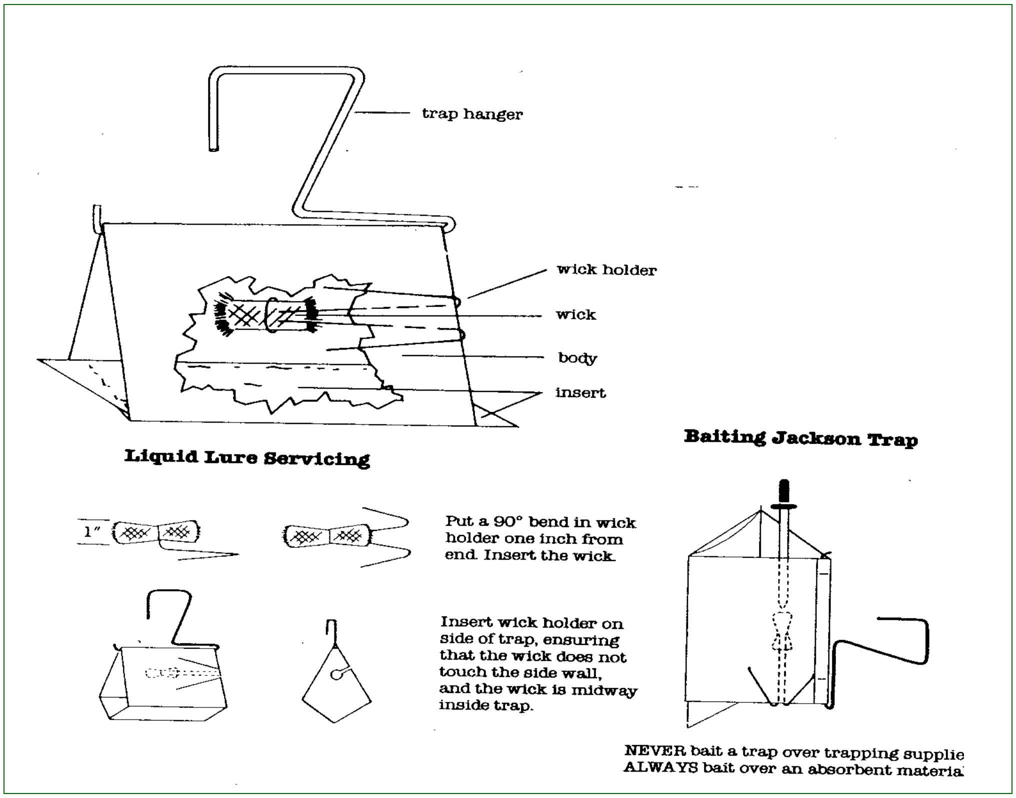


FIGURE D–2:

The initial servicing will require the full lure amount specified. Subsequent servicings will require adding sufficient lure to saturate the wick without dripping. The time period between rebaitings will depend on lure evaporation under existing weather conditions. If a blowing rain should occur, replace all traps as soon as possible due to contamination. **Table D-2** gives details of lures and rebaiting schedules.

TABLE D-2: Jackson Lure Specifics

Lure	Control Agent	Baiting Schedule
99% Methyl Eugenol by volume	1% ai by volume of naled (Dibrom 14 @ 1% or Dibrom 8 @ 2%)	◆ Initial servicing = 6 ml lure ◆ Rebaiting intervals = ◆ 8 weeks - optimum 70-80°F Daytime Highs-Spring/ Cool Fall ◆ 4 weeks - 90°F Daytime Highs - Hot Summer/Fall ◆ 12 weeks - 50-60°F DaytimeHighs-Winter (Stibick, 1988)
8 parts Cue lure	1 part technical malathion (91%)	◆ Initial servicing = 6 ml lure ◆ Wick replacement = 12 weeks (Stibick,1990)
2 ml of Trimedlure	N/A	◆ Initial servicing = 2 ml lure ◆ Rebaiting intervals = ◆ Hot summer (90°F & over) = 2 weeks ◆ Spring, cool summer (70-90°F) = 4 weeks ◆ Winter (50-70°F) = 8 weeks

Each trapper can service 20-50 traps per day.

When baiting traps, turn the trap on end and add half the required amount of lure to the end of the wick. Then turn the trap over and add the rest of the required amount. Take extreme care not to drip any of the lure on the insert or trap body, or the efficiency of the trap will decrease. If lure is on the outside, flies will mill around and may not enter the trap at all.

Take care not to saturate wicks to the point that they will drip sometime after the trap is placed in the host.

Bait the trap carefully. An accidental spill, even a few drops, will cause a decrease in the effectiveness of the trap or may make it totally ineffective.

Solid Lure

The plug contains 70% trimedlure by weight. Place one plug of solid lure as in the diagram shown below. Do not touch lure, as contamination may occur on the trap.

The C&C Trap

This is a new trap, still undergoing some studies. It is already in use as a replacement for the Jackson trap. Advantages include lure attractiveness for 2 months or more, requiring fewer servicing trips and consequently fewer possible mishaps with the trap. It was specificly designed for *Ceratitis capitata* trapping and it is not known how it would work for other species and with different lures.(Wood, 1996; Jeffrey Aldrich, pers. com.)

McPhail Trap

The McPhail trap is another classical standard trap that is basically a food lure, but can be baited with other substances as well.

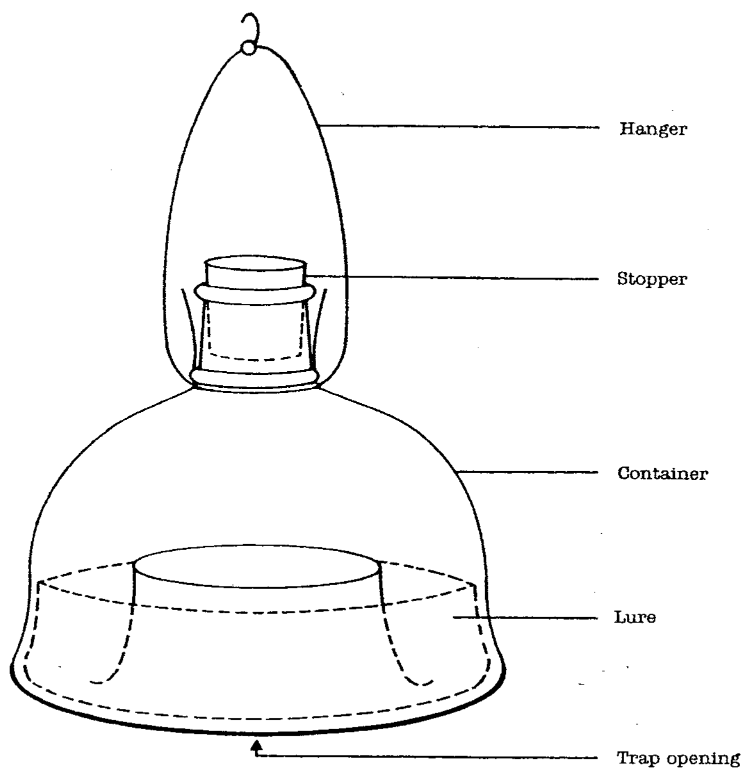


FIGURE D–3McPhail Glass Trap

The trap is filled to 1/4 to 1/2 inch or to just below the lip with approxiately 200-600 ml of the lure. The following chart refers:

TABLE D-3

Lure	Control Agent	Carrier	Baiting Schedules
Miller's NU-LURE - 11 fl oz 9% by weight (Stibick, 1988)	1/2 lb of Borax - 5% by weight	1 gallon of water - 86% by weight	1 week intervals, unless other wise specified. More frequently under dry conditions.
Concentrate Solution: ◆ 1 gallon of water ◆ 4.23 avdp oz of ammonium chloride ◆ 10 fluid oz of Miller's NU-LURE (Stibick, 1990)	Ammonium chloride	Water Mix concentrate with warm water 50/50 before use.	1 week intervals, unless otherwise specified. More frequently under dry conditions.
Entomosyl	Borax @ 1.5% + dimetilan (98.4% t.c.) sprayed over exterior surface of trap (Optional-exemption needed).	Water Mix Entomosyl at 3% by volume with water. (Soultanopoulos, 1986)	1 week intervals unless otherwise specified. More frequently under dry conditions.

Each trapper can service 20-30 traps per day.

- The solution is best prepared with warm water and stirred. Stir again before adding solution to trap. Trap should be filled up to just below rim.
- Use the same procedures as above to record placement of the McPhail trap.

d. The Merrill Trap

This trap is basically a replacement for the McPhail trap. It's construction of lightweight, high-tech plastic makes it far less unbreakable. The yellow bottom attracts fruit flies. This trap, about 9" tall, holds 3 times as much liquid as the McPhail and thus last about 3 times longer in hot weather. Trapping details are otherwise the same. (Wood, 1996)

e. The Modified McPhail Trap

This is actually a dry-type of McPhail that relies on a combination of chemical and visual stimuli to attract and trap fruit flies. It is a cylindrical shape to mimic the 3-D of host fruit. A clear top takes advantage of a fly's orientation towards light. The bait (Biolure), a combination food bait of ammonium acetate, putrescine, and trimethylamine is in a panel near the top, where the flies will feed and then die.

This trap does away with liquid solutions and is therefore easier to handle. It also restricts the large number of nontarget insects which get into the old-style trap. This trap and lure combination is very effective for Medfly. (Garcia, 2001)

Simple Yellow Panel Trap

This is a basic sticky panel trap that is easily available. It may be hung as is, or have food or lure dispensers attached to it to increase attractivity. (Johnson, 2002)

Traps shall generally be placed on the sunny side, near the top of the host unless otherwise specified. They will be carefully placed within the foliage, about 1/2 m (1 1/2 ft) from the periphery. Depending on the pest species, shading foliage may have to be removed to allow full trap exposure to sunlight and for visual sighting by the pest.

Champ Trap

This trap is a variation of the yellow panel, but modified with prepunched holes. It is folded in half before hanging. A food lure is placed in the fold and a pheromone or other lure (if available for the pest species) may be attached to the hanger from which the trap is suspended from the host. (Johnson, 2002)

Traps shall generally be placed on the sunny side, near the top of the host unless otherwise specified. Traps will be carefully placed within the foliage, about 1/2 m (1 1/2 ft) from the periphery. Depending on the pest species, shading foliage may have to be removed to allow full trap exposure to sunlight and for visual sighting by the pest.

The Rebell Trap 78

This trap is esentially two 15 x 20 cm lemon yellow (DM314) plastic strips locked together to form a frame. The surface is coated with stickem (Boller, 1973). A pillbox may be added if a carbonate (food attractant) compound is available.

The unit may then be hung in a host. This trap has proved to be quite successful for Rhagoletis spp. and relies primarily on the visual stimuli of the color. Traps shall generally be placed on the sunny southern to southwestern side, near the top of the host. Traps will be carefully placed within the foliage, about 1/2 m (11/2 ft) from the periphery. Shading foliage should be removed to allow full trap exposure to sunlight and for visual sighting by the pest. (APHIS, 1984b)

Although superior to the yellow panel trap, presumably because of its shape, this design has apparently not caught on with researchers in the field, in part because it is easier to just hang up sticky yellow panels. But for detection of incipient populations it may provide an edge. Further research is needed on this type of trap.

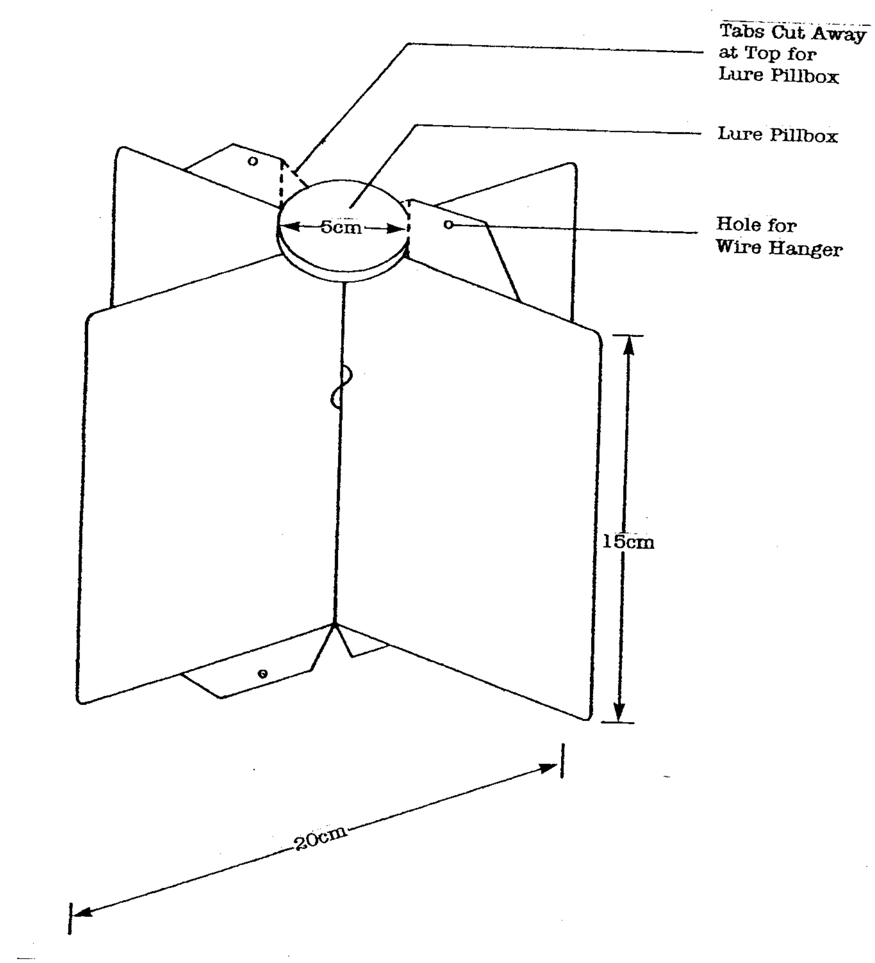


FIGURE D–4: Rebell Trap

The Green Sticky Paper Cylinder Trap

This trap is is somewhat similar to the Rebell trap.. It operates on similar principles. This is essentially a sticky trap with an attractive color and a cylindrical shape as a visual clue and a male produced pheromone in a packet for further attraction. This attracts both males and females. It is a significant improvement over the McPhail, attracting at least 6x as many males and females.

The trap body is of dark green fruit fly adhesive paper covered with white protective paper which is removed when the trap is used It is protected by a 150 X 15 mm petri dish with a 5 cm length of polyvinal chloride tubing glued to it to provide a holder to the trap body.

If available, a packet of the male pheromone is attached by double-sided sticky tape on the inside. The trap bodies are replaced every week, the lures are replaced monthly.

TABLE D-4

Green Sticky Paper Cylinder Trap
Petri Dish Polyvinal Tubing Green adhesive Paper Protective Paper Pheremone Packet

The bait, for *Toxotrypana curvicuda,* for which this trap was designed, is the male pheromone (2,6-MVP). 50 ul of this pheromone may be optimum. The trap is to be placed near immature or smaller fruit 1-2 for this species. (Heath, et al, 1996)

This trap, with an appropriate color and pheromone, or even without the pheromone could be used for other fruit fly species, but this possibility has not been explored.

The Ladd Trap

This trap was orginally designed for *Rhagoletis pomonella*, but may prove valuable for obtaining the females of certain species of *Bactrocera* as well (Cornelius, et al., 1999). It is essentially a panel trap with a 9 cm red sphere attached to the center (so that it shows on each side), and the whole is coated with tanglefoot. For *Rhagoletis* *pomonella* a volatile apple food lure attractant is added (MacCollom, 1987). Today, a 500 ml polyethylene vial containing butyl hexanoate is placed 15 cm from the trap. A Ladd trap, properly prepared and hung in an optimal position in the upper half of the host canopy and surrounded by fruit and foliage in all directions, with 12 cm of space between the trap surface and the nearest foliage or fruit will outperform a red sphere or yellow panel trap under almost all conditions (Rull, 2003).

NOTICE

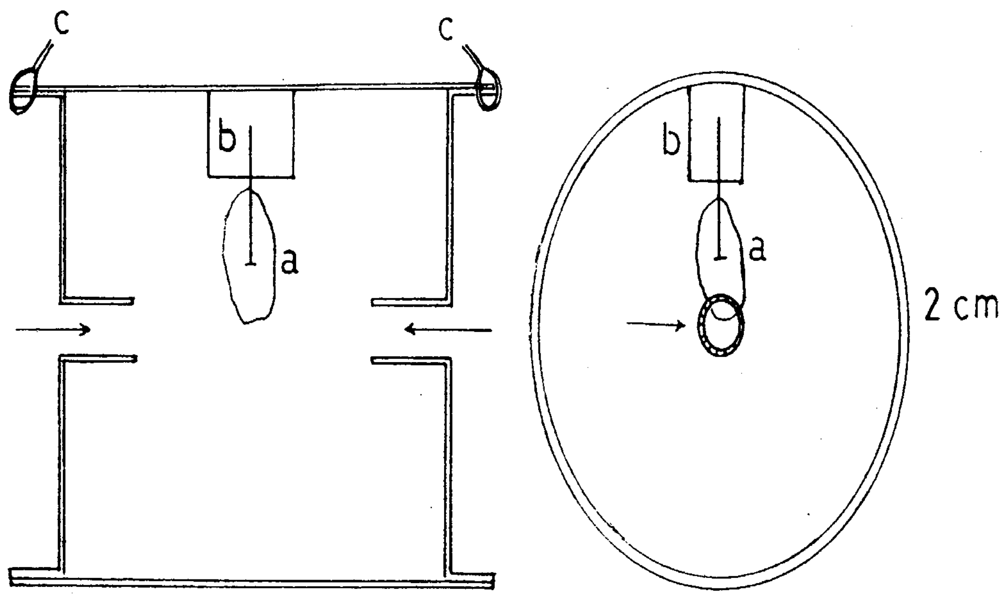
Prior to packaging, all sticky panel traps, Yellow Panel, ChamP, green cylinder, Jackson and Ladd should be reversed so that the sticky surfaces are on the inside (fold the card board tab to the inside-sticky side of the trap. Use this as a barrier to prevent the trap from sticking to itself. If the sticky sides stick together it will be virtually impossible to identify the suspect sharpshooter). Place a rubber band around the outside to hold the two halves in position. Care should be taken to insure that the sticky surfaces are not in contact. Do not submit traps covered with clear plastic.

Sticky traps should be placed in sealed plastic bag(s) before shipment. "Cut-outs" should be placed in dry plastic vials and sized to fit tightly inside so that neither the specimen nor the "stickem" comes in contact with the inner surface of the container. Mark the trap, plastic bag or vial with the field ID or block number and date of the find.

The Tan Trap

This trap has some advantages in that a pesticide need not be used. Instead, the trap relies on the principle that a fly cannot find its way out because of the even light intensity and the small size of the entrance ports. It is not normally used in survey activities unless live flies are needed for further research such as the dynamics of a wild population, or in an ecologically sensitive area where it is determined that a trap with no poison should be used (see 7.d). It may also be used in a mass trapping situation [see F.4.b.(4)].

The Tan trap is cylinderical in shape. A transparent plastic acetate sheet (31x12 cm) is rolled into a cylinder so that the ends tightly fit either the base or the top of a transparent plastic petri dish; the overlapping edges are held together by double sided sticky tape.



Fruit fly attractant trap (left—front view; right—side view).
a—cotton bud to contain attractant;
b—polystyrene block;
c—string or wire;
arrow—port of trap.

FIGURE D–5: Tan Trap

One end of the cylinder is permanently closed by a base/top of two 9 cm clear plastic petri dishes with a hole burned in the center to fit tightly around a 3 cm clear length of clear plastic tubing (internal diameter 0.9 cm). The other end is fitted with similar cover which is hinged to the cylinder with the aid of a string.

In the center of the cylinder a piece of polystyrene foam (ca. 1.5 x 1.5 x 2 cm^3) is glued to the inner wall. A small piece of cotton wool is rolled onto the head of a pin, which is then stuck into the foam. The cotton bud is ca. 2 cm long and 1 cm wide and holds 0.5 ml of the attractant.

This trap has been shown to be successful for *Bactrocera dorsalis, B. umbrosus, and B. cucurbitae*. It would probably be successful with *Ceratitis capitata*. (Tan, 1984)

The Sensus Trap

This trap consists of a blue lid which is attached to the bottom of a clear bucket, with the lure attached to the inside of the lid. The Sensus fruit fly trap is a dry trap for monitoring the presence of male and/or female fruit flies. Different lure capsules are used to attract either male or female fruit flies or both. Used for Marula, Natal and Mediterranean fruit flies. (ARC-ITSC, 2003)

FIGURE D–6: Sensus Trap

The Tephri Trap

This trap is a Mcphail-type trap that is strong and durable (2-3 years or more of service). It can be used to trap any fruit fly and can also be adapted to any other insect provided the right lures are used. It may be used for mass trapping or monitoring. If monitoring, a piece of double-faced glued paper (8cm by 8cm) can be hung on the trap to keep out predators.

It can be used as a wet or as a dry trap. A polyethylene bag dispenser of female lure can be glued to the inside walls. A ring with a central basket makes it possible to put on a piece of DDVP, a plug of trimedlure or some solid baits.

Once properly fitted, the trap may be placed at a height of between 1.5-2 m in the south side of the tree canopy, leaving it visible by removing the foliage, if necessary. It must be left in place from before fruit color change, to well after harvest. Each trap should be 15-20 meters apart. (Sorygar, 2003)

Trap Lures

The following are the lures, both standard and nonstandard, that have been used in traps.

Male Lures

Citronella oil (Horsefall, 1995)—This and huon pine oil are similar to ME in the ranges of species attracted. (White & Elston-Harris, 1992).

Cue—This standard lure is 4-(p-acetoxyphenyl)-2-butanone. It attracts males of many *Bactrocera* and *Dacus* spp.(White & Elston-Harris, 1992)

Latilure —The male lure for the Malayian fruit fly, *Bactrocera latifrons*. This lure is composed of a mixture of cyclohexyl and cyclonexenyl aliphatic alcohols and ketones. (Wood, 1989)

Methanol extract of *Acorus calamus* —See under female lures. However it does attract male oriental fruit flies and male Ethiopian fruit flies. (Jacobson, 1983; Qureshi, et al., 1986)

Methyl Eugenol—This standard lure is the most powerful known attractant and is useful for trapping many *Bactrocera* and some *Ceratitis* species. Chemically, it is 4-allyl-1,2-dimethoxybenzene or 3,3dimethoxy (1) 2 propenyl benzene. (White & Elston-Harris, 1992)

Minus-ceralure—This recently developed lure is still undergoing tests. It is said to be about 4-9 times more attractive, with an attraction radius greater than that for Trimedlure (this has yet to be worked out). It also lasts about 3-4 times longer (McBride & Wood, 2000). Costs associated with producing commercial quantities of this lure will have to be overcome (Jeffrey Aldrich, pers. com).

Olean Lure—Olean 46 is the female-produced sex pheromone of olive fruit fly. The (R)-isomer is active on the males (Haniotakis, et al.,1986).

Terpinyl Acetate—This lure attracts males of a wide range of Ceratitis species, including those attracted to either methyl eugenol or trimedlure, plus some species not attracted to either bait. This ester consists of mixed isomers in dynamic equilibrium. (White & Elston-Harris, 1992)

Trimedlure—The standard lure for Mediterrean Fruit Fly and many related species belonging to *Ceratitis*. The lure is also available in a solid form. (White & Elston-Harris, 1992; Stibick, 1993)

Capulure "Red"/ Ceratitis "Blue" —These lures are produced by Insect Science South Africa. Details are not available, but they are available for *Ceratitis* males, specifically for Medfly, Natal fruit fly and Mango fruit fly. These lures apparently need to be serviced only once per season under South African conditions. (Insect Science, 2002)

Vert Lure—This lure is only known to attract *Dacus vertebratus* males. It is methyl-4-hydroxybenzoate. (White & Elston-Harris, 1992)

Dak Pots (Horsefall, 1995)—Usually used as a male annihilate. Consists of 165 gkg 4-(p-hydroxyphenyl)-2-butanone acetate and 65 gkg of Maidison soaked in a fibreboard bisecting a tin that can be covered when not in use. Can be conveniently used and hung in hosts.Commercially made. . Used against *Bactrocera tryoni* and *B. neohumeralis*, but may be useful for other fruit flies attracted to Cue.

Typically, 2 canisters should cover a residential block. In orchards and market gardens where routine spraying of insecticide occurs, lower densities might be used, depending on crop susceptibility e.g.. 3 per ha. in apple orchards if placed in a suitable grid with extra units outside the crop boundary.

The useful life of one of these traps is one season. Replace each spring. (Bilpin Springs Orchard, 2000)

Vegemite and water (Horsefall, 1995; Warm Earth, 2000)—Vegemite is a yeast extract which attracts fruit flies.

Wild May Fruit Fly Attractant—A commercially produced male lure used in Queensland. Composition unknown, but probably Cue or related compounds. (Brisbane Organic Growers, 2000).

Flowers of *Spathiphyllum cannaefolium*—The flowers of this plant attract many species of fruit flies. This lily is grown extensively around orchard perimeters and by attracting the flies, reduces infection of fruiting trees. The attractants in the emitted odor by the flowers have been determined to be Benzyl acetate, which is attractive to Cue-lure and trimedlure attracted species and Methyl engenol, which attracts ME attracted species. More research needs to be done on this plant and its possible uses. (Lewis, et al., 1988)

Enriched Ginger Root Oil —This is ginger root oil (EGRO) from Angelica flower - (Angelica archangelica), that has been "enriched" by enhancing the concentration of a natural attractant, a-copaene, 20x above natural levels in ginger oil. In field tests recently, baited Jackson traps indicate that trimedlure is superior to EGRO as a detection and monitoring tool in Medfly control program. However, panel traps in field cages with EGRO showed equal, short-range attraction for immature and mature Medfly males to trimedlure baited panel traps. (Shelly & Pahio, 2002)

Female Lures

Methanol extract of *Acorus calamus* —Obtained by steam distillation or solvent extration of the crushed rhizomes, the product is described as highly attractive to female Medflies, melon flies and to male and female oriental fruit flies (Jacobson, 1983). Qureshi, et al. (1986) added males/females of *Dacus ciliatus*. A commercial product from India is Indian Calamus Root Oil.

Olean Lure—Olean 46 is the female-produced sex pheromone of olive fruit fly. The (S)-isomer is active on the females (Haniotakis, et al.,1986).

Orange Pulp (Horsefall, 1995)—d. Qwest Lure "Green"

This lure is produced by Insect Science South Africa. Details are not available, but the product is available for *Ceratitis* females, specifically for Medfly, Natal fruit fly and Mango fruit fly. These lures apparently need to be serviced only once per season under South African conditions. (Insect Science, 2002)

AMPu Lure—This is a 3 component lure developed for Mexican Fruit Fly. It is composed of: ammonium bicarbonate, methylamine HCI, and putrescine.

It works best in a dry trap. One experiment used a sticky trap with the lure suspended from the top. This trapping method was about 50% more attractive then multilure traps containing Medfly lures (Biolures) and antifreeze (Robacker, 2000). Earlier, Robacker (1999) concluded that biolure was 2x more attractive for female Mexican fruit flies, when used with yellow panel traps.

Biolure—A three component lure under development by FAO. It is composed of : Ammonium Acetate, Putrescine, and Trimethylamine.

This compound, in the most recent trials in 2002, was the best attractant system for Medfly when compared with Trimedlure, Nulure and Torula (FAO/IAEA, 2002). It was also the best lure when used with Tephri or McPhail traps for this species (Broughton & Lima, 2002; Economopoulos, 2002).

Male/Female Lures

Papaya Fruit Fly Lure—This lure is produced by males of *Toxotrypana curvicauda*. It is 2-methyl-6-vinylpyrazine or 2,6-MVP for short. It seems to attract both males and females in equal numbers. (Heath, et al., 1996)

Malay Fly Lure (Wood, 1999)—This recently developed lure is a combination of alpha-ionol and cade oil (which is derived from prickly juniper, *Juniperus oxycedrus*). It attracts both males and females of *Bactrocera latifrons*. (Wood,1999)

Dakpot Fruit Fly Attractant—A protein processed to have a much lower salt content than the protein hydrolysate and thus can be used on delicate varieties of plants. Mixed with an insecticide and water. Commercially available and instructions are on the bottle. Usually used as a spot treatment. (Bilpin Springs Orchard, 2000)

Entomosyl—Product of Hoecht Hellas, web site: <www.aventis.gr>, a odor lure. No further information available.

Rotting peach or plum (Horsefall, 1995)—

Food Lures

Protein hydrolysate —An extract of yeasts or grains that act as a broad-spectrum food attractant for male and female fruit flies (and many other protein feeding insects). In instances where a commercial trap with an insecticide is not employed, the above may be mixed with water and pyrethrum or nicotine as a safe alternative. (Horsefall, 1995; Dekker & Messing, 2001)

Formulations of protein lures are often used as ground or air bait sprays for control or eradication. (See Addendum F)

The following list of derivitives partly follows that of Gomes, 2000, which lists 10 variations in an addendum H - Suppliers of Protein Bait, to the Peach fruit fly action plan by FAO, and in which the contact addresses are given for each.

Torula Yeast Pellets—This is a Commercial formulation of yeast protein that acts as a broad spectrum food attractant for male and female fruit flies. It is composed of 45% torula yeast and 55% dry borax decahydrate in pellet form (5 gms each). The pellets are disolved in water and the solution placed in the trap. This attractant is more stable than NU-LURE or Stanley's (below) as the pH is stable at 9.2 and therefore more stable over time.(Lewis, 1999; Dekker & Messing, 2001)

Stanley's Fly Bait No. 7—Commercial formulation of corn extract that acts as a broad spectrum food attractant for male and female fruit flies. This is a hydrolyzed protein, but is not as effective over time as Torula yeast because the pH of this product drops from its initial state of 8.5 towards a more acidic state. (Dekker & Messing, 2001) Has been superceded by Nu-Lure below.

Miller's NU-LURE—Commercial formulation of yeast extract that acts as a broad spectrum food attractant for male and female fruit flies. This is a hydrolyzed protein, but is not as effective over time as Torula yeast because the pH of this product drops from its initial state of 8.5 towards a more acidic state (Dekker & Messing, 2001). Appears to be very successful for attraction of males and females of *Bactrocera cucurbitae* at a concentration of 2% (Fabre, et al., 2003; Gomes, 2000). Also successful for attraction of males and females of *Bactrocera oleae* at a concentration of 9% (Katsoyannos & Papadopoulos, 2003)

Dacus Bait—A formulation that seems to attract species of *Bactrocera* as well as *Ceratitis* (Medfly) with excellent results. (Gomes, 2000)

Buminal—Details are unknown, but the product is made by Bayer SA, Puteaux, France. It appears to be a good general attractant for fruit flies and is used in many countries. (Kaiser & Sheard, 2001; Rogg & Camacho, 2003; Gomes, 2000)

Corn Steepwater—E802 Mazoferm Steepwater is a condensed fremented corn extractive that has been shown to be 4 times as attractive to *Anastrepha ludens* as NuLure. Studies are being conducted on *Anastrepha obliqua.* Also used for control of Medfly in Guatemala (Joo, et al., 1996; Gomes, 2000)

Hym-Lure—This is sold as a protein hydrolysate paste. It is quite similar to NU-LURE. (Gomes, 2000)

Pinnacle Protein Insect Lure—Mauri Pinnacle Protein Insect Lure, is made in Australia and has been used in the Pacific for primarily *Bactrocera* and Medfly (Pacific Fruit Fly Web, 2000a; Gomes, 2000).

Royal Tongalure—Royal Tongalure is made from waste yeast from the Royal Brewery in Tonga This is an excellent lure for *Bactocera* spp. (Pacific Fruit Fly Web, 2000a; Gomes, 2000).

Mexican Fruit Fly Lure—A new lure which was developed recently. It has 3 chemical components: Ammonium acetate, putrescine, and methyl butanol. A synergist, tri-substituted ammonia, is added to increase effectiveness. Few details are provided. Said to catch twice as many flies and more effective in catching both males and females. (Weaver, 1998)

Medfly Food lure—A new food lure which was developed recently. It has 3 components: ammonium acetate, putrescine, and trimethylamine. A synergist, tri-substituted ammonia, is added to increase effectiveness. It has been approved for use in Medfly programs in Florida. (Weaver, 1998)

Jarvis Bait —Vanilla essence, cloudy ammonia and water in the ratio of 1:2:100 or 1/8 oz. vanilla, 1/2 oz. Scrubbs ammonia and 26 oz. water. This formulation has proved to be a good attraction for males and females of *Bactrocera carambolae* = *Chaetodacus ferrugineus* (Miller, 1940; Horsefall, 1995)

Formaldehyde bait —40% formaldehyde 1/8 oz., sugar 13oz., water 26 oz. This formulation has proved to be a good attraction for males and females, especially mature females with well-developed eggs of *Bactrocera carambolae* = *Chaetodacus ferrugineus* (Miller, 1940)

Orange-ammonia lure—This lure has proved valuable in trapping female specimens of many species. The formulation is; 280 g pulped orange, 25 g amonium carbonate, 600 ml water and 1 g of mercuric chloride perservative. This is let stand at least 24 hours before use and will keep for several months. The stock solution is diluted with water at a ratio of 1:10 and used in McPhail traps. (Drew, 1982)

Love's Bait—The formulation is; 1 litre water, 1 1/2 tbsp cloudy ammonia (urine also good) 1 1/2 tsp vanilla essence, 3 tbsp sugar. Stand 24 hours, dilute at a rate of 3 tsp concentrate: 2 litres rainwater. Half fill small jars, and suspend approximately three in each tree. (Warm Earth, 2000)

Unspecified Lures

These may be tried out to see if they will work with a new or unreported fruit fly. There is very little to no information on these lures.

- Ammonia (1 tbsp), vanilla essence (1 tbsp) and water (750 ml) (Horsefall, 1995)
- One banana peel, 2 tsp sugar, water to cover (Horsefall, 1995)
- Sugar, vanilla essence and water (Horsefall, 1995)
- Molasses, treacle, golden syrup or honey with water (Horsefall, 1995; Warm Earth, 2000)
- Bran and sugar with water (Horsefall, 1995)
- Molasses and pyrethrum or flour or Fruit Juice in water (Horsefall, 1995; Warm Earth, 2000)
- Kerosene in a shallow tin (Horsefall, 1995)
- Garlic/ Water solution—Blend garlic with water. Soak strips of rag in the solution and place them in a tin hung from a tree (Horsefall, 1995)
- Vinegar and water, vinegar and bran (Warm Earth, 2000)
- Wheatgerm and hot water (Warm Earth, 2000)—Once a trapper selects a trap site, the location will be plotted on a map which has been sectioned or gridded into 1 square mile blocks. In addition, a trap location record (normally a file card), with a rough drawing or sketch of the specific trap location, will be prepared to document trapping activities such as dates of placement and servicing. The trap should be moved to hosts of equal or greater preference when necessary.

Quality Control

Field supervisors oversee each trapper's work. In addition to arranging schedules, helping with problems, and overall direction, the following quality control items are carried out:

Evaluation

The field supervisor periodically checks a number of traps run by each trapper. On an evaluation sheet the supervisor lists the trap number, location, description, and date and notes the condition of the wick, trap placement, and trapping schedule. Trappers are advised of results and problem areas worked out.

Trapping Directory–Map Requirement

Trap Location Directory—A list of a ll trappers, traps, servicing dates, field supervisors. and a copy of each trap card giving the exact location of each trap is maintained in a directory.

Map—A large-scale master map, gridded to the coordinates used in the survey, will be maintained and updated each day. The map will show the location of all traps and finds throughout the regulated area.

Initial Trap Training and Public Relations

Trap Placement—New trappers will be given individual instruction on proper trap placement.

Selection of trapping sites—In selecting possible trap sites, consideration should be given to the availability of food and shelter near hosts with fruit. If two or more possible trap locations meet this criteria, preference should be given to the site that has a greater variety of hosts and shelter. In many cases, single hosts will be the only host available and should be utilized. Never pick a location solely because it will look good on a map.

For fruit flies generally, traps placed at the edges of orchards or in plants providing food and shelter have a higher likelihood of catching specimens than traps placed near the center. Placing a trap in a poor or second rate host, or even in a prime host without fruit, when food and shelter or hosts with fruit at the right stage of deveopment are available (for the species of fruit fly in question), has the effect of making the lure compete with natural attractants. In some cases, a very desirable host may be lacking in fruit at the right stage or have insufficient shade for trap placement. In such cases, a nearby honeydew source might be a desirable trap location. Generally, it is not advisable to place a trap in a host without fruit unless it shows evidence of abundant honeydew or possesses inflorescences. Both may serve as food sources.

Honeydew is a sweetish, clear excretion produced by certain insects such as aphids, scale insects, mealybugs, and whiteflies. It is a good food source for adult fruit flies. A fungus called sooty mold lives on the honeydew. This mold turns the leaves on the tree black. The presence of sooty mold is an indication that the host is infested with insects that produce honeydew. Inflorescences possess nectar, on which the flies can also feed, and provide shelter during the heat of the day.

Those hosts which are likely to bear mature fruit and/or be attractive feeding/shelter sites for most of the year should form the bulk of the trapped hosts.

Hosts having sparse foliage should be avoided when other protection is available. This is true especially during the summer months, since these hosts do not produce enough shade. When a host does not have sufficient shade, the trap should be placed in some other host or nonhost nearby.

Desirable trap sites should be noted on the Trap Location Record to facilitate future trap locations. Ths may be done at the time of the initial trap placement or as the sites are noted during trap servicing.

Placement of trap in host—Generally, it is not advisable to place a trap in a host without fruit, except when the host is being used as a trap site adjacent to a host which has insufficient shade. The trap should be placed in a host or nonhost at a point high enough to be out of reach of children, livestock or pets. It should be secured in a manner to prevent it from being blown down.

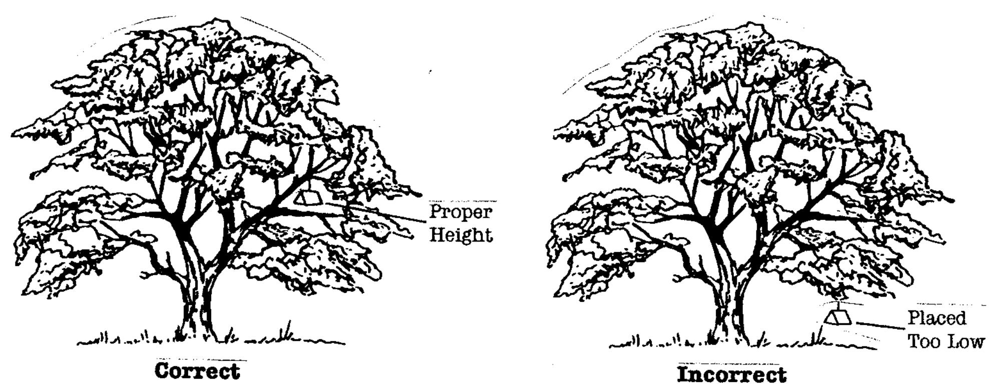


FIGURE D–7: Proper placement of trap

During the summer or warmer portions of the year, the trap may be placed in open shade; whereas, in the winter or cooler time of the year, it should be placed in a southern exposure, but not in direct sunlight. It is preferable to place it 1/2 to 1/3 the distance from center to the outer edge of the foliage.

The trap should not hang below or outside the foliage of the host. The trap should not be placed in dense foliage that may prodtrude into the trap or give the fly a resting place that would prevent it from entering the trap.

It is desirable to have foliage below the level of the trap, but not necessarily directly beneath the trap. A pole with a metal hook attached to one end can be used to place the trap sufficiently high in the host to be out of easy reach of children and curious adults.

Supplemental Surveys

Fruit Cutting Survey

Preferred host fruit from the core area and buffer areas can be surveyed, depending on host availability and. Fruit from the core area is normally cut and examined at the site. Fruit from the buffer areas may be inspected through the discreation of inspectors or crew. If larvae have been found in certain kinds of fruit, such fruit should be suspect, as should any fruit of a similar size or development. Mumified fruit and other fruit should be cut open with a knife, in the general area of obvious depressions or discolorations before being split open to the core.

Any suspcious larvae or eggs may be placed in a vial of alcohol and turned in for identification, if such stages are identifiable. Otherwise, they may be placed with the sample in a vial or other container for transport to the quarantine lab. The larval separation method can be used in addition to fruit cutting:

Separation

Cut fruit into pieces and place in a containter of appropriate size (ie., large jars, or for large volume work, a dip tank). Cover with warm water (Approximately 100^0F) and let stand 2 to 12 hours. If larvae are recovered from the bottom of the container (or collected from the spout end of a dip tank), the fruit may then be disposed of.

If no larvae were recovered, the fruit is poured onto a 20 mesh screen nesting over a 60 mesh screen on a stand. (Note: Golden nematode washing equipment is appropriate). The pulp should be picked by hand from the screen and washed off over the screen by applying water to it from a spray nozzle on a flexible tube.

Use of this technique results in larger larvae lodging on the 20 mesh screen and smaller ones on the 60 mesh screen. A wide-viewer magnifier with lamp attachment may be necessary to find the smaller larvae.

Floation

Split the fruit and place the pieces into a beaker or other suitable container. Pour saline or sugared water over fruit, and then place a coarse mesh (1/4 inch steel cloth) over the fruit to hold it under the surface. The larvae will exit the fruit and float to the top.

Soil Screening

The passing of soil through a screen for the detection of pupae. A minimum 1-meter (39 inch) square, 8 cm (3 inch) deep sample of soil is to be dug out from under and/or around the selected host and placed in a suitable container such as a plastic garbage bag.

Bear in mind that fly larvae provide the only known example of jumping by a soft-bodied legless organism. The Medfly larva is capable of jumping off the fruit and move away 1/2 ft or so horizontally. It can travel after reaching the ground, and can move away about a yard more on average (in one minute in about 8 jumps plus crawling). If attacking ants are present, such jumping will throw the ants off and the larva will move further away. Only Medfly larvae have been studied so far, but it is reasonable to assume that other fruit fly larvae may have similar behaviour. (Maitland, 1992)

Unless otherwise indicated, all samples should be within 656 feet of a larval find under or around suitable host, especially host that shows signs of infestation, such as dropped fruit, ripe fruit, punctured fruit or fruit at the right stage of development. The bag is fully labeled with date and location before transport to the quarantine facility.

Place soil sample in the top of a 1 cm sieve and wash down with water until all the lumps are broken up and only solid objects remain in the sieve. Below the first sieve is a second 1 mm sieve which should catch any pupae in the sample.

Host Collection and Holding

Collect fruit within 200 yards (yd) of a larval detection and hold for at least one target fruit fly life cycle at optimium developmental temperatures and relative humidity for that species.

OR

Door to door sampling (or equivalent) to a radius of 1/3 mile around past larval or adults finds. If new finds are made during a program add surveys in the remainder of the core area at 25 samples per 1/3 mi^2 plus 1/2 mile beyond the core at a rate of 25 samples per quadrant if new finds are discovered during the 3rd life cycle after an initial find.

If a full scale fruit collection is to be carried out, it should throughout the core area and several buffer areas beyond the core.

Priorities for sample locations:

- Homeowner reports of maggots in fruit.
- Quadrants where traps have picked up native flies.
- Confirmed larval finds.
- Random sampling of quadrants picked daily.
- Light, random sampling of other quadrants if time is available

The sample per host should be 6 to 100 pieces of fruit, depending on size. The volume is limited by the size of the collection bucket. Put different kinds of fruit in different buckets if from the same property. Sample alternate hosts if no perferred hosts are available. Alternate hosts whose fruit are of a similar size to any hosts found with larvae during the program are to be considered highly suspect. Check other alternate hosts to see if the target fruit fly has moved into these hosts. This shift may be caused in part by population pressure and/or competition. It may also be the result of disturbances to preferred hosts by program activity or other factors.

Samples are first taken from fallen fruit, followed by overripe and then ripe fruit or fruit at the right stage of development if the target fruit fly attacks green fruit, then nearby overripe fruit or (green) fruit with blemishes or stings. Any hard, mumified fruit must be collected, as trapped larvae can pupate within and come out only when they can escape, thus resulting in much delayed emergence.

Sampling is defined as followed:

- Light or random sampling - A minimum of one sample in any given quadrant.
- Minimally intensive survey - One sample per city block (or equivalent) per quadrant.
- Intensive survey - One to three samples per city block (or equivalent) per quadrant.
- Two types of survey may be employed, depending on program need and resources:

Biased Larval Survey

The 1 mi^2 core area around any find will be intensely surveyed. Random mi^2 in the remaining area will be intensely surveyed, with a bias for mi^2 directly upwind and downwind to the core area.

The coverage possible will be dictated by manpower available, but generally some 5 to 8 mi^2 should be covered outside the core area. Random selection will be made on a daily basis. Light or random sampling may be carried out in remaining areas, depending on manpower or calls from other personnel or the public.

Random Grid Larval Survey

The mi^2 core area around any find will be intensely surveyed as above. Selection of 5 to 8 mi^2 for a minimally intensive survey will be strictly random and carried out on a daily basis. Other aspects are as above.

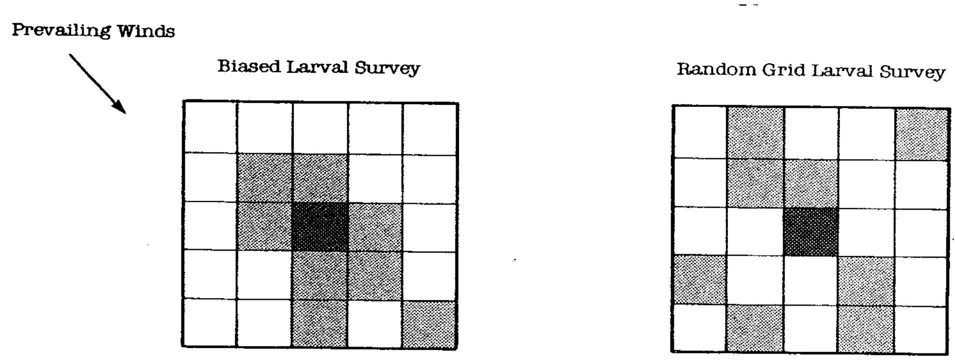


FIGURE D–8: Fruit Fly Larval Survey

The choice of survey to use should be based as far as possible on a knowledge of the target fruit fly's biology, especially anticipated flight patterns, if known.

Pupae recovered from the fruit holding procedures will be held for one month or more at optimium developmental temperatures and relative humidity for that species. It may be necessary to include a cold period (usually 5 to 6 months, 3 months minimum) for those species for which obligate diapause is necessary, followed again by a month (usually) at optimium temperatures and relative humidity

Capture of live flies

There may be a reason, during a program, to capture live flies. This may be due to a need to determine the wild population and its dynamics under pressure, or for mass trapping of males with only a bait for environmental reasons in an ecologically sensitive area. Whatever the reason, the Tan trap(see 4.g) may be used.to fill this function.

Public Relations

Good public relations are an important part of the survey specialist's duties. Trappers are constantly in view and frequently in contact with the public. They should be courteous at all times. Prolonged conversation should be avoided, but short cordial conversations concerning work are desirable. Do not be drawn into arguments concering program activities.

Survey officers represent the U.S. Department of Agriculture and present an image of that agency to the observing public. Dress, personal appearance and actions should be appropriate to make a good impression with the general public.

Shorts and tee-shirts may not be worn. Long pants or slacks, and shirts or blouses with sleeves are prescribed for comfort and protection. Shoes must be worn. Leather shoes with heavy soles help prevent punctures from nails and broken glass.

Identification badges must be worn every workday at chest level for easy identification.

When entering a property for the first time, always attempt to contact the property owner or caretaker, explain the work briefly, and ask permission to place the trap. In conversations with the public, traps should be referred to as "Insect Survey Traps". If no one is home, a "Memorandum to Property Owner or Tenant" should be left.

Preliminary Training

A vial of five dead, marked specimens of the target fruit fly species (wing-clipped and color-marked) is sent to each field supervisor by registered mail. These are randomly placed on a Jackson trap insert and shown to all trappers. As part of the demostration, the flies will be submitted for identification as described in normal operational procedures.

Quality Control Advisors

In a large program, quality control advisors may be employed. These personnel will monitor the trapping program. The advisor works with trappers assisting with proper trap location, baiting, host selection, trap deployment, and record keeping.

Deficiencies and recommended improvments in the trapping district are reported to the field supervisor. Such reports are also given to the program manager. Periodic staff meeting of advisors are held to exchange viewpoints and discuss improvements.

Quality Control Trapping Test Program

During the course of a large eradication program, it may be advisable to bait a selected number of traps with marked, dead specimens of the target fruit fly. This would maintain a high level of trapping awareness as well as ensure consistency in both trapping and reporting procedures. Previously killed and marked specimens will be obtained elsewhere and handled at project headquarters. The following procedure is suggested to minimize risk, but actual procedures may vary, depending on agreement with State or local cooperators.

Trap Selection

Each field supervisor will randomly select 5-15 traps per trapper to be tested and provide all data to the program office at least 1 full week in advance of test date.

Preparation

The field supervisor will be notified of the approximate delivery time of the specimens. Specimens will be selected and checked for color markings. As a precaution, the color will be changed each month, and the right or left wing will be clipped. Only the program office will be aware of the color and the clipping schedule.

Mailing

Each marked specimen will be placed in its own vial with a quality control identification number. The number will be recorded in a quality control log. The marked flies will then be sent by registered mail to the field supervisor. The field supervisor will send the program office a list of the traps to be baited for logging by specimen number. Specimens will be placed in traps no earlier that 1 day before normal servicing.

Return

When a marked specimen is detected, standard trapping procedures are followed. However, the specimen is returned in the original vial, the pest detection report slip is given the quality control number under remarks, and the specimen is returned to the program office via registered mail.

Oral Tests

To maintain trapper awareness, an occasional test may be given. General discussion may follow each test so that all concerned will benefit.

E

Manual Name

Appendix E

Technical Regulatory Information

Certain information, such as the sizes of the core area, the presumed infested area, the regulated area, and the survey areas will dictate the scope of the regulatory program.

The information contained in the following chart is meant to indicate those regulatory parameters that will most likely reflect program needs for each fruit fly species. For species with known lures and no prior program records, the parameters given are that for a known program species with the same lure.

Those species without a known lure are teamed with the same parameters as given for South American Fruit Fly, *Anastrepha fraterculus*, since only food lures can be used for these species until and unless a lure can be identified and its attractive radius determined. For many of these species, the Detection radius has been increased, owing to the uncertainly involved.

TABLE E-1: Technical Regulatory Information by Species

Species	Quarantine Actions	Presumptive Infested Area	Core Area	Regulated Area	Delimiting Survey	Detection Survey
Anastrepha antunesi	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mi. radius beyond Delimiting 280 sq. mi.
Annastrepha bistrigata	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mi. radius beyond Delimiting 280 sq. mi.
Anastrepha distincta	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mi. radius beyond Delimiting 280 sq. mi.
Anastrepha fraterculus	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mi. radius beyond Delimiting 280 sq. mi.
Anastrepha grandis	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mi. radius beyond Delimiting 280 sq. mi.
Anastrepha lepozona	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mi. radius beyond Delimiting 280 sq. mi.
Anastrepha ludens	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mi. radius beyond Delimiting 280 sq. mi.
Anastrepha macrura	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mi. radius beyond Delimiting 280 sq. mi.

TABLE E-1: Technical Regulatory Information by Species

Species	Quarantine Actions	Presumptive Infested Area	Core Area	Regulated Area	Delimiting Survey	Detection Survey
Anastrepha obliqua	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mi. radius beyond Delimiting 280 sq. mi.
Anastrepha ocresia	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mi. radius beyond Delimiting 280 sq. mi.
Anastrepha ornata	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mi. radius beyond Delimiting 280 sq. mi.
Anastrepha pseudoparallela	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mi. radius beyond Delimiting 280 sq. mi.
Anastrepha serpentina	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mi. radius beyond Delimiting 280 sq. mi.
Anastrepha striata	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mi. radius beyond Delimiting 280 sq. mi.
Anastrepha suspensa	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mi. radius beyond Delimiting 280 sq. mi.
Bactrocera albistrigata	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera aquilonis	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey

TABLE E-1: Technical Regulatory Information by Species

Species	Quarantine Actions	Presumptive Infested Area	Core Area	Regulated Area	Delimiting Survey	Detection Survey
Bactrocera atrisetosa	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera carambolae	More than 5 adults or unmated female and male within 1 sq. mi. within 1 life cycle or one mated female, larva, pupae or an adult with current program	1.5 mile radius 9 sq. miles	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera caryeae	More than 5 adults or unmated female and male within 1 sq. mi. within 1 life cycle or one mated female, larva, pupae or an adult with current program	1.5 mile radius 9 sq. miles	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera caudata	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera correcta	More than 5 adults or unmated female and male within 1 sq. mi. within 1 life cycle or one mated female, larva, pupae or an adult with current program	1.5 mile radius 9 sq. miles	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera cucumis	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera cucurbitae	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera curvipennis	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey

TABLE E-1: Technical Regulatory Information by Species

Species	Quarantine Actions	Presumptive Infested Area	Core Area	Regulated Area	Delimiting Survey	Detection Survey
Bactrocera decipiens	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera depressa	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera distincta	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera diversa	More than 5 adults or unmated female and male within 1 sq. mi. within 1 life cycle or one mated female, larva, pupae or an adult with current program	1.5 mile radius 9 sq. miles	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera dorsalis	More than 5 adults or unmated female and male within 1 sq. mi. within 1 life cycle or one mated female, larva, pupae or an adult with current program	1.5 mile radius 9 sq. miles	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera facialis	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera frauenfeldi	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera jarvisi	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey

TABLE E-1: Technical Regulatory Information by Species

Species	Quarantine Actions	Presumptive Infested Area	Core Area	Regulated Area	Delimiting Survey	Detection Survey
Bactrocera kandiensis	More than 5 adults or unmated female and male within 1 sq. mi. within 1 life cycle or one mated female, larva, pupae or an adult with current program	1.5 mile radius 9 sq. miles	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera kirki	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera latifrons	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. miles	1 mile radius 4 sq. mi.	3 mile radius 36 sq. mi.	2 miles radius beyond Core Area 32 sq. mi.	In undefined areas with host beyond dDelimiting survey area
Bactrocera melanota	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera minax	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera musae	More than 5 adults or unmated female and male within 1 sq. mi. within 1 life cycle or one mated female, larva, pupae or an adult with current program	1.5 mile radius 9 sq. miles	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera neohumeralis	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera occipitalis	More than 5 adults or unmated female and male within 1 sq. mi. within 1 life cycle or one mated female, larva, pupae or an adult with current program	1.5 mile radius 9 sq. miles	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey

TABLE E-1: Technical Regulatory Information by Species

Species	Quarantine Actions	Presumptive Infested Area	Core Area	Regulated Area	Delimiting Survey	Detection Survey
Bactrocera oleae	Two or more adults or one or more larvae, pupae or an adult with current program	1/2 mile radius 1 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey in host only
Bactrocera papayae	More than 5 adults or unmated female and male within 1 sq. mi. within 1 life cycle or one mated female, larva, pupae or an adult with current program	1.5 mile radius 9 sq. miles	1/2 mile radius 1 sq. mi.	4.5 mile radius* 81 sq. mi. *31 mile(50km) radius (Cantrell, et al. ,2000)	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera passiflorae	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera philippinensis	More than 5 adults or unmated female and male within 1 sq. mi. within 1 life cycle or one mated female, larva, pupae or an adult with current program	1.5 mile radius 9 sq. miles	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera psidii	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera pyrifoliae	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera tau	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey

TABLE E-1: Technical Regulatory Information by Species

Species	Quarantine Actions	Presumptive Infested Area	Core Area	Regulated Area	Delimiting Survey	Detection Survey
Bactrocera trilineola	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera trilineola	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera trivialis	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera tryoni	One or more adults or one or more larvae, pupae	4.5 mile radius 81 sq. mi.	1/2 mile radius 1 sq. mi.	6.5 miles radius 169 sq. mi.	6 miles beyond Core Area 168 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera tsuneonis	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera tuberculata	More than 5 adults or unmated female and male within 1 sq. mi. within 1 life cycle or one mated female, larva, pupae or an adult with current program	1.5 mile radius 9 sq. miles	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera umbrosa	More than 5 adults or unmated female and male within 1 sq. mi. within 1 life cycle or one mated female, larva, pupae or an adult with current program	1.5 mile radius 9 sq. miles	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Bactrocera xanthodes	More than 5 adults or unmated female and male within 1 sq. mi. within 1 life cycle or one mated female, larva, pupae or an adult with current program	1.5 mile radius 9 sq. miles	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey

TABLE E-1: Technical Regulatory Information by Species

Species	Quarantine Actions	Presumptive Infested Area	Core Area	Regulated Area	Delimiting Survey	Detection Survey
Bactrocera zonata	More than 5 adults or unmated female and male within 1 sq. mi. within 1 life cycle or one mated female, larva, pupae or an adult with current program	1.5 mile radius 9 sq. miles	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Capparimyia savastani	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Carpomya incompleta	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Carpomya vesuviana	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Ceratitis anonae	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Ceratitis capitata	Two or more adults within 1 mi per life cycle or 1 mated female, larva, pupa or adult with current program	1/2 mile radius 1 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	1st bufffer - 4 mi radius beyound Core 80 sq. mi. Outer buffer - up to 100 mi radius 9,919 sq. mi.	In areas with host beyond Delimiting Survey (Area undefined)
Ceratitis catoirii	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey

TABLE E-1: Technical Regulatory Information by Species

Species	Quarantine Actions	Presumptive Infested Area	Core Area	Regulated Area	Delimiting Survey	Detection Survey
Ceratitis colae	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Ceratitis cosyra	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Ceratitis malgassa	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Ceratitis pedestris	Two or more adults within 1 mi per life cycle or 1 mated female, larva, pupa or adult with current program	1/2 mile radius 1 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	1st bufffer - 4 mi radius beyound Core 80 sq. mi. Outer buffer - up to 100 mi radius 9,919 sq. mi.	In areas with host beyond Delimiting Survey (Area undefined)
Ceratitis punctata	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Ceratitis quinaria	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey

TABLE E-1: Technical Regulatory Information by Species

Species	Quarantine Actions	Presumptive Infested Area	Core Area	Regulated Area	Delimiting Survey	Detection Survey
Ceratitis rosa	Two or more adults within 1 mi per life cycle or 1 mated female, larva, pupa or adult with current program	1/2 mile radius 1 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	1st bufffer - 4 mi radius beyound Core 80 sq. mi. Outer buffer - up to 100 mi radius 9,919 sq. mi.	In areas with host beyond Delimiting Survey (Area undefined)
Ceratitis rubivora	Two or more adults within 1 mi per life cycle or 1 mated female, larva, pupa or adult with current program	1/2 mile radius 1 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	1st bufffer - 4 mi radius beyound Core 80 sq. mi. Outer buffer - up to 100 mi radius 9,919 sq. mi.	In areas with host beyond Delimiting Survey (Area undefined)
Dacus axanus	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Dacus bivittatus	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Dacus ciliatus	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Dacus demmerezi	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey

TABLE E-1: Technical Regulatory Information by Species

Species	Quarantine Actions	Presumptive Infested Area	Core Area	Regulated Area	Delimiting Survey	Detection Survey
Dacus frontalis	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Dacus lounsburyii	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Dacus punctatifrons	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Dacus smieroides	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Dacus solomonensis	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Dacus telfaireae	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Dacus vertebratus	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey

TABLE E-1: Technical Regulatory Information by Species

Species	Quarantine Actions	Presumptive Infested Area	Core Area	Regulated Area	Delimiting Survey	Detection Survey
Dirioxa pornia	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Epochra canadensis	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Monacrosthcius citricola	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Myiopardalis pardalina	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Rhagoletis cerasi	One or more adults or one or more larvae, pupae	1.5 mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.
Rhagoletis cingulata	One or more adults or one or more larvae, pupae	1.5 mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.
Rhagoletis completa	One or more adults or one or more larvae, pupae	1.5 mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.
Rhagoletis conversa	One or more adults or one or more larvae, pupae	1.5 mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.

TABLE E-1: Technical Regulatory Information by Species

Species	Quarantine Actions	Presumptive Infested Area	Core Area	Regulated Area	Delimiting Survey	Detection Survey
Rhagoletis fausta	One or more adults or one or more larvae, pupae	1.5mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.
Rhagoletis indifferens	One or more adults or one or more larvae, pupae	1.5mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.
Rhagoletis juglandis	One or more adults or one or more larvae, pupae	1.5mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.
Rhagoletis lycopersella	One or more adults or one or more larvae, pupae	1.5mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.
Rhagoletis mendax	One or more adults or one or more larvae, pupae	1.5mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.
Rhagoletis nova	One or more adults or one larva, pupa	1.5mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.
Rhagoletis pomonella	One or more adults or one or more larvae, pupae	1.5mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.
Rhagoletis ribicola	One or more adults or one or more larvae, pupae	1.5mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.
Rhagoletis striatella	One or more adults or one or more larvae, pupae	1.5mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.

TABLE E-1: Technical Regulatory Information by Species

Species	Quarantine Actions	Presumptive Infested Area	Core Area	Regulated Area	Delimiting Survey	Detection Survey
Rhagoletis suavis	One or more adults or one or more larvae, pupae	1.5 mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.
Rhagoletis tabellaria	One or more adults or one or more larvae, pupae	1.5 mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.
Rhagoletis tomatis	One or more adults or one or more larvae, pupae	1.5 mi. radius 9 sq. mi.	1/2 mi radius 1 sq. mi.	4.5 sq. mi. radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	5 mil radius beyond Delimiting 280 sq. mi.
Toxotrypana curvicauda	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Trirhithromyi a cyanescens	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Trirhithrum coffeae	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Trirhithrum nigerrimum	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey
Zonosemata electa	Two or more adults within 3 mi per life cycle or one mated female, larva, pupa or adult with current program	1.5 mile radius 9 sq. mi.	1/2 mile radius 1 sq. mi.	4.5 mile radius 81 sq. mi.	4 miles radius beyond Core Area 80 sq. mi.	Up to 100 mi. radius beyond Delimiting Survey

Regulatory Treatments

No treatment

Under certain conditions selected commodities and host material can be moved without treatment from the regulated area and /or the eradication area (Example green tomatoes - except certain fruit flies attacking green fruit, bagged and certified fruit, fruit shrinkwrapped fruit, if held for 5-6 days). Host material originating outside the regulated area may be certified for export without treatment, provided that it was properly safeguarded and has not transited the treatment area or was transited under tarps, enclosed vans, etc.

Soil Treatment

Diazinon-- (Diazinon AG-500) 3.68 ounces (oz) (1.92 avoirdupois (avdp) ounces active ingredients (oz ai)) of 48 percent diazinon in enough water to soak the top 2 inches (in) of soil over 1,000 square feet (ft^2) to kill larvae, pupae and emerging adults. The water hydrogen-ion concentration (ph) should be adjusted to a ph of 6.5 or less, prior to adding insecticide. The treatment interval will be described in the exemption issued by the Environmental Protection Agency (EPA). Normally, treatments are applied at a 14 to 16 day intervals.

Diazinon may be dropped from commercial use due to concerns about the effects of synthetic chemicals on public health and the environment. However, an emergency Section 18 Quarantine exemption may still be applied for.

It may be possible to use Silwet L-77, part of a new class of silicone-based surfactants which increase the movement of pesticides into plants or soil substrates. Silwet L-77 has low mammalian toxicity and environmental safety. It kills insects indirectly by allowing water to infiltrate the respiratory system, including that of pupae and is potent for up to 14 days. (Purcell, 1998)

Fumigation

The application of an approved fumigant. An emergency exemption may be necessary. Methyl Bromide is scheduled to be phrased out by 2002 to 2005, but an emergency Section 18 Quarantine exemption may still be applied for.

Methyl Iodide, which is an environmentally acceptable alternate, may be used instead, but it has yet to be registered for such use (Sharp & King, 1997). See also, Armstrong, 1992, for a discussion of fruit fly disinfestation strategies beyond methyl bromide. Some of the following treatments can be used; others are restricted or still not available.

High Carbon-dioxide Atmosphere

The procedure involves charging the gas mixture of a chamber or other container with the desirable mixture of Carbon dioxide (CO_2). This is done for certain commodies, such as apples, in order to delay softening during storage. Usually, a 12% concentration is used over 14 days. If the concentration is increased to 19% at 10^{0}C this should be enough to kill eggs of the apple maggot.

Mortality of eggs and larvae of the Caribbean fruit fly approached 100% when specimens were exposed to high concentrations of CO_2 at tempertures between 10-15.6^{0}C for 10 days or less. (Agnello, et al., 2002)

Cold Treatment + Fumigation

The procedure above may be used alone or in conjunction with cold treatment procedures. See T108 or T109-d-1 in the PPQ Treatment Manual.

Fumigation + Heat

The application of an approved fumigant in conjunction with high temperature procedures. (Armstrong & Couey, 1984).

Cold Treatment (Including quick frozen)

The use of cold temperatures as a treatment on selected products along or in conjunction with fumigation. See T107, T109 and T110 in the PPQ treatment manual.

Heat + Cold Treatment

The use of heat treatment, then followed by cold treatment. (Couey, et al., 1984).

Hot Water Dip

The use of a hot water immersion for a specified period of time. See T102 in the PPQ Treatment Manual.

CAUTION

Some fruit flies species tolerate heat better than other species - ie., *Ceratitis cosyra* survives heat treatment better than *C. capitata* or *C. rosa* (Steck, 2000).

CAUTION

T102 is only approved for Mangoes under 700 grams. A new treatment for Mexican Fruit Fly for Mangoes **over** 700 grams suggests that immersion in water at 115^{0}F (**46.1 ^{0}C**) for **110** minutes would be adequate at Probit 9 level quarantine security. (Shellie & Mangan, 2002- and see T102-a in the PPQ Treatment Manual).

Vapor Heat Treatment

The use of heated air saturated with water vapor to raise the temperature of the commodity to a required point and held there for a specified period as a treatment. See T106 in the PPQ Treatment Manual.

CAUTION

For *C. capitata* in tomatoes, the air, at **92%** RH, should be heated to just below 112 ^{0}F (40 ^{0}C) to maintain a minimum fruit core temperature for **two** hours to meet Probit 9 level quarantine security (Heather, et al., 2002 - and see T106-b-7 in the PPQ Treatment Manual.).

High Temperature—Forced Air

The use of heated air alone to raise the temperature of the commodity to a required point and help there for a specified period as a treatment. See T103 in the PPQ Treatment Manual. Also see Wood (1998a).

Irradiation Treatment

The use of low dosages (2.5 kGy minimum) of radiation to treat a commodity. See T105 in the PPQ Treatment Manual. An alternate to get even lower dosages of radiation (0.30 to 0.50 kGy) plus storage at low temperatures (5.5-11.1^{0}C), for 14 to 21 days. (Ohta, et al., 1989). Irradiation may be the most widely applicable quarantine treatment from the standpoint of fruit quality.

However, some important fruits shipped across quarantine barriers, such as mangos and citrus, may suffer from doses as low as 150 Gy when applied on a commercial scale where much of the fruit may receive >300 Gy. Fortunately, some of the tephritids, ie. *Anastrepha* ssp. can be controlled with lower doses (Hallman, 1999).

Shrinkwrap

Wrapping each fruit individually in shrinkwrap forces the larvae to emerge from the fruit within 30 to 60 minutes. There they are caught between wrap and fruit and die. The eggs perish within the fruit. The wrap extends the shelf life of the fruit, which is the reason for the shrinkwrap. If properly wrapped (no holes, tightly wrapped), the shrinkwrap disinfects the fruit if held for 5 or six days. More research is needed, but this would be a good way to examine such fruit for larvae prior to shipment. (Jang, 1990)

Bagged Fruit

Fruit, if properly bagged on the host at a stage when it is not susceptable to attack, and removed under cover when ripe, is free from fruit fly and may be so certified and taken out of the regulated area or to a processing facility. (Pacific Fruit Fly Web, 2000)

Insect growth regulator + wax

Treating each fruit with a formulation of 20% methoprene in wax resulted in a Probate 9 mortality to papayas infested with *Ceratitis capitata*, *Bactrocera dorsalis* and *B. cucurbitae*. (Saul & Seifert, 1990).

Processing

Handling of host material in such a manner that it is transformed into an end product for consumption or other use, and which also eliminates the pest (ie. juiced, diced, canned, bottled, packaged).

Pulsed Electric Field

Treating fruit or other host with a pulse of electric energy for a very short period of time in pulsed bursts of up to 9,000 volts in up to 10 bursts of 50-microseconds each. This is sufficient to kill 90% of Mexican fruit fly eggs, with survivors expiring before reaching the adult stage. A electrical pulse generator is needed. The economic feasibility and efficacy of PEF needs to be researched before approval of this procedure, which could be employed on the assembly line at the packing plant. (Cooper, 1999)

F

Manual Name

Appendix F

Technical Control Information

Overview

The following control options are those currently in use for recognized fruit fly pest species in the United States and elsewhere. It is suggested that for a hitherto unknown pest species, the selection of control options for that species be based on those characteristics that most closely match one of the known species given below, at least in the initial stages.

It must be emphased at the outset that **combined treatments** for eradication or control have proven to be one of the most successful approaches to handling a pest population of fruit flies. This is mentioned in Bateman (1982) where eradication with combined treatments, specifically protein hydrolysates plus male attractants was discussed and Silvinski (1996) who discussed combined releases of sterile males and augmented releases of natural enemies against a pest. A variety of the control options, and especially bio-control and cultural options may be employed at the same time. More recent literature, Permalloo, (2002) and Stonehouse, et al., (2002) continues this approach and appear to achieve good control with Bait ApplicationsTechnique(BAT)andMaleannihilationTechnique(MAT).

Constraints against multiple options include total program costs vs. the stated objective (Control, Suppression- including fly-free zones, Eradication), practical difficulties in delivery of more than one or two control options, and possible biological or logistical or other difficulties in application

Control Options available for different species of the Tephritidae

TABLE F-1: Basic Table of Control Options

Species	Biological Control	Conservation Parasites/ Predators	Augmentation of Parasites/ Predators	Insecticides Biological Insecticides	Insecticides Chemical Insecticides	Autocidal Control Options	Cultural Control
A. fraterculus					4.b.(1). Ground Bait Spray 4(2). Aerial Bait Spray 4(3). Soil Treatment	N/L	6.a. Fruit Stripping 6.b. Clean Cultural Control
B. cucurbitae					4.b.(1). Ground Bait Spray 4(2). Aerial Bait spray 4(3)Soil Treatment 4(4). Spot treatment 4(6). Cordelito Treatment. - Ground & Aerial 4(7) Blocking	Sterile Release: ◆ Static ◆ Roving ◆ Aerial	6.a. Fruit Stripping 6.b. Clean Cultural Control 6.h. Interruption of cropping.
B. dorsalis					4.a.(1). Naturalyte bait spray 4.b.(1). Ground Bait Spray 4(2). Aerial Bait spray 4(3) Soil Treatment 4(5). Spot Treatment 4(7, 8) Blocking	Sterile Release Roving aerial	6..a Fruit Stripping 6.b. Clean Cultural Control 6. e. Plowing
B. frauenfeldi					4.b.(1)Ground Bait Spray 4(7) Blocking		6.a. Fruit Stripping 6.b. Clean Cultural Control

TABLE F-1: Basic Table of Control Options (continued)

Species	Biological Control	Conservation Parasites/ Predators	Augmentation of Parasites/ Predators	Insecticides Biological Insecticides	Insecticides Chemical Insecticides	Autocidal Control Options	Cultural Control
B. latifrons					4.b.(1).Ground Bait Spray 4(2).Aerial Bait Spray 4(3) Soil Treatment		6..a. Fruit Stripping 6.b. Clean Cultural Control
B. oleae (Fletcher, 1986)					4.b.(2) Aerial Bait Spray (Initial spray in midsummer, prior to new host fruit, for maturing females) 4(1) Ground Bait Spray (If necessary) 4.b(5) Bisexual Annihilation		6.a.Fruit Stripping 6.b. Clean Cultural Control 6.c. Host Cleaning 6.h. Interruption of Cropping
B.papayae (Cantrell, et al., 2000)					4.b.(1). Ground Bait Spray 4(8).Blocking		6.a.Fruit Stripping 6.b. Clean Cultural Control 6.d. Bagging
B. tryoni					4.a.(1). Naturalyte bait spray 4.b.(1) Ground Bait Spray 4(2) Aerial Bait Spray 4(3) Soil Treatment 4(4). Spot Treatment or Jackson trap spots 4(7, 8) Blocking	Sterile Release: Roving aerial	6.a Fruit Stripping 6.b. Clean Cultural Control
B. xanthodes					4.b.(1)Ground bait spray 4(7) Blocking		6.a. Fruit Stripping 6.b.Clean Cultural Control

TABLE F-1: Basic Table of Control Options (continued)

Species	Biological Control	Conservation Parasites/ Predators	Augmentation of Parasites/ Predators	Insecticides Biological Insecticides	Insecticides Chemical Insecticides	Autocidal Control Options	Cultural Control
B. zonata					4.a.(1). Naturalyte bait spray 4.b.(1) Ground Bait Spray 4(2). Aerial Bait Spray 4(3) Soil Treatment 4(4). Spot Treatment		6.a. Fruit Stripping 6.b. Clean Cultural Control
C. capitata					4.a.(1). Naturalyte bait spray 4.b.(1)Ground bait spray 4(2) Aerial Bait spray 4(3) Soil Treatment 5(5). Bisexual Annilihilation 6.a. Fruit Stripping	Sterile Release Roving Aerial	6.a. Fruit Stripping 6.b. Clean Cultural Control
R. cerasi					4.b.(1). Ground Bait Spray 4(2). Aerial Bait Spray 4(3). Soil Treatment		6.a. Fruit Stripping 6.b. Clean Cultural Control 6.f. Host Destruction or Removel 6.g. Pruning 6.i. Treatment during cropping intervals

Biological Insecticides

A basic premise of classical biological control is that the target pest will be brought under some degree of control while nontarget organisms are not affected. To do this, the introduced bio-control agent must be relatively host specific.

Often, this can only be determined after release of the agent into the environment. To remedy this dilemma, lab studies attempt to determine the physiological host range of the agent to predict the ecological host range. This does not always work when nontarget possible hosts are exposed to the agent under the confined circumstances of the lab. Many conditions in the outside environment determine which possible hosts are attacked, such as spatial or temporal overlap, host ranges and/or substrates of target and nontarget species, temperature and humidity, tolerances, and others. (Solter, et al, 1997; Hajek, et al, 1996)

To the extent possible, biocontrol agents should be carefully considered for their possible impact on nontarget organisms. Some general rules are as follows:

- Predators are usually more generalist than parasites.
- The known host specificity of an agent, including information on behavior of related taxa.
- Selection of agents known to only attack certain target or closely related non-target species.

To this end, information on the available Biological insecticides (BI) are given in table form to allow comparisons between different Tephritid species as a decision-making tool, and to help in the selection of the best combination of BI.

Some of these tables involve classical biological control, which is covered in a separate, but related publication, should consideration of their use be warranted. This related publication is “Natural Enemies of True Fruit Flies” by the same author and is on the internet as well as stored at the ARS Biological Control Documentation Center in Beltsville, Maryland.

A listing of the micoorganisms/micobial toxins used against the fruit flies species listed therein is given in the publication just given in **Table F-1**. In this table, Biological Modes are given separately under each species. The Products are consecutively numbered under each Biological Mode.

Table F-3 lists those Juvenile Hormone mimics and Insect Growth Regulators which have been found to be useful for the Tephritidae. It should be remembered that nongenetic resistence may take place. This includes phenotypic changes in insect behavior or physiology and of host plant interference with pesticide Action (Appel & Schultz, 1994). Currently, adverse reaction against JH or IGR has not been documented

TABLE F-2: Juvenile hormone (JH) mimics or Insect Growth Regulators in the Tephritidae

Pest Name	Formulation	Specifics
Anastrepha ludens	Cyromazine	In lab, 1-2day old adults fed with 95%TI resulted in reduced oviposition and few eggs. (Martinez & Moreno, 1991)

Table F-3 gives those known pheromones and parapheromones for the Tephritidae, with an outline of details for their use from the literature.

It should be remembered that nongenetic resistence may take place. This includes phenotypic changes in insect behavior or physiology and of host plant interference with pesticide action. (Appel & Schultz, 1994).

Only two pheromones have been used in program efforts for eradication. In theory, these could be used against all species which are attracted to them, but there is variation between species in the power of the attraction, and this fact would auger for caution on their use against untested species. A powerful combined effort, using a food bait as well as a pheromone would have a better chance of success. It is worth it to note that only Methyl Eugenol may be powerful enough to be used in a stand-alone system. The recent development of minus-ceralure, a much more powerful attraction for *Ceratitis capitata* than the standard TML attractant, has lead to some speculation that this lure could be used for mass-trapping (McBride & Wood, 2000).

Currently, adverse reactions against Pheromones in the Tephritidae have not been documented.

TABLE F-3: Known Pheromones in the Tephritidae and their current use.

Pest Name	Pheromone	Specifics
Anastrepha ludens	Mexican Fruit Fly Lure	No Records
Bactrocera cucurbitae *Bactrocera tryoni* *Bactrocera cucurbitae* *Bactrocera frauenfeldi*	Cue Lure	See F.4.b.(4). Toxic Male lure bait See F.4.b.(5). Bisexual Annihilation See F.4.b.(6). Cordelitos See F.4.b.(7). Blocking (APHIS, 1982a, 1982b, 1984a; Stibick, 1990) F.4.b.(7). but with 5 x 5 x 1.27 cm blocks (PFFW, 2000)
Bactrocera dorsalis *Bactrocera zonatus* *Bactrocera carambolae* *Bactrocera dorsalis* *Bactrocera xanthodes*	Methyl Eugenol	See F.4.b.(4). Toxic Male lure bait See F.4.b.(5). Bisexual Annihilation See F.4.b.(6). Cordelitos See F.4.b.(7). Blocking (Stibick, 1988,1989; Steiner, 1965) F.4.b.(7). but with 10 x 7.5 x 1.3 cm blocks (CFFP, 2000) F.4.b.(7). but with 5 x 5 x 1.27 cm blocks (PFFW, 2000)
	Latilure	No Records
Bactrocera oleae	Olean Lure	F.4.b.(9). Bisexual Annihilation (Haniotakis, et al., 1986)
	Trimedlure	No Records
	Trimedlure extract	No Records
	Terpinyl Acetate	No Records
	Vert Lure	No Records
	Papaya Fruit Fly Lure	No Records

Table F-4 gives those plant extracts for which various uses have been found as a lure for the Tephritidae. These extracts have not been shown to possess any toxicity and no use has been recorded in which plant extracts were used to control fruit fly populations.

It should be remembered that nongenetic resistence may take place. This includes phenotypic changes in insect behavior or physiology and of host plant interference with pesticide action. (Appel & Schultz, 1994)

Currently, adverse reactions with Plant Extracts have not been documented.

TABLE F-4: Plant Extracts Successfully Employed Against the Tephritidae

Pest Name	Plant Extract	Specifics
Bactocera cucurbitae	(1). Commercial formulation not known Agent: *Acorus calamus.* (2) Commercial formulation not known. Agent: *Acorus calamus*	One ml sample crude plant extract in hexane attracted males to a trap in the field (Qureshi, et al., 1986). One ml sample crute plant extract in methanol attracted males to a trap in the field at same rate as Cue lure (Qureshi, et al., 1986).
Bactrocera latifrons	(1) Cade oil + alpha-ionol Agent: *Juniperus oxycedrus + Osmanthus fragrans*(?)	Contact ARS, Hawaii. The oil makes the lure (a perfume) more effective. (Wood, 1999; Leffingwell, 1999)
Bactocera zonata	(1) Commercial formulation not given. Agent: Rosa spp.	One ml of Rose oil in trap attracted males only at rate between Dorasalure and methyl eugenol, ie, 245>311>467 (Qureshi, et al., 1986).
Dacus ciliatus	(1) Commercial formulation not known. Agent: *Acorus calamus*	One ml sample crute plant extract in methanol attracted males and females to a trap in the lab. No other lure is known, but this extract failed to attract any flies in the field (Qureshi, et al., 1986).
Tephritidae, general	(1) Azadirachtin (Neem) A number of commercial formulations are available. Agent: *Azadirachta indica*	Use a 1:40 dilution with water in an extremely fine mist spray. Apply after sundown, under lower canopy to wet lower leaf surface and all young budding fruit. 3 applications, 1 at flowering, fruit swell, and first color (Horsefall, 1995).

The classical biological control of fruit flies has not always been reguarded as successful when measured by economic returns, partly because the economic threshold for fly damage is very low. Classical control also suffers from a commonly encountered set of biological difficulties; especially (1) low fecundity of parasitoids compared to fruit flies, (2) poor tracking of fly population growth by parasitoids, due either to relatively ineffectual foraging at low host densities or poor survival through periods when fruit and hosts are absent, and (3) refuge from parasitoid attack for fly larvae in large/thick-skinned fruit (Sivinski, 1996).

The solution to the first two problems is comparatively simple: augment the numbers of parasitoids at critical times and places and use the technique in conjunction with other controls, notably sterile release. The third problem may be partly addressed by employing parasites, especially late instar or pupal parasites, which forage extensively over fallen/broken fruit or even enters damaged fruit cracks, and crawls through the pulp. Again, such parasites should be augmented. (Sivinski, 1996)

The usefulness of certain particularly effective predators should also not be overlooked, especially if one can be obtained and released in large numbers.

A table listing the known parasites and predators of the fruit pest species of the Tephritidae is given in the related “Natural Enemies of True Fruit Flies”, mentioned previously. They are given under the Tephritid species involved, with such notes from the literature that are available. While an effort has been made to keep up with the literature regarding synonymous names, there is no guarantee that these names will still apply to the parasite or predator in question.

Limitations to this list include restrictions on the number of citations given for each parasite or predator, since a repeat of citations serve no useful purpose. Generally, a citation would have to add some useful information or fact about a given parasite or predator.

In addition, due to time constraints, there is no guarantee that all parasites of the listed economic species are given here, although a reasonable effort has been made. Parasites of many noneconomic fruit flies were included in order to provide reasonable coverage of most of the known Tephritid parasites as an aid in program efforts.

Under NOTES, a very brief line or two may provide some information about the parasite or predator which may be useful if the species is to be considered for program purposes. In all cases, the references are cited in this column.

Conservation of Predators and Parasites

This Section is also covered in NETFF, mentioned previously.

Augmentation of Parasites/Predators

Various efforts have been made to suppress fruit fly populations through augmentation of their parasites/predators. This technique is useful where more traditional methods such as insecticide-bait sprays and sterile male releases are impractical. A table illustrating past procedures is given in the related NETFF, mentioned previously.

Releases are either made aerially or by static release stations on the ground. Messing (1993) demonstrated a release platform that seems superior to the standard white plastic bucket release bucket of 3.5 or 4.5 liter capacity with escape holes just under the rim of the lid. The release platform is a circular release platform constructed to hold and protect the paper bags with parasitoids and allow the parasitoids to escape at any angle through a hardware cloth (see figure below). Use of the platform substantially reduced (by 29%) the mortality of parasitoids that died in the buckets.

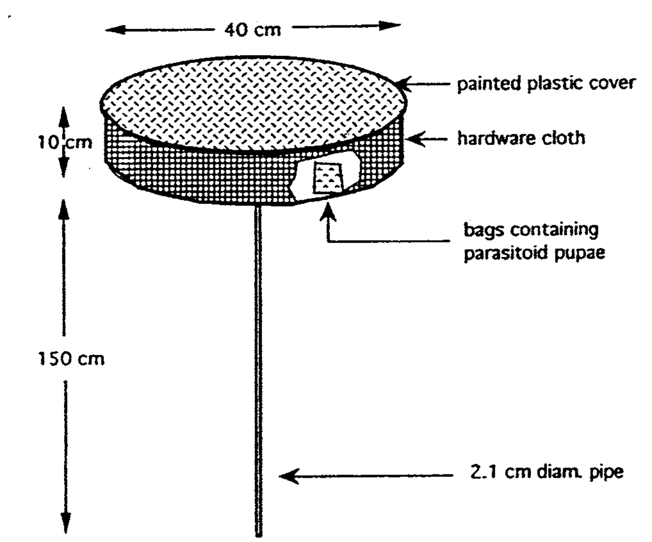


FIGURE F–2: hardware cloth = 1.2 cm^2 openings, height 10 cm, circumference 105 cm
Total escape area 1050 cm2

Insecticides

NOTICE

Stonehouse, et al. (2002a) through "single-killing-point" field assessment appears to demonstrate that bait spots are more effective applied to natural foliage than to cut wood, cloth, or plastic. Wooden blocks kill four times more flies than traps, are cheaper and less vulnerable to theft and weather, and require no recharging and replacement. Blocks made of plywood kill more flies that those of mulberry or poplar. Square and oblong blocks are more effective than round and hexagonal ones.

CAUTION

These generalizations, while reasonable, may not apply under all conditions.

Approved Biological InsecticideTreatments

Ground Applied Proteinaceous Bait Spray-Naturalyte

Application of protein bait spray should be initiated as soon as an eradication project is began. All host plants or trees of the target species within 400 yards (yd) of the detection site will be sprayed at the prescribed intervals. Ground spraying may be discontinued after an estimated two generations of negative trapping or after the initiation of aerial bait spray treatment.

Formulation

GF-120-----Spinosad (Spinosyn A + Spinosyn B mixture)----0.02%

Inert ingredients: (water, sugars, attractants)-------------------99.98%

NAF - 550----------diluted, ready to use product of above.

Use 12 to 96 fluid ounces of product (0.0011 - 0.00883 oz of a.i.) per acre.

The active ingredient is spinosad. a naturally occurring extract from *Saccharopolyspora spinosa*, a bacteria (Thompson, et al., 1999).

GF-120 is a bait concentrate that must be diluted with 1.5 parts of water for every 1 part of GF-120. NAF-550 is ready to use.

This product may be used under Section 18 of the Federal Insecticide, Fungicide and Rodenticide Act and 40 CFR, part 166 for emergency use for all exotic fruit fly members of the Tephritidae, including; *Anastrepha ludens, Anastrepha suspensa, Bactrocera dorsalis, Bactrocera correctus, Bactrocera tryoni, Bactercera zonatus and Ceratitis capitata.* (Shields, 2003)

This treatment is also satisfactory for the apple maggot, *Rhagoletis pomonella* (Moreno & Mangan, 2000).

The bait spray will be applied by means of a backpack sprayer or equivalent unit that has constant agitation. In some cases where large areas of host are involved, the use of motorized spray units such as trucks or even specially equipped all-terrain vehicles may be necessary. It is applied to the leaves on shady areas of hosts.

When applied as a full-coverage foliar spray, mist blowers or similar units can be used. Treatments are to be applied no more frequently than every five days.

If evidence surfaces that the target species population is not declining as a result of treatment, recourse must be made to the application of approved chemical bait treatments.

(2). Ground- Applied Ginger Spray

Another varient is Last Call FF, put out by Insect Science SA.

This consists of :

permethrin (synthetic pyrethroid).....60 g/kg

Fruit Fly Attractant (EGO)..............100 g/kg

It is for use against Ceratitis spp., specifically Medfly, Marula fruit fly and Natal fruit fly. The attractant is enriched ginger oil.

It may be applied with a disposable hand held dispenser pre-calibrated to deliver 50 micro liter drops. Apply 3,000 drops per hectare to the top 2/3 of hosts, giving a dose of 150 grams of product per hectare.

The risk to biological control agents and bees is limited by the method of application. It may also be safe for aerial application, but it is toxic to bees and must not contaminate surface water. This treatment will require a Section 18 exemption (Insect Science, 2002a)

b. Approved Chemical Insecticide Treatments

(1). Ground Applied Proteinaceous Bait Spray

Application of protein bait spray should be initiated as soon as a project is began. All host plants or trees of the target species within 400 yd of the detection site will be sprayed at the prescribed intervals.

Gound spraying may be discontinued after an estimated two generations of negative trapping or after the initiation of aerial bait spray treatments.

(a) Standard Bait Spray

Formulation

Malathion 50 WP or ULV----------------------1 pound (lb) ai/acre

Protein (Miller's)-------------------------------- 2.5 gallons (gal)

Plus sufficient water (if applicable) to meet application equipment requirements.

(b).1 Suredye Bait

Formulation

0.688 % Phloxine B

0.312 % Uranine or Fluorescein

40 % Mazoferm E802

20 % Fructose

Plus sufficient water to meet application equipment requirements. This light-activated formulation is largely experimental, but has been used against *Ceratitis capitata, Bactrocera dorsalis*, and *Anastrepha ludens* in California, Hawaii, Texas and Mexico. The formulation is nontoxic to honeybees (Wilson,et al., 1997), and doesn't contaminate groundwater, (Alcantara-Licudine, et al., 1999).

NOTE: Suredye Bait acts as a defoliant and can put holes in leaves. A protective waxy covering helps. The less waxy a leaf is, the worse the damage. In an urban setting, aerial applications sprays of this product will stain cars and buildings. It will also stain some fruits but will wash off the fruit.(Sakovitch, 2000).

(b).2 Standard Bait + Porphyrins

Formulation

8 *umol-ml Hemotoporphyrin*

Standard sugar/protein bait

Plus sufficient water (if applicable) to meet application equipment requirements.

This strictly experimental treatment, at fluence rates of 1220 uE $s^{-1}m^{-2}$ for *Ceratitis capitata* and 2080 uE s^{-1} m^{-2} for *Bactrocera oleae* resulted in 100% mortality during a 1 hour exposure to light. (Amor, et al., 1998)

(c) Application

The bait spray will be applied by means of a backpack sprayer or equivalent unit that has constant agitation. In some cases where large areas of host are involved, the use of motorized spray units such as trucks or even specially equipped all-terrain vehicles may be necessary. It is applied to the leaves on shady areas of host.

When applied as a full-coverage foliar spray, mist blowers or similar units can be used. Treatments are be be applied 1 week apart. (Stibick, 1993)

(2). Aerial Proteinaceous Bait Spray

Full-coverage bait spray should be applied on a 7 to 10 day schedule.

Protein bait spray for aerial application of ULV Malathion is applied at the rate of 2.4 oz of 91% of technical grade malathion plus 9.6 oz of protein bait per acre.

The area of full-coverage bait spray will extend a minimum of 1 1/2 mi beyond any known fly detection.

After an estimated two target fly generations of negative trapping, spray operations may be discontinued.

Treatment or retreatment should not be considered if weather reports indicate a 50 percent or greater chance of percipitation within 48 hours. Rainfall immediately following a treatment reduces the effective period of the treatment.

The objectives of this treatment are to eradicate or control the pest with minimal environmental contamination. Any treatment or retreatment recommendations must consider these objectives.

(Stibick, 1984, 1993)

Application of aerial bait spray treatments with spinosad formulations appear not to have been tested.

(3). Soil Treatment

Approved soil treatments should be applied under host plants on properties with confirmed larval infestations, and may be applied under host plants within 200 yd radius of infested properties. The prescribed treatments should be applied at intervals stated in section 18 or section 24(c), as appropriate. Normally the interval is 14-16 days.

Diazinon--(Diazinon AllPro-4E) 1.8 oz of 47.5 percent diazinon in enough water to soak soil over 1,000 ft^2 to soak the top 2 in of soil. To avoid premature degradation of the ai, adjust pH of water to 6.5 prior to adding insecticide.

(Stibick, 1993; Hazen, 1999)

Diazinon Granules--Work Diazinon 14G 2 inches into soil at the rate of 35 lb per acre (a) or 1.45 oz per 12 ft diameter drip circle (113 ft^2). The area may be pretreated with water that has been buffered (6.0 - 6.5) to enhance distribution of the material into the soil.

(Stibick, 1993)

(4). Toxic Male Lure Bait (Male annihilation)

Naled--------30% Dibrom 14

Minu-gel-----23% minu-gel 400

Male Lure---47% Cue-Lure or 67% Methyl Eugenol

Apply above mixture, formulated by weight, with a hydralic oil squirt can or Panama pump♦ gun out of the reach of children. The lure is squirted on tree trunks, fences, utility poles, etc., at the rate of 3 to 5 mls per station, with 6,000 per square mile. Treatment to be applied every 7 to 14 days.

Do not apply treatment to surfaces that appear greasy, wet, or stained with other substances which might interfere with the attractive and killing powers of the bait (i.e., creosote on utility poles). Certain types of trees might suffer from the application (i.e., palms will exude sap from the sprayed areas).

The application of a protein source such as Dakpot Fruit Fly Attractant (DFFA) to hosts is another varient of this technique. This protein is processed to have a much lower salt content than protein hydrolysate and so causes far less burn on delicate varieties of host plants. It is combined with an insecticide component and water (on the label) to attract the male (mostly) of the species. Species known to be attracted to DFFA are Queensland, Mediterranean, Melon, Papaya and Oriental fruit flies. Because this bait is a protein, it would seem that this application would fall under 4.(6), but the males are primarily attracted to this source. DFFA is one of the early attractants for fruit flies.(Dakpot Products, 1999).

A varient of this technique, and to protect the environment in an ecologically sensitive area, is the use of traps in lieu of the bait spots. Jackson traps need not be equipped with inserts and need only be serviced to check on the condition of the trap and the lure.

For *Bactrocera dorsalis* and B. *zonata* mass trapping, the traps should be set at a height of 1 meter and no more than 1.5 meters (Ali, et al., 1999).

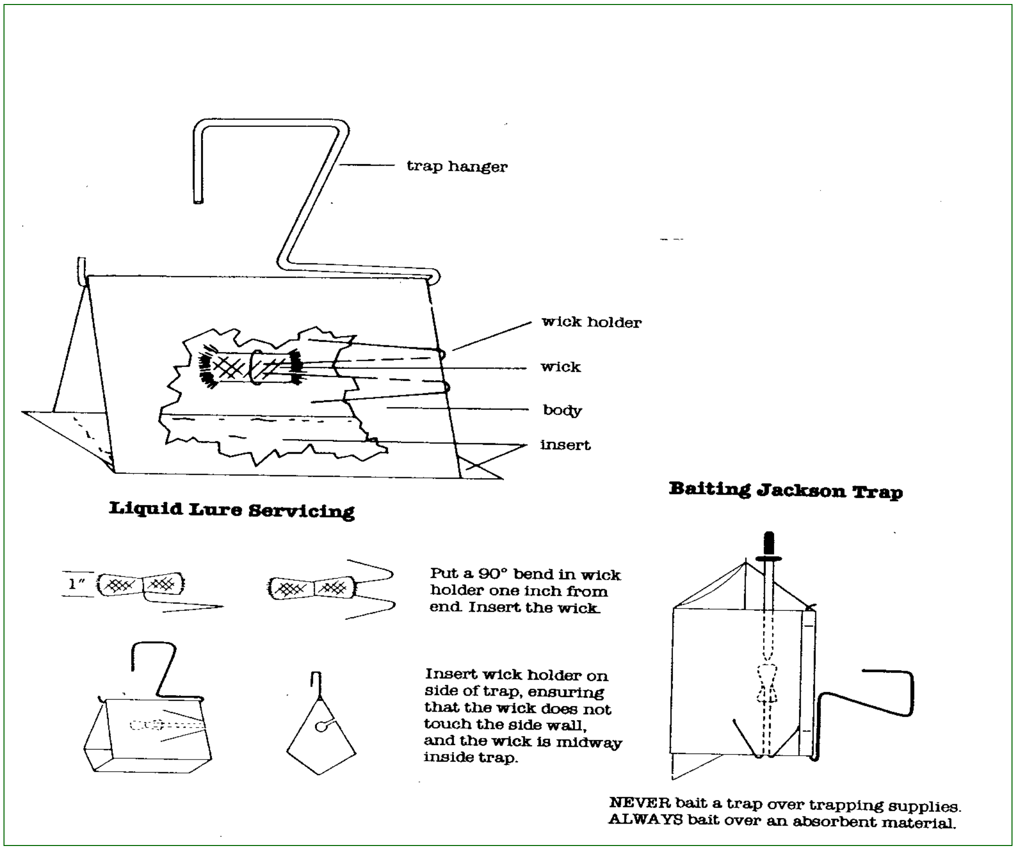
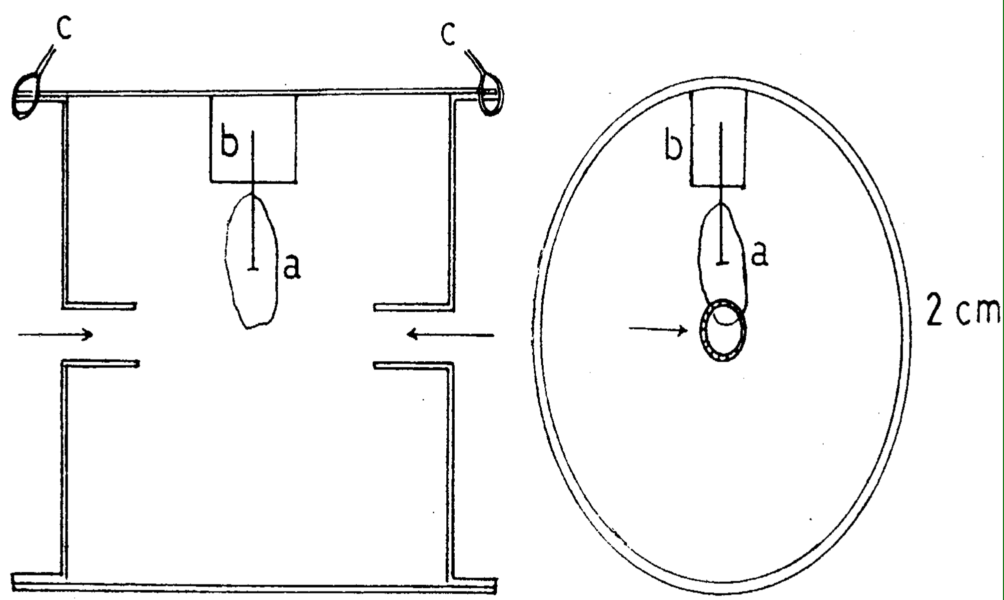


FIGURE F–3:

An alternative, the dakpot lure, comes already impregnated in a fiberous shelf in sealed tins. The lid is removed and a hanger taken out for instant placement. This is a commercial product and attracts species drawn to Cue lure. *Bactrocera tryoni* and *Bactrocera neohumeralis* are specificly mentioned (Bilpin Springs Orchard, 2000).

For strict protection of an ecologically sensitive area, the Tan trap may be used. Since it contains only the attractant, and prevents escape due to the even light intensity and small size of the entrance ports, the flies are generally collected live. A disadvantage is that such traps may have to be serviced daily if populations are high.



Fruit fly attractant trap (left—front view; right—side view).
a—cotton bud to contain attractant;
b—polystyrene block;
c—string or wire;
arrow—port of trap.

FIGURE F–4: Tan Trap

Generally, it will be difficult, if not impossible or impractical, to set out traps at the bait spot density and a lower density may be necessary. From experience, a minimum of 1,000 traps per sq mi is necessary.

Traps used in this manner for male annihilation, are considered a control devise by the EPA, and therefore requires an emergency exemption. (Stibick.1990)

Another varient has been used with;

Eugecide-S:

85% ME + 5% naled + 10% sugar.

Eugecide-S has been successfully applied to eradicate *B. dorsalis* from the Okinawa islands in Japan (Sonda & Ichinohe, 1984), and reduced the populations of these two species in India by 77.37% (*zonatus*) and 80.48% *(dorsalis)* (Marwat, et al., 1992).

Populations of *B. zonatus* in India have also been suppressed using gallon plastic traps to reduce the catch to12.1 flies/trap per day down from 1108.3 flies/trap before the experiment (Qureshi, et al., 1981).

Traps used in this manner for male annihilation, are considered a control devise by the EPA, and therefore requires an emergency exemption. (Stibick.1990)

(5)Bisexual Annihilation

A further varient of the above is to attempt to destroy both sexes in a ecologically sensitive area in the core area. All properties will be trapped at the rate of 3 sites per 1/4 acre lots where shade or hosts exist. This rate is about 7,777 sites per mi^2 ; but in practice, in urban areas, only about 1/4 of this area may need to be trapped. This option will be selected with full knowledge of its labor-intensive nature. To save on costs, only designated traps will be serviced to monitor the Target fruit fly population; others will be serviced strictly to replace lures/insecticides as needed.

If the bait is one attractive to both sexes, each site will consist of one Jackson or similar dry-type trap, hung in preferred fruiting host, fruiting host, non-fruiting host or shade tree/bush at standard height. If the bait is a food bait, a McPhail trap or similar type shall be hung at the site. If one or the other sex is attracted to a different bait, than both a Jackson/ McPhail trap, attract and kill traps or Sensus traps, shall be hung at the site, within one yard of each other. All traps will be baited with standard lures and insecticides. (APHIS, 1993 Draft)

The Ladd trap may also be deployed in a similar trapping strategy (Trap-Out) against *Rhagoletis pomonella*. It is deployed at the rate of one trap every other tree in an orchard and each wild or abandoned tree within 300 to 400 yards of the orchard perimeter. (MacCollom, 1987)

Traps used in this manner for male/female annihilation, are considered a control devise by the EPA, and therefore requires an emergency exemption. (Stibick.1990)

Attract and Kill Device

There is a specific device designed to attract and kill both male and female Olive Flies (*Bactrocera oleae*). It is not a trap, as the flies will walk across a treated surface and wander off to die elsewhere. This device is called the AgriSense Attract and Kill (A&K). Two out of three devices will attract mainly the female and a third trap has the male pheromone attached to it and attract chiefly males. The reason for this is that the food devices attract olive flies from roughly 36 to 45 feet away, while male pheromones attract the male from roughly 75 to 100 feet away.

The device contains:

Lambda-cyhalothrin 0.05% (a pyrethroid killing agent)

Ammonium bicarbonate 12.70% (food attractant)

1,7-dioxaspiro-(5,5)-undecane (Spiroketal-male attractant every 3rd device)

The device consists of a cardboard unit with a packet containing the food attractant and a plastic dispenser containing the male attractant attached. The killing agent is spread across the cardboard. This device is positioned around a branch in a cone-like shape and locked into place with a simple precut snap, and with the treated surface and attractants on the inside. The device should be placed as high as possible on the sunny side of the olive tree.

For ornamental trees, the devices should be hung at the rate of one device per tree. For commercial plantings, a maximum of 42 devices per acre is allowed (EPA Section 18 exemption). This rate is about 26,880 devices per sq mi^2 and a maximum of 2,000 acres may be treated. However, these devices do not have to be serviced and will last about 4-6 months. (Kirkpatrick, 2002; California Olive Oil Council, 2002; Cline, 2002; Shields, 2002; Tedeschini, et al., 2002)

NOTE: This device has potential for use against other fruit fly species, provided the proper attractants are employed.

NOTE: This device has been used in an integrated control situation, where one device per tree was employed with one treatment by ground bait spray with a protein hydrolyzate/dimethoate combination in Greece. (Mazomenos, et al., 2002)

Traps used in this manner for male annihilation, are considered a control devise by the EPA, and therefore requires an emergency exemption. (Stibick.1990)

Eco-Trap

This is a newer trap than the above, which was also specifically designed for mass trapping. It consists of a light green paper envelope 15x20 cm (5.89”x 7.86”) with an internal plastic film lining for water and air proofing. This contains a food attractant (70 grams of ammonium bicarbonate salt). Its surface is covered by the contact insecticide deltamethrine. A pheromone dispensing capsule with 80 mg of the major pheromone is externally attached. It attracts olive flies from distances further than 200 m and remains active for more than six months. (Vioryl, 2001; Broumas, et al., 2002)

For mass trapping, traps should be hung at a density of one every other tree in orchards with small to medium sized trees with distances between trees of 8 metres or less (approximately 150 or more trees per/ha). A density of one per tree should prevail in orchards with large size trees and/or longer distances between trees. For ornamental or wild trees, the density will be one per tree. (Broumas, et al., 2002)

Traps used in this manner for male annihilation, are considered a control devise by the EPA, and therefore requires an emergency exemption. (Stibick.1990)

.(6). Foliage Baiting (Food bait)

This treatment is a more limited application of 4.b.(1), which is a full drench of the host. Instead, the bait spray is spread over a one metre square area of the host.

Protein autoysate----2 1/2 gallons

Malathion-----------2 pounds

Water---------------260 gallons

Apply using a backpack sprayer or equivalent unit or a truck-mounted pump with a wand over 20 feet (6 meters) in length to deliver 3.3 fl. oz. (100ml) of bait over one square metre of host leaves per host. There will be 6,000 stations per square mile.

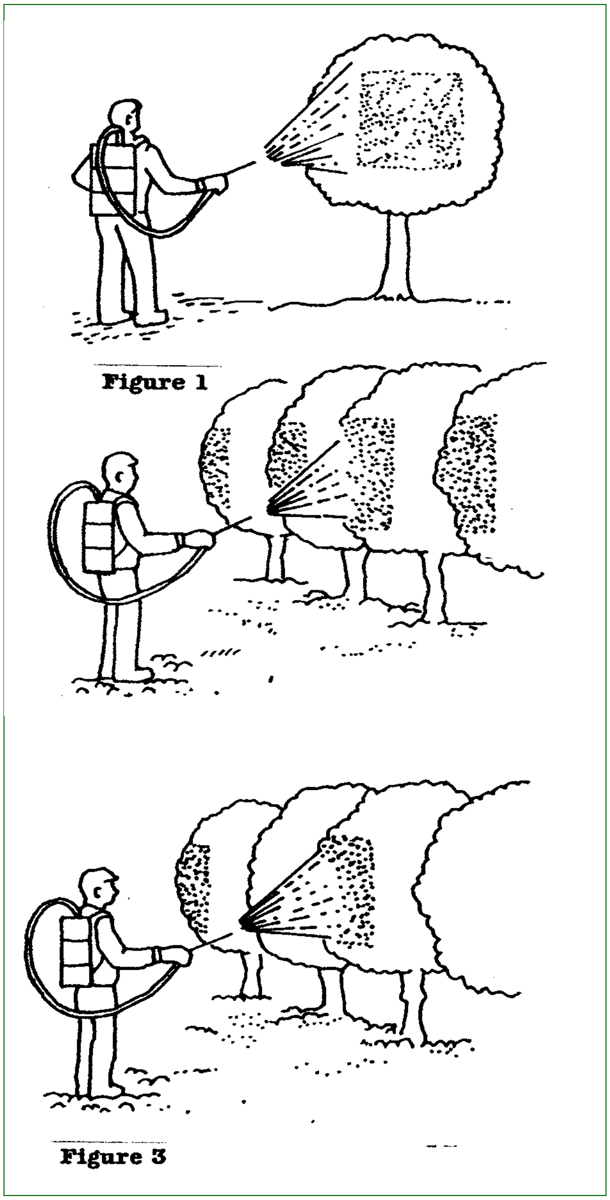


FIGURE F–5:

Each host or station (alternatives include nonhosts) shall be given a foliage drench until leaf surface is wet. Applications are sprayed on one side out of reach of children or pets.

Subsequent treatments may be decreased by an application to every other host only. Generally used in pest “hot spots” and for treating large host trees. (APHIS, 1984c; APHS, 1999)

The same principle may be applied with:

- Mauri Pinnacle Protein Insect Lure or Royal Tongalure--50ml
- Fipronil or Malathion(50% EC)--4ml

- Water--to make up one litre of solution

This formulation is sprayed as large droplets onto leaf surfaces of hosts at the rate of 180 litres of protin bait or 50 to 100 ml on the undersurfaces of 1 sq metre of leaves of host (trees)on a weekly basis. Surrounding trees or shrubs may also be sprayed. For vegetables, 20-25 litres of bait solution per hectare are applied weekly. For cucurbits, spraying the crop and vegetation surrounding it with spots of 50-100 ml is recommended. Adding a thickener (xanthane gum) makes this treatment a bait spot application. (Pacific Fruit Fly Web, 2000)

Another related protein treatment is as follows:

- 2 liters of Buminal or Hym-Lure per 100 liters of water
- 275 grams of fenthion or 500 g malathion or 500 g mercaptothion

The poison bait is applied to the host in the form of large droplet sprays at a rate of 250 to 1,000 ml/host, depending on host size. It is not necessary to wet the entire host, a section on one side of the host will be adequate.

This formulation appears to work for *Ceratitis* spp., Medfly and Natal fruit fly. (Quilici & Franck, 1999; Quilici, 1999; Kaiser & Sheard, 2001; Directorate Communication, 2000)

The application of a protein source such as Dakpot Fruit Fly Attractant (DFFA) to hosts is another varient of this technique. This protein is processed to have a much lower salt content than protein hydrolysate and so causes far less burn on delicate varieties of host plants. It is combined with an insecticide (Maldison) component and water (on the label) to attract the male (mostly) of the species. It is applied to the foliage at the rate of 100 mL per host, avoiding the fruit and is therefore favored by those worried about pesticide residues and those using some form of IPM, in which most beneficial insects remain undisturbed. Species known to be attracted to DFFA are Queensland, Mediterranean, Melon, Papaya and Oriental fruit flies. DFFA is one of the early attractants for fruit flies.(Bilpin Springs Orchard, 2000).

‘Splash on’ Bait

A ‘splash on’ bait is made with 50 g of sugar in one litre of water. Add 7 ml of concentrated pyrethrum or nicotine. Splash it on trees but don’t spray it because the result will be too dilute to be effective. Re-apply it at least every week because pyrethrum breaks down on contact with light, and nicotine is only effective for a few days. (Warm Earth, 2000)

Trapping to thin out the pest population with a food bait has been attempted. Most recently this has been tried to control *Rhagoletis*. A formulation of:

- table sugar,
- high-fructose corn syrup,
- water,
- corn flour, and
- sorbic acid

is used with an insecticide such as imidacloprid plus hot cayenne pepper (to discourge wildlife). The formulation is solidified into a ball-like shape and painted black (or red) with a latex enamel paint. This is a biodegradable decoy, which, lasts 11 weeks and hung in suffient density, should depress the target population just as well as 3 applications of azinphosmethyl. The process is still experimental and the traps used in this manner may be considered a control devise by the EPA, and therefore may require an emergency exemption. (Hardin, 2000)

A varient is the use of an 8 cm ball consisting of :

- 42-50% sugar entrapped in a mixture of ;
- gelatinized corn flour and wheat flour in;
- glycerin;

the whole coated with a layer of latex paint (red or yellow) containing dimethoate + sugar. This outer layer of paint prevents cracking of the sphere upon drying and creates a barrier to control the release of both sugar and dimethoate. This sphere lasts for 11 weeks with 70% insecticidal activity.

It may, in fact, be moulded into a shape, color, and texture into forms known to be attractive to target insects and by employing various toxicants designed to be effective against such insects. It has been used experimentally against *Rhagoletis pomonella* and *Ceratitis capitata*. The process is still experimental and the traps used in this manner may be considered a control devise by the EPA, and therefore may require an emergency exemption. (Hu, et al., 1998a; 1998b)

Cordelitos (Male annihilation)

- Naled---------0.6 gm.
- Male Lure----2 gm of cue-lure or 6 gm of methyl eugenol per carrier
- Carrier-------30 mm of 6-ply cotton dental wick

Cords should be placed on vegetation, etc., out of reach of children and pets at the rate of 6,000 per square mile. To be applied by air in unpopulated areas, by hand in populated areas. Treatment to be applied every 7 to 14 days. (APHIS, 1984a; Drew, et al., 1982, p124)

Blocking (Male annihilation)

- Malathion----30% technical malathion (91%)
- Male Lure---2 gm of Methyl Eugenol or Cue Lure per block
- Carrier------Caneite Block

Blocks should be placed on vegetation, etc., out of the reach of children and pets at the rate 250 blocks per km^2 in rural areas of 400 blocks/km^2 in rural residental areas and 600 blocks/km^2 in urban areas. Blocks are replaced every eight weeks. Blocks are nailed to trees at least 4.5 to 5 feet above the ground (APHIS, 1982d and e; Steiner, 1965; Cantrell, et al., 2000)

- Fipronil----concentrate
- Male lure--Methyl Eugenol or Cue Lure
- Carrier----fibreboard blocks (50mm x 50mm x 12.7mm)

Blocks are soaked in either male lure and the insecticide. They are distributed at intervals of 50 metres over the regulated area in all accessable areas. (Pacific Fruit Fly Web, 2000)

A new alternate is a commercial tablet produced by an Australian Company; Aventis Cropscience.

Commercial name: MATkill M-E

A 2 cm diameter tablet charged with highly concentrated and long lasting fipronil and the bait (Methyl or Cue Lure).

This would presumably be placed at the same rate per 50 metres as above. (Anon., 2000d)

NOTICE

Enclosed Blocks

In environmentally sensitive areas, blocks may be enclosed by encasing them in a 2 litre plastic milk bottle which has been modified by cutting two entrance holes at about mid-height.

This will satisfy environmental concerns about possible leaching of maldison by rainwater from exposed blocks. (Cantrell, et al., 2000)

NOTICE

Fibrous trees such as palms develop rot around the nail holes. to avoid this, blocks should be attached with wire. (Cantrell, et al., 2000)

Blocking (Bisexual annihilation)

- Insecticide/Food Solution, in g(AI)/per liter
- Deltamethrin -1g
- Sugar - 100 g
- glycerine - 100 g
- Pheromone
  - Major pheromone component: Olean Lure (1,7 dioxaspiro[5.5]undecane) in racemic form = equal amounts of a male sex attractant and a female aggregation pheromone. (Haniotakis, et al, 1986)
- Attractants Amount/per carrier
  - 50 g food fomulation above + 50 mg pheromone
  - Carrier----Plywood rectangles (20 x 15 x 0.4 cm)

The carrier is dipped for 30 minutes in a water solution containing the solution above. They are installed at the rate of 1 to 2 per tree approximately 1-2 weeks before before new fruit becomes susceptible to insect attack. They require no replacement in the case of *Bactrocera oleae*, the only species tested for this method to date, during the olive fruiting period. These blocks are left in the trees for an entire year and are recovered when new ones are installed. The old blocks may be retreated and reused. This particular method has, in addition to greatly reducing the target pest population, in the area, the advantage of providing protection by eliminating bait sprays and increasing the populations of beneficial organisms. (Haniotakis, et al., 1991)

Autocidal Control Options

In situations where SIT is the most appropriate response, the technique may be employed. It may be used after initial treatments have reduced pest population densities or in conjunction with those treatments. The sterilization method of choice has been irradiation, but some interest in chemosterilization has been revived in recent years.

A trap array of five traps per mi^2 using Steiner or Nadel traps will be utilized in a monitoring survey throughout the area where sterile flies are released. The traps will be baited with the male lure appropriate to the species, and serviced on a one week schedule. In addition, an identification laboratory will be set up near the sterile release area for rapid identification of sterile flies.

Sterile release can be achieved using three methods These methods are utilized to ensure that no less that 1/2 million flies are dispensed in the core area per week and no less than 250,000 adult flies per mi^2 are to be dispensed in the buffer zone completely surrounding the core area. Additional flies are to be released in any mi^2 where monitoring surveys indicate that the overflooding ratio is less than 100 sterile flies to one native fly.

NOTICE

If sterile males are fed their corresponding attractant no earlier than 1 day before release, this may enhance their mating behaviour. This has been shown for *Bactrocera cucurbitae* males fed on Cue lure (Shelly and Villaobos, 1995). This same treatment may also make sterile males relatively insensitive to the attractant and consequently such males may be used in a combined program using both male annihilation and sterile release as was shown for *Bactrocera dorsalis* exposed to ME lure (Shelly, 1994).

NOTICE

If sterile males are fed the appropriate juvenile hormones and kairomones, they may become more competitave than wild males in mating and inseminating wild females (Teal, 2002).

NOTICE

If entirely male populations become available from sterile rearing facilities (using a temperature-sensitive lethal (tsl) strain such as that under development for *Ceratitis capitata*), these are to be preferred, as they will reduce larval rearing costs (Anon., 2000c).

The following methods will be utilized to achieve sterile fly distribution:

Static Sterile Release

Static release stations will be established per square mile at the rate determined for the Target fruit fly. Use the detection site as an epicenter to establish the square mile. A static release station is to be established at all positive detection sites. Static release stations consist of a lanoi bucket with sterile pupae ready to pupate.

Roving Sterile Release

This release system involves the release of adult flies from a moving vehicle. Use of this system permits rapid dispersal of large volumes of adult flies under various favorable biological and environmental situations.

Roving sterile release is generally utilized within the core area or 1/2 mile beyond all positive detections. The roving sterile release method also may be used to distribute the sterile flies within the minimum buffer zone surrounding the core area.

Quality control data secured for the Rearing Supervisor will be used to determine how many flies to release.

Aerial Sterile Release

This method of releasing sterile flies provides better general distribution over an area than the other methods.

Fly distribution should be accomplished over the entire aerial release zone for any day aerial operations are conducted. It will be necessary to conduct additional aerial release flights over the core area to maintain the ratio of populations (i.e., core area versus buffer zone) when aerial sterile release is the only method of release being utilized.

Either system, (i.e., static, roving or aerial release) or a combination of these techniques is a satisfactory method of achieving desired sterile fly distribution. Infestation size and location will influence the release method selected. This selection is to be made by control personnel.

Booby-trapping

If chemical sterilization is employed, it may be possible to sterilize the wild population by releasing chemically sterilized adults. This was tried on a caged population for *Bactrocera tryoni*. Females of that species were sterilized by a topical application of 400 ug of N,N-tetramethylenebis(1-aziridinecarboxamide), a mutagen, and sterilized males with which they copulated in turn. The sterilant may be spread more by attempted matings then by actual matings, but in any case male sterility was complete and persisted for at least 10 days. This practice may cause a considerable drop in overall fertility. (Smart, et al., 1976; Smart & Gilmour, 1976).

TABLE F-5: Sterile Release Parameters by Species

Species	Monitoring Survey Traps	Sterile Flies	Overflooding Ratio Needed	Static Sterile Release	Roving Sterile Release	Aerial Sterile Release
A. fraterculus (Gonzalez, et al, 1971)	60 traps in a circle 50 meters apart	8,000 released at site for 21 days	?	Yes	——	——
A. ludens (Brown, 1985a)	5 traps per mi2 throughout core and 3 mi buffer area	250,000 per m2	100 sterile flies to 1 native fly	50 static release stations per sq mi2 witnin core	Within core Optional within buffer	Aerial release flights to maintain 20:1 ratio of core and 3 mi buffer zone
A. suspensa (Brown, 1985b)	5 traps per mi2 throughout core and 3 mi buffer area	250,000 per m2	100 sterile flies to 1 native fly	50 static release stations per sq mi2 witnin core	Within core Optional within buffer	Aerial release flights to maintain 20:1 ratio of core and 3 mi buffer zone
B. cucurbitae (APHIS, 1984a)	5 traps per mi2 throughout core and 3 mi buffer area	500,000 per mi2 in core and 25,000 in 3 mi buffer per week	50 sterile flies to 1 native fly	50 static release stations per sq mi2	Within core Optional within buffer	Aerial release flights to maintain 20:1 ratio of core to buffer zone
B. dorsalis (Stibick, 1989)	5 traps per m^{i2} throughout core and 3 mi buffer area	1,000,000 per m^{i2} in core and 50,000 in 3 mi buffer per week	100 sterile flies to 1 native fly	—	Within core Optional within buffer	Aerial release flights to maintain 20:1 ratio of core to buffer zone
B. minax (Wang & Zhang, 1994)	?	56,000 and 95,000 in 1987 and 1989 in Orchard of 34 hectares	Attained ratios of 12.5:1 and 45:1	Yes		
B. tryoni (Fisher, 1994)	1 km grid over 1400 km sq Supplementary traps of 5 lynfield traps + 5 Nakagawa ttraps within 300 meters and 7 lynflelds within 500 m of an infestation	40 million steriles per week over 800 sq km. Preliminary suppression of wilds through Male annihilation + foliage baiting.	Attained ratios of of up to 824-5,470 steriles to 1 native fly	Yes, every other day Avoidance of dispersal by high frequency of low density releases.		

TABLE F-5: Sterile Release Parameters by Species (continued)

Species	Monitoring Survey Traps	Sterile Flies	Overflooding Ratio Needed	Static Sterile Release	Roving Sterile Release	Aerial Sterile Release
B. tryoni (Stibick, 1990)	5 traps per mi ^{2} throughout core and 6 mi buffer area	500,000 per mi2 in core and 250,000 in 6 mi buffer per week	100 sterile flies to 1 native fly	—	Within Core Optional within Buffer	Aerial release flights to maintain 2:1 ratio of core to buffer zone
C. capitata (APHIS, Draft, 1993)	5 traps per m^{i2} throughout core and 3 mi buffer area	1,000,000 per m^{i2} in core and 250,000 in 3 mi buffer per week	100 sterile flies to 1 native fly	—	Within Core Optional within Buffer May be combined with Aerial Release	Aerial release flights to maintain 4:1 ratio of core to buffer zone
Dacus ciliatus Note: Huque & Ahmad, 1969, only determined optimum sterilizing dosage as 8.5-10 krad	Suggest guidelines as for Ceratitis capitata. Stated objective to eradicate fly from Karachi area of Pakistan.	ibid	ibid	?	ibid	ibid

Cultural Control

Any of the following supplementary options may be selected. Fruit stripping is routinely practiced as part of any program measure for control.

Fruit Stripping

All ripe host fruit within 200 yd of an infested property when a larval find has occurred, and which has either dropped or is still on the host, will be stripped. Stripped and dropped fruit is to be double bagged in thick plastic bags, securely tied, and disposed of by deep burial in an approved landfill (Stibick, 1993). This practice also reduces the incidence of disease which is spread by fruit flies (Ito, et al., 1979).

Clean Cultural Control (Sanitation)

Sanitation in nurseries, farms, gardens, and other establishments where hosts are present will be carried out within the core and buffer areas. Scrupulous attention must be paid to host hygiene. If possible, fruit should be picked green and ripened inside. Decaying fruit must never be laid on the ground, but picked up each day. Never leave affected fruit in uncovered compost heaps.

Sanitation will otherwise consist of the cleaning and/or destruction of the hosts and their removal, as given under c. Host Cleaning and f. Host Destruction and Removal.

It is recommended that clean cultural control, which includes picking up all dropped fruit and fruit that is damaged*, diseased or otherwise in poor condition be disposed of in this manner by the general public, especially growers, throughout the regulated area to reduce likelihood of spread of the target fruit fly.

NOTICE

Damaged fruit has been shown to be very attractive to female fruit flies, which are opportunists capable of responding to unfamiliar fruit in an unnatural area. (Robacker, 2002)

Host Cleaning

In certain cases it may be advisable to clear the undergrowth away from hosts, leaving the soil swept clean around the stem of each host. (Frohlich & Rodewald, 1970)

Bagging

Bagging can be an effective control measure if the numbers of available host is limited and in small plantings (1 to 25 plants or less than 1/10 hectare). Bagging should began when the fruit is small, shortly after the flowers have fallen off. Each fruit should be enclosed in a double paper bag or rolled tube of a double layer of newspaper stapled into a bag. Prior to placing the bag over the fruit, blow into it to inflate it and tie around the stem. Then push the bottom of the bag upwards to make it “v” shaped. This prevents rain damage, keeps the bag inflated and the fruit away from the sides of the bag. This method can be very practical and successful if enough labor is available. Attention to covering new fruit and increasing the covering as the fruits increase in size may be necessary. This is partically effective against fruit fly species whose host range is very limited. (Selman, 1998, Pacific Fruit Fly Web, 2000)

NOTICE

Plastic bags may be used but are not ideal, because the inside gets hot and moisture favors the growth of fungus. Such bags are more suitable for large cucurbits. (Pacific Fruit Fly Web, 2000)

Bagged fruit produces very high quality fruits at harvest. The bag may be carefully opened to see if the fruit is ripe. If precautions are taken, and the fruit is shipped under cover direct to the processing facility without delay, the fruit need not be quarantined. (Pacific Fruit Fly Web, 2000)

Use water-proof, re-usable paper bags, of various sizes, to cover individual fruits. As this is labor intensive, it can only be used for certain select hosts. For reasonably priced bags, contact Palmwoods Farm and Garden Supplies, P.O. Box 44, Palmwoods, Victoria, Australia 4555; phone 074-459-076 (Horsefall, 1995).

Plowing

Plots of fields of annual or perennial hosts, such as tomatoes, which are within 200 yd of a confirmed larval find, should be plowed to 6 inches to minimize survival of any life stages present in the soil (Stibick, 1993).

Host Destruction or Removal

In situations with a very limited infested area and when the hosts are all herbaceous, vinelike and/or decumbent, consideration may be given to host destruction by (1) herbicides, (2) disking or plowing, and (3) removal and burial or incineration. In cases of such destruction, all fruit and sometimes certain soft or young parts of the host must be completely destroyed.

In areas of extreme environmental sensitivity, as a limited alternative to adulticide treatment, all host plants in the immediate areas are to be taken out and destroyed by burning or removal in a sealed plastic bag to an approved landfill for burial. (APHIS, 1984b)

Burning of Debris

When host material is collected, it may be piled into heaps and burned if local ordinances permit. The residue can be disked under or otherwise buried in an approved landfill. Care should be taken not to unduly disturb egg masses or pupal cases, which could result in scattering eggs or pupae so that they escape destruction.

- **Animal Food—**Some kinds of host material may be used as animal food, with any residue disposed of by burning/burial at an approved landfill.
- **Bagged and Buried—**Host material may be collected in suitable containers and transported to an approved landfill. Care should be taken not to unduly disturb material which could result in scattering larvae so that they escape burial. Fruit and other possible susceptable plant parts may otherwise be covered with water, kerosene or placed in a sealed plastic bag until it decomposes.

Pruning

If there are few host plants in the infested area or the area is small, pruning the plants back so that no fruits will be produced for three years could be an effective supplemental treatment procedure.

Interruption of Cropping

If the area is small or the host(s) few in number, or only cultivated hosts (annual or perannual) are available to the pest, then there could be an Interruption of Cropping for a period of two years in which no crops would be raised or harvested during that time. (Leblanc, 1997)

Treatment during Cropping Intervals—If there are intervals between cropping, such as vegetative intervals during which treatment or other steps can be taken against the pest, than this can be employed to reduce the effect of the pest.

For example, blueberries are grown in a biennial management system. After a harvest, the fruiting field is pruned during dormancy to induce the growth of new fruit-bearing shoots in the following growing season, denoted as the vegetative year. This pruning, by mowing or burning, optimizes fruit production in the second growing season, the fruiting year.

Most adults of blueberry maggot (*Rhagoletis mendax*) emerge from the soil in the vegetative fields and will feed for several days before they migrate to nearby fruiting flelds to lay eggs. Insecticide applications aimed at the adults between emergence and migration to a fruiting field avoids insecticidal contact on developing blueberries. (Gaul, et al., 2002)

Small Mammal Preservation—It may be prudent to schedule irrigation and weed control measures when fruit is not evident in a given field, area or situation because these practices displace the rodent population into surrounding field margins (Thomas, 1993).

Genetic Resistence

Certain hosts may be grown with genetic resistence to infestation. Planted in an infested area, such crops may hold the population down and allow other measures to work, as well as permit agriculture to proceed in the affected area. (Hennessey & Knight, 1996; Stanley, 1998) Very little literature is available on this option. Some ideas involve:

Seedless varieties of host for fruit flies which attack the seed. (Selman & Heppner, 2001)

Varieties of host with higher levels of chemicals that are toxic to the larvae. (Selman & Heppner, 2001)

Genetically engineered hosts (transgenetic plants) with factors that enhance inhibiting influences on the pest or even enhance the effectiveness of biopesticides. (Hukuhara, 1999)

G

Manual Name

Appendix G

Special Considerations for Home Gardens

Factors in Regulatory Decisions

Home gardens and similar situations present a higher risk of invasive fruit fly spread because their produce may be privately as well as commercially distributed and they may not be well tended to and treated for pests.

Because home gardens are diverse and occur in diverse situations, survey options such as fruit cutting and collecting and trapping should be regularly used to monitor these locations. All dropped fruit should regularly picked up and checked for life stages before disposal. It is to the homeowners advantage if the fruit is individually bagged to protect them from fruit fly females.

Regulatory actions and control, suppressive or eradicative procedures will decided on a case by case basis. Procedures are usually or should be mutually approved by cooperative State and local regulatory officials.

Factors in regulatory decisions include:

- Proximity of the site to areas of commercial production.
- Size of garden.
- Movement of hosts and fruit fly pest.
- Changes in size or location of garden on a property over the years.
- Proximity of site to dwellings.

Suitability of the site to regulatory measures.

2. Regulatory Options

These include:

- Control, suppression, or eradication measures.
- Prohibition of host crops at the infected site.
- Host crops of special risk, such as *Citrus*, may need significantly stronger controls to avoid fruit being taken out of the quarantine area.

Alternative options may be developed if deemed necessary. A quarantine or compliance agreement may or may not be required.

H

Manual Name

Appendix H

Life History

Systematic Position

Class: Insecta

Order: Diptera

Family: Tephritidae

The species listed below are those taken from the literature which are either pests, or seem to show some promise of being pests. The criteria involved reputation, location, available life information and recorded hosts. For the most part, those pests selected by White & Elson-Harris, 1992, as fruit pest species were also selected for this document. *Other Species of Economic Interest* also listed by these authors are not included here, partly because little enough is known of these species, partly because the hosts are not really very important and/or the evidence not conclusive, and of course because these authors quite obviously did not feel them worthy of a full discussion.

A few additions have been made, however, most notably with the economic species from the Bactrocerus dorsalis complex (Drew & Hancock, 1994)

Common names and geographical distribution are also from the same references, unless otherwise noted. There may be more than one common name for a given pest. In this case, the common name selected is either the first one in the list given by the references, or the one most commonly used throughout the literature.

Other, still unrecognized species could also prove to be pests, especially if established in a new geographical area. It should be noted that high-speed evolution, such as evidenced in *Drosophia subobscura*, a fruit fly species in the Drosophilidae which is related to the Tephritidae, could possibly be applied to the Tephritidae as well. In this scenario, an invader can, in fact, evolve very quickly, in just a few years, and potentially have a big impact (Higgins, 2000). The simplest manifestation of such evolution might be expressed in the kinds of hosts utilized, to the optimal temperatures a given pest thrives in.

Common Name	*Scientific Name*	Geographical Distribution
	Anastrepha antunesi	Costa Rica, Panama, Brazil, Peru, Venezuela, Trinidad
	Anastrepha bistrigata	Brazil, Peru(?)
Inga Fruit Fly	*Anastrepha distincta*	Costa Rica, Guatemala, Mexico, Panama, Texas, Brazil, Colombia, Guyana, Peru, Venezuela
South American Fruit Fly	*Anastrepha fraterculus*	Belize, Costa Rica, Guatemala, Honduras, Mexico, Nicaragua, Panama,Texas, Argentina, Bolivia, Brazil, Colombia, Ecuador, Galapagos Islands, Guyana, Peru, Suriname, Uruguay, Venezuela, Trinidad & Tobago
South Amercian Cucurbit Fruit Fly	*Anastrepha grandis*	Panama(?), Argentina, Bolivia, Brazil, Colombia, Ecuador, Paraguay, Peru, Venezuela
——	*Anastrepha leptozona*	Guatemala, Mexico, Panama, Bolivia, Brazil, Guyana, Venezuela
Mexican Fruit Fly	*Anastrepha ludens*	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Texas, Bolivia? (Rogg & Camacho, 2003)
——	*Anastrepha macrura*	Argentina, Brazil, Paraguay, Venezuela
West Indian Fruit Fly	*Anastrepha obliqua*	Belize, Costa Rica, Guatemala, Honduras, Mexico, Nicaragua, Panama, Argentina, Brazil, Bolivia (Rogg & Camacho, 2003), Colombia, Ecuador, Guyana, Peru, Suriname, Venezuela, Bahamas, Bermuda, Cuba, Dominica, Dominican Republic, Guadeloupe, Haiti, Jamaica, Martinique, Montserrat, Nevis, Puerto Rico, St. Lucia, Trinidad & Tobago, Virgin Islands

Common Name	*Scientific Name*	Geographical Distribution
——	*Anastrepha ocresia*	Florida, Cuba, Dominican Republic, Jamaica, Puerto Rico
——	*Anastrepha ornata*	Ecuador
——	*Anastrepha pseudoparallela*	Argentina, Brazil, Peru, Bolivia (Rogg & Camacho, 2003)
Serpentine Fruit Fly	*Anastrepha serpentina*	Costa Rica, Guatemala, Mexico, Panama, Texas, Argentina, Brazil, Colombia, Ecuador, Bolivia (Rogg & Camacho, 2003), Guyana, Peru, Suriname, Venezuela, Dominica, Trinidad
——	*Anastrepha sororcula*	Brazil
Guava Fruit fly	*Anastrepha striata*	Costa Rica, Guatemala, Honduras, Mexico, Panama, Texas, Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname, Venezuela, Trinidad
Caribbean Fruit Fly	*Anastrepha suspensa*	Florida, Bahamas, Cuba, Dominican Republic, Haiti, Jamaica, Puerto Rico
——	*Bactrocera albistrigata*	Indonesia, Malaysia, Thailand; Nicobar Is. (India) (Ranganath, & Veenakumari, 1996)
——	*Bactrocera aquilonis*	Western Australia, Northern Territory
——	*Bactrocera atrisetosa*	Papua New Guinea
Carambola Fruit Fly	*Bactrocera carambolae * (Drew & Hancock, 1994)*	Thailand, Malaysia, Singapore, Borneo, Indonesia, Andaman Island, Surinam, French Guinea (Drew & Hancock, 1994)
——	*Bactrocera caryeae*	India, Sri Lanka (Drew & Hancock, 1994)
——	*Bactrocera caudata*	Brunei, India, Indonesia, Malaysia, Myanmar, Taiwan, Thailand, Vietnam

Common Name	*Scientific Name*	Geographical Distribution
Guava Fruit Fly	*Bactrocera correcta*	India, Nepal, Pakistan, Sri Lanka, Thailand; Vietnam (Thuy & Duc, 1999)
Cucumber Fruit Fly	*Bactrocera cucumis*	Queensland, New South Wales, Northern Territory(?), Prince of Wales Island
Melon Fly	*Bactrocera cucurbitae*	Egypt, Kenya, Tanzania, Mauritius, Reunion, Bougainville, indonesia, Papua New Guinea, New Britain, New Ireland, Solomon Islands (?), Bangladesh, Brunei, Cambodia, China, India, Indonesia, Japan, Laos, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam, Guam, Hawaii, Mariana Islands, Iran
——	*Bactrocera curvipennis*	New Caledonia, Vanuatu
Pumpkin Fruit Fly	*Bactrocera decipiens*	New Britain
——	*Bactrocera depressa*	Japan, Taiwan
——	*Bactrocera distincta*	American Samoa, Western Samoa, Fiji, Tonga
——	*Bactrocera diversa*	China, India, Sri Lanka, , Thailand
Oriental Fruit Fly	*Bactrocera dorsalis*	India, Sri Lanka, Nepal, Bhutan, Myanmar, Thailand, Laoes, Vietnam, Cambodia, China, Hong Kong, Taiwan, Hawaii, Mariana Islands (Drew & Hancock, 1994); Guam (White & Elson-Harris, 1992)
———	*Bactrocera facialis*	Tonga
Mango Fly	*Bactrocera frauenfeldi*	Queensland, Bougainville, Papua New Guinea, Solomon Islands, Stuart Island, Belau, Kiribati, Marshall Islands, Micronesia, Northern Marianas

Common Name	*Scientific Name*	Geographical Distribution
Jarvis' Fruit Fly	*Bactrocera jarvisi*	Western Australia, Northern Territory, Queensland, New South Wales
———	*Bactrocera kandiensis* (Drew & Hancock, 1994)*	Sri Lanka (Drew & Hancock, 1994)
———	*Bactrocera kirki*	Austral Islands, Niue, American Samoa, Western Samoa, Tahiti, Tonga
Malaysian Fruit Fly	*Bactrocera latifrons*	Hawaii, China, India, Laos, Malaysia, Pakistan, Sri Lanka, Taiwan, Thailand
———	*Bactrocera melanota*	Cook Islands
Chinese Citrus Fly	*Bactrocera minax*	Bhutan, China, India
Banana Fruit Fly	*Bactrocera musae*	Queensland, Bismarck Aarchipelago, Papua New Guinea, Solomon Islands, Indonesia (?)
Northern Territory Fruit Fly	*Bactrocera neohumeralis*	Queensland, New South Wales, Papua New Guinea
Philippines Fruit Fly	*Bactrocera occipitalis*	Philippines, Borneo (Drew & Hancock, 1994); Taiwan (Chen & Tseng, 1992)
Olive Fruit Fly	*Bactrocera oleae*	Algeria, Canary Islands, Egypt, Ethiopia, Kenya, Libya, Morocco, South Africa, Sudan, Tunisia, France, Portugal, Spain, Yugoslavia, all Mediterranean Islands, Greece, Switzerland, Georgia (USSR), Isreal, Lebanon, Syria, Turkey, India, Pakistan
Asian Papaya Fruit Fly	*Bactrocera papayae* (Drew & Hancock,1994)*	Thailand, Malaysia, Singapore, Borneo, Indonesia, Sulawesi, Christmas Island (Drew & Hancock, 1994); ?Taiwan (Chen & Tseng), 1992); Papua New Guinea (Tenakanai, 1996)
Fijian Fruit Fly	*Bactrocera passiflorae*	Fiji, Niue Island, Tonga
———	*Bactrocera philippinensis* (Drew & Hancock, 1994)*	Philippines (Drew & Hancock, 1994)

Common Name	Scientific Name	Geographical Distribution
——	*Bactrocera psidii*	New Caldonia
——	*Bactrocera pyrifoliae* (Drew & Hancock, 1994)*	Thailand (Drew & Hancock, 1994)
——	*Bactrocera tau*	Bhutan, Cambodia, China, India, Indonesia, Laos, Malaysia, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam
Vanuatu Fruit Fly	*Bactrocera trilineola*	Vanuatu only
——	*Bactrocera trivialis*	Torres Strait Islands, Papua New Guinea, Indonesia
Queensland Fruit Fly	*Bactrocera tryoni*	Queensland, New South Wales, Victoria, Papua New Guinea, French Polynesia, New Caledonia
Japanese Orange Fly	*Bactrocera tsuneonis*	China, Japan, Taiwan
——	*Bactrocera tuberculata*	Myanmar,Thailand,Vietna m
Breadfruit Fly	*Bactrocera umbrosa*	Papua New Guinea, Bougainville, Bismarck Archipelago, Solomon Islands, Indonesia, Malaysia, Philippines, Palau Islands, Thailand, New Caledonia, Vanuatu
Pacific Fruit Fly	*Bactrocera xanthodes*	Cook Islands, Fiji, Tonga, Vanuatu, Western Samoa
Peach Fruit Fly	*Bactrocera zonata*	Mauritius, India, Indonesia, Laos, Sri Lanka, Thailand, Vietnam
Caper Fruit Fly	*Capparimyia savastani*	Tunisia, France, Italy, Malta, Egypt, Israel, Pakistan
Naleback Fruit Fly	*Carpomya incompleta*	Egypt, Ethiopia, Sudan, Italy, Iraq, Israel, Spain (Oakley, 1950)
Ber Fruit Fly	*Carpomya vesuviana*	Italy, USSR, Mauritius, India, Pakistan, Thailand, Afghanistan
Annona Fruit Fly	*Ceratitis anonae*	Cameroun, Congo, Cote d'Ivorie, Ghana, Nigeria, Tanzania, Togo, Uganda, Zaire

Common Name	*Scientific Name*	Geographical Distribution
Mediterranean Fruit Fly	*Ceratitis capitata*	Africa, , Azores, Canary Islands, Cape Verde Islands, Maderia, St Helena, Sao Tome, Western Australia, Costa Rica, El Salvador, Guatemala, Nicaragua, Panama, Albania, Austria, Cyprus, France, Greece, Italy, Malta, Portugal, Spain, USSR, Yugoslavia, Madagascar, Mauritius, Reunion, Seychelles, Israel, Jordan, Lebanon, Saudi Arabia, Syria, Turkey, India, Hawaii, Mariana Islands, Argentina, Boliviak Brazil, chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela, Jamaica., California(?)
Mascarene Fruit Fly	*Ceratitis catoirii*	Mauritius, Reunion, Seychelles
Kola Fruit Fly	*Ceratitis colae*	Cameroun, Cote d'Ivoire, Ghand, Nigeria, Sierra Leone, Zaire
Marula Fruit Fly	*Ceratitis cosyra*	Kenya, Malawi, Mozambique, South Africa, Sudan Tanzania, Zaire, Zambia, Zimbabwe
Madagascan Fruit Fly	*Ceratitis malgassa*	Madagascar, Puerto Rico? (Steyskal, 1982), Southern Spain? (Gaskins, 1968)
Strychnos Fruit Fly	*Ceratitis pedestris*	Angolia, South Africa, Zambia, Zimbabwe, Madagascar
Cacao Fruit Fly	*Ceratitis punctata*	Cameroun, Cote d'Ivoire, Gambia, Ghana, Kenya, Nigeria, Sierra Leone, South Africa, Uganda, Zaire, Zamiba, Zimbabwe
Five Spotted Fruit Fly	*Ceratitis quinaria*	Botswana, Malawi, Namibia, South Africa, Sudan, Zimbabwe, Yeman

Common Name	*Scientific Name*	Geographical Distribution
Natal Fruit Fly	*Ceratitis rosa*	Angola, Ethiopia, Kenya, Malawi, Mali, Mozambique, Nigeria, Rwanda, South Africa, Swaziland, Tanzania, Uganda, Zaire, Zamiba, Zimbabwe, Mauritius, Reunion
Blackberry Fruit Fly	*Ceratitis rubivora*	Cameroun, Kenya, Malawi, South Africa, Uganda, Zimbabwe
——	*Dacus axanus*	Queensland, Western Australia, Indonesia, Kei, Lihir, New Britain, New Ireland, Papua New Guinea
Greater Pumpkin Fly	*Dacus bivittatus*	Angola, Cameroun, Kenya, Malawi, Mozambique, Nigeria, Sierra Leone, South Africa, Tanzania, Uganda, Zaire, Zimbabwe, Senegal ?
Ethiopian Fruit Fly	*Dacus ciliatus*	Angola, Botswana, Cameroun, Chad, Dahomey, Egypt, Ethiopia, Ghana, Guinea, Kenya, Lesotho, Malawi, Mozambique, Nigeria, Senegal, Sierra Leone, Somalia, South Africa, South West Africa, Sudan, Tanzania, Uganda, Zaire, Zanbia, Zimbabwe, St Helena, Madagascar, Mauritius, Reunion, Saudi Arabia, Yemen, Iran(?), Bangladesh, India, Pakistan, Sri Lanka
——	*Dacus demmerezi*	Madagascar, Mauritius, Reunion
Pumpkin Fly	*Dacus frontalis*	Egypt, Kenya, Lesotho, South Africa, SW Africa, Sudan, Tanzania, Zimbabwe, Cape Verde Islands, Saudi Arabia, Yeman
Great Pumpkin Fly	*Dacus lounsburyii*	Angola, South Africa, Zimbabwe

Common Name	*Scientific Name*	Geographical Distribution
——	*Dacus punctatifrons*	Angola, Cameroun,Ghana, nigeria, Kenya, Sierra Leone, South Africa, Tanzania, Uganda, Zambia, Zimbabwe, Mauritius, Yemen
——	*Dacus smieroides*	Brunei, Indonesia, Malaysia
Solomon Fly	*Dacus solomonensis*	Bougainville, Solomon Islands
Oyster Nut Fly	*Dacus telfaireae*	Kenya, Malawi, Tanzania, Zimbabwe
Jointed Pumpkin Fly	*Dacus vertebratus*	Angola, Botswana, Ethiopia, Gambia, Ghana, Kenya, Liberia, Malawi, Nigeria, Sengal, South Africa, SW Africa, Tanzania, Zambia, Zimbabwe, Madagascar, Saudi Arabia, Yemen
Island Fruit Fly	*Dirioxa pornia*	New South Wales, Queensland, American Samoa (?), Fiji (?), French Polynesia (?), New Caledonia (?), New Zealand(?), Vanuatu (?)
Currant Fruit Fly	*Epochra canadensis*	Canada, USA
——	*Monacrosthcius citricola*	Malaysia, Philippines
Baluchistan Melon Fly	*Myiopardalis pardalina*	USSR, Cyprus, Iran, Iraq, Israel, Lebanon, Syria, Turkey, India, Pakistan, Afghanistan, West Africa, South Africa
European Cherry Fruit Fly	*Rhagoletis cerasi*	Europe, , Iran, USSR
Eastern Cherry Fruit Fly	*Rhagoletis cingulata*	Canada, Eastern USA
Walnut Husk Fly	*Rhagoletis completa*	USA, Mexico, Switzerland
——	*Rhagoletis conversa*	Chile, Easter Island
Black Cherry Fruit Fly	*Rhagoletis fausta*	Canada, USA
Western Cherry Fruit Fly	*Rhagoletis indifferens*	Western USA, British Columbia, Switzerland
——	*Rhagoletis juglandis*	Mexico, New Mexico, Arizona, Utah
Peruvian Tomato Fly	*Rhagoletis lycopersella*	Peru
Blueberry Maggot Fly	*Rhagoletis mendax*	Canada, USA
——	*Rhagoletis nova*	Chile, Peru (Salazar, et al., 2002)

Common Name	Scientific Name	Geographical Distribution
Apple Maggot	*Rhagoletis pomonella*	Mexico, USA, Canada, Afghanistan (?)
Dark Currant Fly	*Rhagoletis ribicola*	Western USA, British Columbia
——	*Rhagoletis striatella*	Mexico, USA, Canada
——	*Rhagoletis suavis*	USA
——	*Rhagoletis tabellaria*	Canada, USA
——	*Rhagoletis tomatis*	Chile (in far Northern area - Salazar, et al., 2002), Peru
Papaya Fruit Fly	*Toxotrypana curvicauda*	Costa Rica, Guatemala, Mexico, Panama, Brazil, Colombia, Bahamas, Cuba, Dutch Antilles, Florida, Texax
Tomato Fruit Fly	*Trirhithromyia cyanescens*	Madagascar, Mauritius, Reunion
——	*Trirhithrum coffeae*	Cameroun, Cote d'Ivorie, Ethiopia, Ghana, Kenya, Tanzania, Togo, Uganda
——	*Trirhithrum nigerrimum*	Cameroun, Ghana, Niger, Nigeria, Rwanda, South Africa, Tanzania, Uganda, Zaire, Comoro Islands
Pepper Maggot	*Zonosemata electa*	Canada, USA

Biology

The following biology is based on those species for which information is available and which may differ in some particulars from a generalized biology.

Anastrepha fraterculus

- Eggs hatch in 3-6 days.
- Larval development takes 9 to 25 days, depending on temperature. There are three instars.
- An inactive prepupal stage within the puparium is formed, either within the host or in the ground. The pupae takes 12-18 days, up to 25 days in colder weather, In extreme cases, the pupa has been known to last up to 18 months.
- Post-ternal adults take about 10 days to mature.
- The average life cycle is between 64-109 days.

Notes:

- Females mate only once, producing an average of 416 eggs in 45 days.
- Eggs are deposited singly and as many as 50 can be deposited in a single fruit.
- Both sexes live about 3 months, 5 months seems to be the maximum. (APHIS, 1982b)

Anastrepha grandis

- Eggs hatch in 3-7 days on average. 50% of eggs hatch in about 4 days. Total egg hatch is about 16.6%.
- Larval development time ranges from 13 to 28 days (mean 17.7 days). Pupation rate is 88%.
- Pupal development time ranged from 14 to 23 days, with 46.8% of adults emerging 20 days after pupation. Mean pupal developmental time is 19.7 days.
- Male survivorship is higher than the female with a maximum longevity of 62 days for the female and 195 days for the male. The pre-oviposition time is 13 days.
- Artificial diet is not acceptable to the larvae.
- Egg, larval and pupal development times and preoviposition period are longer than for any other *Anastrepha* species studied or for *Ceratitis capitata*. The length of this life cycle is closer to *Bactrocera cucurbitae* and may be due to the large size of *A. grandis.*
- A low population density may be a factor in preventing female ovipositing. (Silva & Malavasi, 1996)

NOTICE

Females only lay eggs in whole fruit. They will not lay eggs in artificial medium or in pieces of host and will inspect the whole fruit first before selecting an oviposition site. This behaviour is similiar to that of *Bactrocera latifrons.* Eggs will not hatch in artificial media or host pieces using traditional techniques.

Anastrepha ludens

- Eggs hatch in about 7 days.
- The larvae burrow and feed on the pulp for 10 to 42 days, depending on temperature. They enter the soil and form a pupa within 3-5 cm of the surface.
- Pupation may take 10 to 50 days, again depending on temperature.

- Post-ternal adults pass an 11 to 25 day period in the preoviposition period, when the first mating occurs. The adult female pentrates the skin of the host fruit and inserts 2 to 20 eggs. She may produce 400 eggs over a lifespan of 11 months (Clausen, 1978).
- The average lifespan lasts 3 months. Three generations develop annually under Mexican-Texas conditions. (APHIS,1986; see also McPhail & Bliss, 1933 and Flitters & Messenger, 1965)

Note:

The pupal period cannot be extended beyond 90 days, even under the most unfavorable conditions. (APHIS, 1986)

Both males and females may have a lifespan of up to 11 months (Clausen, 1978)

Anastrepha obliqua

- Eggs hatch in about 3 days.
- The larvae pass through 3 instars in 9 to 12 days.
- The pupae take about 14 days to develop.
- The adult emerges after about 29 days since the egg was laid. The female has a preovipositional period of 10 days. She lays 99.5 eggs over her life at about a rate of 3.69 eggs over a period of 26 days. The rate is fairly constant, tapering off towards the end. She may last as long as 64 days afterwards to make a total of 100 days as an adult, but the average is 21.7 days, less that half of her ovipositional period. The male may last a total of 90 days, but again usually lasts only as long as the female. (Celedonio-Hurtado, et al, 1988)

Anastrepha serpentina

- The eggs hatch in about 3-4 days for this species.
- The larval stage lasts about 9 to 10 days. There are 3 instars.
- The pupae take about 13 to 16 days to develop.
- The adult emerges after about 25-30 days since oviposition. The female has a preovipositional period of 10 days. She lays 83.9 eggs over her life at about a rate of 1.68 eggs per day over a period of 16 days. Most of the eggs are laid in the first 7 days. She may last as long as 38 days afterwards to make a total of 64 days as an adult, but the average is 30.4 days, still well past her ovispositional period. The male lasts as long as the female.

NOTE: This species displays a much higher survival rate in the first two weeks of adult life than *A. ludens* or *A. obliqua*, which therefore results in a higher net reproductive rate, in spite of a lower fecundity relative to the other two species. (Celedonio-Hurtado, et al, 1988)

Anastrepha sororcola

- The average age to mating was 24 days for this species (Silva, et al., 1985)
- The average lifespan of males and females lasts 2.6 to 4.9 weeks, but they have lived 13 weeks under laboratory conditions (Bressan & Teles, 1991).

Anastrepha suspensa

- Females lay eggs singly just under the skin of the host. Only mature to overripe fruit is infested. She may lay over 300 eggs in her lifetime. Eggs take 2-3 days to hatch.
- The larvae have 3 instars. They tunnel through the fruit, feeding on the pulp. Decay organisms enter the fruit, and leave the interior a rotten mess. Larvae emerge from the fruit in approximately 10-14 days.
- The larvae drop to the ground and burrow beneath the soil to pupate. The pupal period lasts another 10-14 days.
- The newly emerged adults require about 14 days to reach sexual maturity prior to egg-laying. The adult life span ranges from 17 to 49 days. Breeding is continuous with several annual generations.
- The entire life cycle may be completed in 42 days under optimal conditions, but require longer time intervals at cooler temperatures. (Brown, 1985b; Weems, 1965b)

Bactrocera bryoniae

- Adults mate at dusk (Pacific Fruit Fly Web, 2000)

Bactrocera carambolae

- Eggs take 1-2 days to hatch.
- The larval stage lasts 6-9 days. Larvae have 3 instars (stages) inside the fruit where they feed on the pulp and make tunnels in the fruit. At the end of the third instar, the larvae leave the fruit
- Usually the fruit has fallen on the ground by this time and the larvae leave the fruit and burrow 2-7 cm into the soil to pupate. The length of time the pupal stage lasts depends on the soils' temperature and humidity. Pupation lasts 8-9 days.

- The adults emerge from the puparium and wait for their wings to expand before flying away. Both males and females begin to look actively for food once they reach maturity at 8-12 days of age. Adults become sexually mature 8-10 days after emergence. They need to eat protein to produce eggs and sperm. The adult flies eat spoiled fruit, plant nectar, bird dung, honeydew and other substances. Mature adults copulate after groups of males gather and perform a courtship dance in the early evening, just before the sun falls. This behavior, known as lekking, attracts females to the group and they choose a male with which to copulate. Females puncture the skin of green or mature fruit and lay eggs in groups of 3 to 5 just under the skin.
- Adults usually live 30-60 days in nature but may live as long as 6 months. Females can lay more than 1,000 eggs over their lifetime.
- Life cycle: From egg to the mature adult takes about 22 days under good conditions The minimum period of time for one generation is approximately 30 days, under good conditions (26^0C and 70% RH).

NOTE: Males and females are strong flyers and will fly long distances if they cannot find a good source of food or site to lay eggs. Data from *B. dorsalis* have shown that the adults can fly over 50 km from the emergence site. Likewise, they tend to remain in the place where they emerged if host trees with fruits are nearby. (WWW.carambolafly.gov, 2000)

Bactrocera caudata

- The egg stage lasts 2.5 days.
- The larval stage lasts 9-15 days.
- The pupal stage lasts 11.5 days.
- Egg to adult is 23 to 29 days based on the above. (Oakley, 1950)
- All data taken from rearing on tomatoes.

Bactrocera cucumis

- Egg development lasts 27-28 hours or roughly 2.125 days (Corcoran, et al, 1993).
- Larval development lasts only 5 days in cucumber (Fitt, 1986), and up to one week (May, 1946).
- Pupation takes place in the soil and lasts another week.
- The period from egg to adult is about 2 weeks. (May, 1946)
- The female lays eggs in groups beneath the rind. (May, 1946)

- Infests the fruit of cucurbits when they are mature or damaged or sunburnt. Eggs laid in immature fruit do not hatch. The life cycle may be completed in about 2 weeks in Queensland. (Oakley, 1950) (But see above) (Oakley, 1950, May, 1946)

Bactrocera cucurbitae

- Eggs hatch in 6-28 hours.
- The larvae pass through 3 instars in 4-17 days depending on temperature. Larvae drop to the ground and pupate under 20-50 mm of soil.
- The pupal period may be 7-13 days before adult eclosion. In colder weather, 59 days may be required.
- Post-ternal adults pass 11-12 days in the preoviposition period.
- Total life cycle is usually 12 days, usually about 1-2 months. The longest life cycle is 7 months.

NOTICE

- Adults are strong flyers and are capable of flying long distances.
- Adults are found on plants, hosts, nonhosts, in shady locations, except when visiting the host to oviposit.
- Females can produce up to 1000 eggs.
- Females oviposit in tender plant tissues, not just young to ripe fruit. Terminals, unopened flowers, young stems, roots and seedlings are targets. (USDA, 1984a)

Bactrocera decipiens

Larvae of this species infest pumpkins and can coexist with melon fly larvae, but their rate of development is much slower. Up to 44% of pumpkins can be infested by both species. Attempts to study this fly have not been successful. (Pacific Fruit Fly Web, 2000)

Bactrocera distincta

Adults of this species mate at dusk. (Pacific Fruit Fly Web, 2000)

Bactrocera diversa

- Eggs hatch from 29 1/2 to 33 hours after being laid.
- The average larval development period took 5.7 days. There are 3 larval instars of durations 1.8, 1.6 and 3.8 days respectively.
- The average pupal period was 8.6 days.
- Total development on average was 15.5 days.
- The period between mating and commencement of oviposition is fairly long in this species, the maximum being 29 days. The preoviposition period itself ranges from 8 to 39 days (average 21

days), from emergence to egg-laying. The females can deposit up to 53 eggs per day. They can lay 39 to 870 eggs in their lifetime. The maximum gap between successive egg-layings was 41 days.

- The life cycle is between 23.5 and 54.5 days.
- The females live for 64 days on average and the males for 35 days. Mating starts around sunset and usually continues for over 12 hours until after sunrise.
- This species is mainly active in autumn from September through November. The species overwinters in the adult stage. It attacks flowers and fruits of cucurbits, but is dominated by *B. curcurbitae* when both occur on the host. It also attacks Citrus. (Syed, 1970; Kapoor, 1993)

Bactocera dorsalis

- The eggs may hatch in 24 hours, but in cooler weather may take up to 20 days, depending on temperture.
- The larval stage may last from 6-35 days. There are three instars. Pupation occurs in 2 inches of soil, rarely deeper, to 5 inches. If surface conditions are poor, the larva will move as much as a yard in search of suitable soil.
- The pupal stage takes 10-12 days, but cool conditions (overwintering) can result in diapause and extend emergence for 120 days.
- Post-ternal adults need about 8-12 days to mature, but can mate at 5-6 days if daylight hours are as long or longer than nighttime hours. At temperatures below 55^{0}F for two weeks, the species is reproductively inactive. .
- Adults usually live about 1-3 months, but cool weather will increase survival up to a year.

NOTES:

There are two daily peaks of activity when adults feed in the morning and when they mate at dusk.

Males will feed on methyl eugenol-bearing plants such as Papaya, if available, as this confers a mating advantage and there are a significantly larger number of matings in such a population. ME-bearing plants are found in the leaves, flowers or fruits in over 10 families of plants. (Shelly, 2001)

Adults tend to remain in an area when host is available and do not move more than 656 yards, but can move if host is not available for ovipositioning, warm weather following cool weather, or by young pos-ternal adults. This movement is greater than 3 mi and if forced, over open water, is as much as 40 miles

This species can overwinter in the pupal stage. Adults have been able to survive frosts and slight snowfall. (Stibick, 1989)

Bactrocera facialis

Adults mate at dusk. It can heavily damage hosts. Damage on chilli is 89-97%, on capsicum is 97-100%, on guava is 90% (with *B. kirki*). (Pacific Fruit Fly Web, 2000)

Bactrocera frauenfeldi

- Adults mate during the day. One female can lay an average of 25 eggs in 24 hours.
- Eggs hatch in 2 days.
- Larval ddevelopment through 3 instars takes 10.5 days.
- The pupal stage lasts 11 days.
- Mean total time from egg to adult is 21.5 days. Adults mate during the day. One female can lay an average of 25 eggs in 24 hours.

NOTES: This species prefers attacking commercial fruits and edible hosts over wild fruits. (Pacific Fruit Fly Web, 2000)

This species attacks mature or nearly mature fruits. (Oakley, 1950)

Bactrocera jarvisi

- Egg development takes 9 to 10 days by deduction from data below.
- Larval development lasts 8-9 days. (Fitt, 1986)
- Egg to pupa is 18 days (Jarvis, 1927).
- The pupal stage lasts 22 days in the soil.
- Adults emerge after some 40 days all told, from egg to adult. The adults seem to appear much later in the season than the Queensland fruit fly and for that reason, damage is more limited (Fitt, 1983).
- Caculation from the first appearance of the flies on the 17th Feb. to first oivposition on the 3rd March in (Jarvis, 1927), yields a preoviposition period of 15 days. (Jarvis, 1927; Fitt, 1986)

Bactrocera kirki

Adults mate in late morning to early afternoon, when light intensity is highest.

NOTE: This species infests 45-99% of guavas in Samoa (Pacific Fruit Fly Web, 2000)

Bactrocera latifrons

- Eggs hatch in 1.9-2.7 days.
- The larvae pass through 3 instars in 8.4-8.6 days.
- The pupae last about 10-10.4 days.
- The adult begans emerging on the 20th day, with emergence peaking on the 21st day. The preovipositional period lasts from 6-17 days. Adult females live about 64.1 days with a maximum of 136 days. Mating is triggered by low light intensity about 15 minutes before sunset.
- The total life cycle is 31 days under ideal conditions.

NOTES:

The female tends to deposit eggs singly about 86% of the time rather than in clutches as in other fruit flies. She will only lay eggs in whole fruit and not in cut pieces nor in artifical media (Silva & Malavasi, 1996). About 12% had 2 eggs and 1% 3 eggs. Egg laying may began on day 27 and increase rapidly during the second and third weeks, dropping off gradually over a a nine week period. Each female is capable of laying 9 to 587 eggs, average 232-280. She may lay up to 30 eggs per day, and up to 134 eggs per month. The ovipositional period ranges from 6-117 days, average 50 days. Egg viability averages 80%.

The population will double every 8 days or so. Since this species lays small numbers of eggs over a long time period, it obviously allocates more energy to efficient use of resources than to maximization of the reproductive rate. For that reason, the population will generally be found in solanaceous vegetables, with scattered populations in curcurbitaceous vegetables. (Stibick, 1993)

Bactrocera melanotus

- Eggs are laid in ripening fruit on trees and also on fallen fruits. Late eggs of this species are the most heat tolerant of all fruit fly species studied so far in the Pacific.
- Adults mate in late morning to early afternoon, when light intensity is highest. (Pacific Fruit Fly Web, 2000)

Bactrocera minax

- Eggs hatch each year about late spring to early summer.
- The larvae develop from the middle of May to the end of July. Their activity rots the pulp of the fruit. When the infested fruit drops in October, the larvae leave and pupate in the soil.
- The pupal stage takes about 180 days or about 6 months.

- Adults begin to emerge and mate in late April. Oviposition in fruit occurs from the middle of May to the end of July. Males live an average of 40+ days, females an average of 39+ days.
- The total life cycle is about one year.

NOTICE

The movement of adults is strictly local. At most, dispersal takes place about 1500 meters in a favorable wind direction. (Wang & Zhang, 1994)

Bactrocera musae

- Eggs are laid in green and young fruit at the "full" stage. Incubation time lasted for 3-11 days while the host fruit is maturing. If the pulp has not softened after 11 days, the eggs fail to hatch.
- Larval development lasts 7-11 days in banana. (Fitt, 1986; Smith, 1977). Larvae leave the rotting fruit to pupate in the soil.
- The pupal period lasts 7-10 days.
- Upon emergence, the female, when mature mates at dusk and deposits eggs in batches of 7-12 just below the skin and into the hard pulp of banana.
- Under normal conditions, the egg to adult stage lasts 17 to 32 days.

NOTE: 10-40% of banana fingers are infested. (Pacific Fruit Fly Web, 2000; Smith, 1977)

Bactrocera neohumeralis

A sibling species of *Bactrocera tryoni*, this species mates during the day rather than at dusk, like *B. tryoni*. This behaviour keeps them reproductively isolated, however, hybrids do occur. Flying swarms or leks have never been recorded. (Pacific Fruit Fly Web, 2000; Pike & Meats, 2003)

Bactrocera oleae

Eggs hatch in two to four days in summer and 10 to 16 days in winter.

The larval stages take 9 to14 days depending on temperature.

The pupal period is about 10 to 14 days in summer and up to 3 months at lower temperatures. During the year, early generations pupate mostly in fruit; the last generation (before winter) leave the fruit to pupate in soil and elsewhere. Soil pupation occurs from the surface to mostly the top 2 inches, and sometimes up to almost 4 inches (Dimou, et al., 2003).

Adults survival exceeds 6 months. The female takes 2 to10 days to mature after emergence., but will remain in an immature state or enter a reproductive diapause (older females from a previous generation) if host fruit is not available. 10 to 12 eggs are laid daily; about 200 to 250 in the female's lifetime, usually no more than one egg per fruit. The female ovipositional period lasts 25-100 days, which may be interrupted for 5 to 6 months. (Fletcher, 1986; HYPPZ, 1998a; Christenson & Foote, 1960)

NOTE:

- The larvae of the early generations (post-winter) pupate in green fruits in a cell hollowed out in the pulp of the fruit, whereas those in ripe olives leave the fruits and pupate in litter and soil beneath the tree.
- The winter is passed in the pupal stage, which may be 4 months or more, although in mild climatic conditions, adults may be found throughout this period. (Clausen, 1978)
- The adult passes the fruitless early summer in an immature state or reproductive diapause, until the appearance of host fruit, which is usually late summer, early fall. (Fletcher, 1986)
- Usually 2 to 4 generations per year, but up to 7 generations in warmer climates. (HYPPZ, 1998a) (Christenson & Foote, 1960)

Bactrocera papayae

- Eggs hatch within one to two days.
- The larvae cause considerable damage inside the flesh before obvious signs of infestation can be seen on the fruit. The most obvious signs of infestation are small discoloured patches on the skin, which develop from punctures or 'stings' made by the female as she lays her eggs. decay and feeding in healthy plant tissue, cause premature fruit drop.After 7-12 days the larvae leave the fruit to develop into pupae in the soil.
- The adults emerge from the pupa in another 10 to 14 days and become
- sexually mature after one to two weeks. They can live for 3-4 months. The adult female flies lay their eggs just under the skin of fruit. She can lay up to several hundred eggs.

NOTES: A major problem with this pest is that it can infest some fruit at a greener stage than the Queensland fruit fly, particularly fruit such as pawpaw, mango and banana. (larvae) which damage the fruit by bacterial

These fruit flies may live for 3-4 months and are capable of reproducing throughout their life span. The long life of a female means that she can still be laying eggs when her great-grandaughters are attacking their first fruits.

Rapid population growth: Like most tropical fruit fly species, Papaya fruit fly multiplies rapidly.

It can quickly spread over large distances. (Bellas, 1996; Anon., 1996, 2000; Dammerman, 1929)

Bactrocera passiflorae

- Eggs hatch in 36 hours.
- The larval stages take 7 to 16 days. Third instar larvae emerge to pupate.
- The pupal stage takes 8 to 10 days.
- When adults emerge, the preovipositional stage takes about 18 days, longer than some other species. Mature adults mate at dusk. Females oviposit up to 24 eggs in a chamber approximately 3 mm beneath the skin in ripening fruits as well as in fallen fruits (Pacific Fruit Fly Web, 2000; Clausen, 1978). Two or more females may oviposit in the same puncture, resulting in 2-72 eggs (Oakley, 1950).
- From the above, the life cycle is 34.5 to 45.5 days.

NOTE: Damage to fruits: Kumquats, 60%; Guavas, 40-90%; Kavikas, 62%; Mangoes, 20-25%. (Pacific Fruit Fly Web, 2000; Clausen, 1978)

Bactrocera psidii

- The egg stage lasts 3 days.
- The larval stage lasts 6-7 days.
- The pupal stage is passed in the soil. (Oakley, 1950)

NOTES:

- Adults mate during the day, when light intensity is high (Pacific Fruit Fly Web, 2000).
- Successful infestation in some fruits, such as immature bananas and mangoes, is prevented by abundant sap exudations (Oakley, 1950).

Bactrocera tau

- The egg hatches in 20.4 to 21.7 hours.

- The freshly emerged larva immediately starts feeding in the fruit. There are 3 instars. The first and second instars lasts 1-2 days each. The duration of the third instar is very variable and lasts from 5-17 days, even under similar temperature conditions and from the same brood of eggs. The total larval period ranges from 7 to 21 days.
- The pupal period varies between 7-10 days, average is 8.7 days.
- The preovipositional period lasts 18-20 days after emergence. Mating starts just around sunset. Before mating the adults are very active, moving about in a disorderly manner. Copulation lasts from 5-10 hours.
- Females laid eggs from 1-6 (average 2.8) days after mating. In most cases, egg laying activity started in the afternoon at about 2:30 pm. When about to lay eggs, a female became very active, flying from place to place in search of a suitable host. From 74 to 679 eggs (average 286.6) are laid by a single female, at the rate of 5-78 eggs per day. There may be a gap of up to 20 days between egg-laying.
- From the above, the life cycle is 33-52 days.
- This species is only present in November-December when winter has almost arrived. It is absent or indetectable during the warmer period of the year. (Syed, 1970)

Bactrocera trilineola

- Egg to adult stage takes 21-22 days at 25^{0}C.
- Preovipositional period is 11 days.
- Adults mate in the morning and tend to mate over a long period of the day when light intensity is high.

NOTE: Population peaks occur in January-Feburary and April-May, corresponding to the mango and guava seasons respectively.

This species infests 95% of ripe guavas , 64% of ripe Malay apples and 11% of ripe mangos. (Pacific Fruit Fly Web, 2000)

Bactrocera tsuneonis

- The biological and ecological characteristics are very similar to *B. citri* and is repeated here, with appropriate changes.
- Eggs hatch each year about late spring to early summer.
- The larvae develop from the middle of May to the end of July. Their activity makes the pulp of the fruit become white, dry and contracted. When the infested fruit drops in October, the larvae leave and pupate in the soil.

- The pupal stage takes about 180 days or about 6 months.
- Adults begin to emerge and mate in late April. Oviposition in fruit occurs from the middle of May to the end of July. Males live an average of 40+ days, females an average of 39+ days.
- The total life cycle is about one year.

NOTICE

The movement of adults is strictly local. At most, dispersal takes place about 1500 meters in a favorable wind direction. (Wang & Zhang, 1994)

Bactrocera tryoni

- Eggs are deposited in groups of up to 7. They are often laid in puncture made by other fruit flies. They hatch in 2-3 days.
- The larvae eat their way to the center of the host, causing it to decay, but leaving few external signs. Fruit may be attacked repeatedly. As many as 40 to 67 larvae have been found in peaches and apples. The larval period varies from 7 days to more than 6 weeks depending on temperature and host.
- Third instar larvae emerge in 5-7 days and drop to the ground, burrowing 20-30 mm into the soil.
- The pupal period may be 1 week, but usually 22-60 days. There is no pupal diapause.
- The complete life cycle usually takes 5-9 weeks. It can be as short as 2-3 weeks and up to 2 months when the temperature is cold. There may be as many as 5 overlapping generations, as adult females may live for a year or more under cool conditions.

NOTES: There are several adult periods of migration. Post-ternal adults have a migratory phrase of 2-3 weeks. 75% of them leave the area in the first week. Dispersal is uniform, independent of hosts and prevailing wind direction. There is some orientation towards broadleaf trees or bushes with surface bacteria, especially if rains have occurred. These provide adult feed areas. Dispersal is 4 mi av., but extends up to 6-10 mi. after 2 weeks and 10-16 mi. after 3-7 weeks. The longest recorded distance is 37.8 mi.

Immature flies take 8-10 days and up to several months to mature and then to respond to pheromones. The female mates only once, but may resorb ovaries in cold weather. Depletion of sperm or resorbtion will result in mating again. Males will mate repeatly over several weeks. Mating is at dusk.

A second migrating phrase results with maturity. Host fruit is sought out and mating takes place. The distances traveled are about the same, but if suitable host is in the area, only 50% will emigrate, their place taken by net immigration from other areas.

- If conditions become adverse, a third migration occurs, as flies will leave areas with a lack of fruit, water, or food, and shelter in areas where these are available. Cold weather results in adults searching for, and aggregating in overwintering sites. When warmer weather returns, the adults become mature again and resume their activities. The QFF is capable, through acclimination, to tolerate a wide range of environments and a range of temperatures from 26.6 ^{0}F to 109.4 ^{0}F. (Stibick,1990; Weems, 1965a)
- Apart from these major movements, males of QFF have a greater tendency to move upwind, both at midday and at dusk. It is likely that upward movement is only partially attributable to the swarming activity outlined above. (Pike & Meats, 2003)
- Populations can reach 16,000 mature adults per mi. sq^2 in dry woodland, heavier populations can be expected where food, moisture, and host fruit are in ample supply. (Stibick,1990; Weems, 1965a)
- The Queensland fruit fly readily hybridizes with *Bactrocera neohumeralis* whenever a breakdown occurs in their mating times. The hybrids have intermediate mating times. This species is also under investigation for possible evolution, hybridisation, or invasion in the NW of Australia, a matter which is not clear as of yet. (Anon., 2003)

Bactrocera tsuneonis

- Up to six eggs are laid in a single puncture in August, but only only hatches.
- Larvae appear about the beginning of October and devour about 2-10 carpels each. They are mature by the beginning of November and about this time the infested fruit falls.
- Pupation occurs in the soil and lasts from the end of November until the end of December or January.
- Adult flies begin to appear (in Japan) at the end of June, reach maximum emergence during July, and gradually disappear until October. (Oakley, 1950)

Bactrocera umbrosa

- The larval stage lasts 9 days.
- The pupal stage lasts 9 days.
- The female has a life span of 30 days. (Oakley, 1950)
- Adults mate at dusk. Females attack young to ripe fruits, causing premature ripening and dropping.

NOTE: Damage is estimated at up to 30-75% of breadfruits. (Pacific Fruit Fly Web, 2000)

Bactrocera xanthodes

- The egg stage lasts 2-3 days.
- The larval stage lasts 5-6 days.
- The pupal stage lasts 11-12 days. (Oakley, 1950)
- Adults mate at dusk. Females oviposit in ripening and fallen fruits.

NOTE: Damage to different hosts is as follows: Papaya, 4-37%; Breadfruits, up to 62%.   (Pacific Fruit Fly Web, 2000)

This species is not a forest species and is commonly found in the village, suburban, and coastal environments. (Laiti, et al., 2002)

Bactrocera zonatus

- Eggs hatch in 2-3 days.
- The larvae pass through 3 instars in 1 to 3 weeks, then emerge to pupate in the soil at depths of 1 to 6 inches.
- The pupal period varies from 4 days in warm weather to over 6 weeks in cold weather.
- The post-ternal adult takes about 8 to 16 days to maturation. Adults will survive about 78 days (under lab conditions) and produce several generations within a year. They will disperse as much as 25 miles from the source very quickly into new areas in search of food, and hosts, but tend to remain in one area if adequate food and hosts are available. Dispersal is affected by adult flight, wind, and movement of infested fruit by man. Local dispersal is to trees or hosts with aphid infestations and to host with suitable fruit for oviposition and feeding, which may last all day, peaking in the mornings and afternoons. Mating is at twilight. During the heat of the day, adults may hide in foliage of hosts or other such places where they are protected from high temperatures.
- The life cycle may be completed in 20 days, under optimum conditions, but is prolonged by cool temperatures.

NOTES: Two to seven days after mating, the female lays an average of 137 eggs in batches of 2-9 under the rind of the host fruit.

- Soil is not necessary for pupation.
- This species can apparently survive winters in temperate climates. (Stibick, 1988; Ghana, 1972)

Capparimyia savastani

- Eggs hatch in two days.
- Larvae complete development in as little as 4 days to as long as 31 days.
- In the soil, pupae take from 14 to 28 days to eclosion.
- Adults reach sexual maturation in 2 days. They survive, on average 17 days; overwintering adults survive 70 days up to 3 months or 87 days.

NOTE: The periods of the life cycle are very variable. (Soria & Yana, 1959)
Carpomya incompleta

Newly formed fruits are infested by the larvae which feed in the mesocarp.

The pupal period is two weeks. (Oakley, 1950)

Carpomya vesuviana

- Eggs hatch in 2-3 days.
- Larvae develop for 15-20 days.
- Pupation takes place in the soil at depths of 2-3" or rarely in fallen fruits. The pupal stage may be short as 12 days or less, or long. when it occupies up to 305 days, overwintering until the following fall.
- Adults usually appear in the Spring, following showers, when flowering begans. The female deposit up to 22 eggs singly or in groups of 2-4 in the rind of fruits. Adults are long lived.

NOTICE

- Activity takes place from autumn and continues through winter and spring. Hibernation takes place from spring to autumn in the pupal stage.
- Infestation ranges from 1.4 to 44.4% and up to 72-77%.
- Four or five overlapping generations may occur during the season.
- As many as 18 larvae have been recorded in a single fruit. (Basha, 1952; Narayanan & Batra, 1960)

Ceratitis capitata

- The eggs hatch in 2-3 days.
- Larvae feed on fruit pulp for 6 to 42 days. They jump to the ground and pupate up to 1' deep in the soil.

NOTICE

The Medfly larva is capable of jumping off the fruit and move away 1/2 ft or so horizontally. It can travel after reaching the ground, and can move away about a yard more on average (in one minute in about 8 jumps plus crawling). If attacking ants are present, such jumping will throw the ants off and the larva will move further away. Only Medfly larvae have been studied so far, but it is reasonable to assume that other fruit fly larvae may have similar behaviour. (Maitland, 1992)

- The pupal period normally lasts 6 to 10 days, but can be delayed by cold weather for as long as 50 days.
- Post-ternal adults have a preovipositional period of 4 to 6 days (as short as 2 days to as long as 20 days at 15^{0}C). About 50% live for 2 months, survival extended over 3 months if food is available. Under cooler conditions they may live as long as 10 months to a year. Female feeding starts on host fruit/leaves, at food sites in the morning, males in the afternoon. Males form calling leks in the morning and feed in the afternoon. If hot, flies may rest under leaves during midday.
- A female may lay over 1,000 eggs in approximately 24 sites at a rate of one every 3 1/2 days during her lifetime. The life cycle averages approximately 3-4 weeks (up to 33 days) on average.
- This species is not a strong flyer and a population may drift a little with prevailing winds if food resources are available. Flight range is 3/4 mile under these conditions. Strong winds cause flies to seek shelter.Host scarcity or population pressure may result in adult flights of up to 5 miles and as far as 9 miles.

NOTICE

This species can apparently survive winters in temperate climates. The adult is the major hibernating stage through its ability to survive cold and starvation by managing water through collapse of the abdomen and oosorption of the eggs. Adults survive under conditions where eggs and larvae die and only 1% of pupae survive.

Females mated to sterile males with inactive sperm have a higher remating frequency that those mated to normal males, but the significance has not beeen determined. (Vera, et al., 2002)

In tropical areas, this species apparently infests mostly introduced temperate zone fruits (Eskafi & Kolbe, 1990b).

Duyck and Quilici (2002) note that the high survival rates of Medfly over a broad range of temperatures (15-30^{0}C) may explain its wide distribution under different climatic zones, but seems much more adapted to a Mediterranean rather than a tropical climate, where it prefers less rainy areas.

Four aspects of Medfly life history help make it an economic pest. These are:

- Multiple, highly overlapping generations.
- High net reproduction while young.
- High larval survival in certain hosts.
- Lack of diapause.

(Stibick, Draft,1993)

Ceratitis catoirii

- A study of the biology was undertaken by Duyck & Quilici (2002). However, the results are qualified because the diet may not have been optimal for this species.
- The development of immature stages ranged from 16.8 to 65.8 days at 30-15^{0}C. and took a total of 356 DD.
- Eggs last from 2 to 8 days. (35 DD)
- Larval stages last from 6 to 22 days. (127 DD)
- Pupal stages last from 9 to 36 days. (194 DD)
- The preovipositional stage lasts 11 to 14 days, but not when the temperature is below 20^{0}C or above 35^{0}C.
- All figures were acquired at temperatures ranging from 15-30^{0}C.
- The total life cycle appears to be between 28 to 80 days, depending on temperature. (Duyck & Quilici, 2002)

Ceratitis malgassa

- Eggs last 3 to 4 days.
- Larval stages last 13 to 19 days.
- Pupal stages last 13 to 36 days

- The preovipositional stage lasts 4 to 14 days.
- The total life cycle takes from 33 to 73 days. There are 8-9 generations a year in the uplands of Madagascar. The adults live for up to 100 days or more, especially at optimum temperature of 69.8^{0}C. Females lay 83 to 246 eggs each.

NOTICE

1. Females oviposit only in sunny weather after feeding on fruit juices or on honeydew from aphids or coccids.
2. The eggs and larvae for at least the first 4-5 days, are able to develop in a liquid or almost liquid medium, but during the prepupal and pupal stages, excessive soil moisture will (as well as excessive dryness) kill the insects before adult emergence. (Dubois, 1965)

Ceratitis punctata

- The female lays eggs in ripe fruit, which is necessary for the eggs to hatch. (Gowdey, 1913)
- Life History and habits are said to be similar to those of *Ceratitis capitata.* (Oakley, 1950)

Ceratitis rosa

- Eggs usually hatch within 4 days, but may require longer in cold weather.
- The three larval stages take 10 days and a prepupal stage take up to 12 days.
- Pupation takes place in the soil. The pupal stage lasts 10-20 days.
- The adult lives for several months. Preovipoisition lasts 7-8 days. Eggs are laid 10-20 at a time just below the surface of the fruit. They may be laid in unblemished fruit and in ripe or unripe fruit.
- The life cycle lasts from 36 days to 46 days. In cold weather, development may be delayed a week (Clausen, 1978). Adults go into a hibernation phase in South Africa in May and have a high resistance to low temperatures, but cannot withstand frost (Oakley, 1950).

NOTICE

- This species overwinters in the adult stage and withstands temperatures as low as 20^0 F, provided the warming period comes slowly.
- Food, water, and shelter are more important overwintering factors than temperature.
- This species is not attracted to traps during the winter.
- This species could produce 10 generations per year under Florida conditions.
- A larger and more aggressive fly, this species largely displaces Medfly in areas where both coexist. It can be more serious and more difficult to control (Weems, 1965). Displacement also seems to be related to better cold tolerance in this species as the minimum temperature threshold is lower, particularly during the larval stages (Duyck & Quilici, 2002).

Ceratitis rubivora

General habits of the larvae are similar to those of related species. In the case of blackberries, generally one larva, rarely two occur in a berry. Pupation normally takes place in the soil, but some may pupate in dried berries (Oakley, 1950)

Dacus bivittatus

- Eggs hatch in 3-5 days
- The larvae feed for 18 to 29 days.
- The pupal stage lasts for 12-24 days.
- Adults of the fall generation apparently suvive the coller months until spring arrives. They attack cucurbits from the time fruits are formed until the rind becomes too hard for oviposition, but there is disagreement on this and it is said that they infest fruit at any stage of development. Eggs are laid just below the rind. (Oakley, 1950)

Dacus ciliatus

- Eggs have an incubation period of 2-4 days. The eggs are enbedded 2.5 mm deep under the rind of semi-ripe fruit. There may be as many as eight punctures and as many as 22 eggs per puncture.
- Larvae take 4 to 7 days to develop. As many as 45 larvae have been bred from a single host. The larva may enter the soil 1/2 to 2" deep to pupate, **but** may also pupate within the fruit.
- The pupal period takes 6 to 8 days in summer and is longer in winter when it overwinters.
- Adults emerge in the morning. Females have a preoviposition period of 4 days. Adults mate from sunset till sunrise, pairing lasting for 11-12 hours. They have an unusual egg-laying ritual. Females lay up to 51 eggs in 24 hours and up to 457 eggs (Av.

186 eggs) during their life. Males live for 8-49 days, females for 8-54 days. Flies are active throughout the year, but in colder climates, overwinter in the pupal stage. Adults search curcurbit fruits and coexists in an interrelated pattern with *Bactrocera cucurbitae*, where that species exists.

- The complete life cycle takes 16 to 22 days and longer in winter. About six generations may occur during the year.

NOTICE

1. Coexists in competition with *B. cucurbitae*, where the two exist in the same area. (But Oureshi, et al, 1974, states that this balance has been changed to one of dominence of *D. ciliatus* over *B. cucurbitae*, apparently because the former is a far more active species.)
2. Differs markedly from *B. cucurbitae*, by pupating inside as well as outside the fruit. *B. cucurbitae* invariably pupates outside the fruit.
3. Mate at night. (Narayanan & Batra, 1960; Ghani, 1972)

Dacus demmerezi

As serious as *Bactrocera cucurbitae*, with which it can coexist and dominate in colder areas or higher elevations. (Etienne, 1973)

Dacus frontalis

This species breeds exclusively in the Cucurbitaceae. Adults are mostly found on rest plants such as Citrus, maize, or pidgon pea. Females visit young fruits for oviposition only in the late afternoon. Five or more females may visit a host and oviposit at the same time on a small fruit without competitive behaviour between them and may oviposit in the same puncture. Overcrowding occurs among the larvae. (Steffans 1982)

The edges of host fields are preferred to the central parts. The population is depressed by rains and abundance peaks during the dry season.

Dacus solomonensis

- At 25 ^{0}C eggs start hatching in 46 hours (two days).
- Larval development takes 12 days
- The pupal period takes 9 days
- The preovipositional period lasts for 16 days after adult emergence, when adults start mating.
- The entire life cycle, based on the above, takes 39 days

NOTICE

This species helps to cause over 90% of the damage to snake gourds and 60-87% on pumpkins (along with *B. cucurbitae*). (Pacific Fruit Fly Web, 2000)

Dacus vertebratus

- Eggs hatch in 2-5 days.
- The larvae feed in the fruit for 15-18 days.
- The pupal stage lasts less than 14 days in summer.

NOTICE

1. Adults pass the winter, even in the coldest part of South Africa, in the adult stage, which lasts 1 to 9 months. (Females have been recorded living from 171 to 258 days, males up to 168 days (Daiber, 1966)).
2. Adults fly actively on warm, sunny days when the shade temperature is 62^{0}F or over.
3. Females attact cucurbits from the time fruits form until the rind becomes too hard for oviposition. Eggs are laid just below the skin of the host, chiefly on the lower side. (Oakley, 1950)

Dirioxa pornia

- The egg stage lasts a few days.
- The larval stage lasts 2-4 weeks. The larvae prefer softer and rotten parts of the fruit.
- The pupal stage lasts 10-28 days.
- The total life cycle, from the above appears to vary from 26 to 58 days.

NOTICE

Females appear to lay eggs in damaged fruit, but may also choose sound fruit. (Oakley, 1950)

Epochra canadensis

- The egg period is 4-7 days in the laboratory and 6-8 days in the field
- The larval stage takes 15 days. Larvae began to emerge the first day after the fruit drops to the ground and emergence continues for 19 days afterwards.
- Pupation takes place in the soil or in litter under the bushes. Pupae live in the soil for 10 months of the year until the following spring when they emerge. There is one generation a year.
- The female mates 5 days after emergence, the first egg is laid on the 6th day after temperatures go up to a range of 77^{o} to 44^{o}F. Females lay some eggs almost every day, only 1-2 per fruit, but as many as 33 eggs are laid. (Jones, 1937; Christensen & Foote, 1960)

Myiopardalis pardalina

- Eggs are laid in the morning, during warm sunshine. Eggs are laid just below the rind. The egg stage lasts 2-3 days in summer, 7 days in autumn.
- Larvae burrow into the fruits where they feed on the seeds and surrounding pulp. The larval stage lasts 8 to 18 days; and pupate in the soil.
- The pupae pass the winter for up to 6 months in the soil, normally the pupal stage lasts 13 to 20 days or more.
- Adult emergence begins in June in Transcauasia, continuing for about 3 weeks. Females lay at least 100 eggs in pulp of tender fruit, preferably in newly set fruit. 5 eggs are laid at one time. The maximum # of eggs observed in a single fruit is 120 of which only 6 or so survive. Adults rest under sunflower or corn when not ovipositing. There may be much overlapping of the generations, especially in warmer areas. In Saudi Arabia there are about 6 overlapping generations a year. (Christensen & Foote, 1960; Nanayanan & Batra, 1960; Ghana, 1972)

NOTICE

1. Females cannot penetrate older fruit, selecting fruit about 2-3 days old for oviposition.
2. If it rains, pupae are capable of being washed away and dispersed to new localities, where they start their life cycle anew. Pupae are capable of submergence for for 2-3 weeks.
3. There is some question that this species exists in Africa (White & Elston-Harris, 1992). But USDA interception records indicate that peaches imported into New York in 1948 (# 100,496) from South Africa contained 79 adults (which were reared), 6 pupae and 124 larvae of this species in 37 out of 56 peaches. For this reason the South African record is added and the West African record by CIE is no longer regarded as questionable. In addition, peach is added as a host.

Rhagoletis cerasi

- The egg period is 5-12 days on average.
- The larvae move to the center of the fruit and feed near the pit. Larvae thrive on mature fruit, and cannot develop in green fruit. The larval period is 2-4 weeks.
- The larvae pupate in the top 3 inches of soil. Diapause is obligatory and 5 months (min. 3 months) of overwintering low temperatures are needed. Some will overwinter a 2nd or even a 3rd year if not enough low temperatures accumulate.
- Emerged adults mature in about 5 days. Each female usually mates once and oviposition starts are early as the 6th or 7th day, but usually 10-11 days after their emergence. Females lay 50-80

eggs which are inserted singly under the skin of the host. Adults live for 60 days, females usually die in 2-3 weeks. Dispersal is within 350 meters if hosts are present.

NOTICE

The life cycle is usually one, but may be two or three years, depending on the obligatory diapause. (APHIS, 1984b; HYPPZ, 1998b)

Rhagoletis cingulata

- The egg hatch into larvae in about 1 week.
- Newly hatched larvae burrow directly into the fruit where they feed. Inside the fruit, the larvae pass through 3 instars, each of 11 days duration. Last instar larvae develop a breathing hole in the fruit surface. After about 3 days near the surface, the larvae emerge, drop to the soil and form a puparium at a depth of approximately 3”.
- The pupa overwinter in the soil.
- Adults appear in cherry orchards through June and July. They mate soon after emergence. To attain maximum emergence from the soil requires 150 days at temperatures of 32-40ºF. After a five to 10 day preoviposition period, during which adults feed in aphid honeydew and other sources, egg laying in cherries begans and can continue for about 25 days. Over 350 eggs may be laid by one female. (Hogmire, 1995)

Rhagoletis completa

- The egg takes five days to hatch under field conditions.
- The larvae pass through the various stages in 36.8 days at temperatures ranging from 45-104ºF (with a mean of 64ºF) and 27.9 days at temperatures ranging from 67-90ºF (with a mean of 82ºF).
- Because this species has an obligate diapause, the Pupal stage ranges from 291 to 328 days.
- Adult females mate after 7 to 14 days under average field conditions in the summer. The first eggs appear an average of 18 days under lab conditions. average is 18 to 24 days under field conditions. Each female produces 200 to 400 eggs under summer conditions. Adults live 42 days under lab conditions, but 30-40 days under field conditions. (Christensen & Foote, 1960)

Rhagoletis fausta

- The egg hatch into larvae in about 1 week.

- Newly hatched larvae burrow directly into the fruit where they feed. Inside the fruit, the larvae pass through 3 instars, each of 11 days duration. Last instar larvae develop a breathing hole in the fruit surface. After about 3 days near the surface, the larvae emerge, drop to the soil and form a puparium at a depth of approximately 3”.
- The pupa overwinter in the soil.
- Adults appear in cherry orchards through June and July about one week before *Rhagoletis cingulata* adults emerge. They mate soon after emergence. To attain maximum emergence from the soil requires 150 days at temperatures of 32-40ºF. After a five to 10 day preoviposition period, during which adults feed in aphid honeydew and other sources, egg laying in cherries begans and can continue for about 25 days. Over 350 eggs may be laid by one female. (Hogmire, 1995)

Rhagoletis lycopersella

- The combined egg and larval period is 16 to 18 days on average.
- There are two periods of emergence for adults, depending on if the pupa passes through a protracted period of estivation. The first period of emergence occurs from 26-38 days after pupation, giving a minimum egg to adult stage of 55.5 days to 69 days for 58% of all flies. The remainder (42%) pass through an extended estival period of 3 to 8 months. The extreme limits of estivation have never been determined.
- Suriviorship of the adult is unknown.

NOTICE

- The adult attacks chiefly very green tomato fruit, and fruits may all be destroyed while they are still green.
- The pupal stage weathers periods of adverse circumstances.
- The adult occurs year round in its native habitat. (Smyth, 1960)

Rhagoletis mendax

- Eggs hatch in about 5 days.
- Larvae burrow into the berry and feed on the pulp of the host for about 2 weeks, developing through 3 stages. Mature larvae drop out of the berry and burrow into the soil to pupate, which occurs 7-10 days later.
- The pupae overwinter, buried 2.5 to 15 cm deep (1-6 inches) in the soil. Warm temperatures in the spring trigger pupal development and the adult flies unually began emerging shortly after highbush berries start to ripen.

- Female flies take 7-10 days to mature (preovipositional period). After mating near the host fruit, they then began to lay eggs on large ripening berries.

NOTICE

- There is only one generation per year.
- A few pupae may remain in the soil for 2 or 3 years. (Meyer & Cline, 1997; Geddes, et al., 1997; Gaul, et al., 2002)

Rhagoletis pomonella

- The egg lasts 3-7 days under field conditions,with an average of 4.5 days at a mean temperature of 75ºF
- The larvae last a minimum of 2 weeks in early apples to several months in winter apples. On average 20 to 22 days in summer, longer towards fall.
- Pupae remain in the top 2-3 inches of soil over 1 winter, a few over 2 winters, and a very small number over 3 or 4 winters.
- Adults emerge from the soil starting in late June through September of the following or subsequent years. After a period of feeding for 8-10 days, adult females have the potential to lay 288-300 eggs, inserted under the outer skin of the host fruit. Adults may live 53 days, 19 to 24 days in the field, with an average of 3 weeks to 60 days in captivity.

NOTICE

- The life cycle could be stretched out over a 5 year time-span at the maximum.
- Adults move readily from tree to tree but normally only for short distances, usually no more than 200-300 yards. (Christensen & Foote, 1960; Howitt, 1993)

Rhagoletis tomatis

Almost nothing is known about this species. It occurs in both Peru and Chile, in the latter confined to a localized small area around Vallenar in unsuitable habitat for its chief host, Tomato. (Salazar, et al., 2002)

Toxotrypana curvicauda

- Eggs hatch approximately 12 days after oviposition.
- Larval development in the fruit lasts about 15 to 16 days. The young larvae feed on developing seeds and interior parts of the fruit. As the larvae mature, they begin to eat their way out of the fruit, drop to the ground beneath the plant and pupate just below the soil surface.

- Adults emerge in about two to six weeks, depending upon humidity and temperature of the soil, and the cycle continues as they mate and seek fruit in which to lay eggs. They apparently have a negative reaction to sunlight and seek the shady side of the fruit. They do not form leks and in fact, spend little enough time on the host, probably because of its exposed nature. Considerable time is instead spent on nonhost vegetation. Adults also do not feed on protein rich vegetation for egg development and reproductive maturation. This function is apparently carried out in the larval stage by the consumption of host seed. Adults do not feed much, if at all and live for about 5-7 days on average.
- The female is capable of producing 100 or more eggs. The female fruit fly oviposits, usually in the evening, in green immature fruit by thrusting her ovipositor through the flesh of the fruit. She then deposits a group of 10 or more long, slender eggs among the seeds in the seed cavity of the papaya. Eggs are usually laid in small fruit, about two to three inches in diameter, but they may be deposited in smaller or larger fruit. Usually only one cluster will be placed in a single fruit.

NOTICE

Unripe papaya juice is fatal to the larvae so it is necessary for the fruit to be ripe once the larvae begin to eat their way out of the inner cavity.

There are about 6 generations a year, although they overlap and are in no way distinct.

Adults are not strong fliers and their movement is strictly local. They are apparently restricted to within a two mile radius. (Mason, 1922; Selman, 1998; Landolt, 1984)

Zonosemata electa

- Eggs hatch in about 10 days.
- Larvae feed within the peppers for about 18 days. They exit the fruit to pupae in the soil.
- The pupae overwinter 5 to 10 cm below the soil surface.
- Adults emerge from late June through August and mate. Females insert eggs just beneath the skin of young peppers about 1-4 cm in diameter.
- Only one generation occurs per year.

NOTICE

Said to originate in New Jersey, and spread throughout the eastern half of North America as far north as Canada and South to Florida, and West to Indiana, Oklahoma, and Texas (Anon., 1998)

I

Manual Name

Appendix I

FORMS

Forms used by PPQ and other cooperating authorities

Forms as developed by APHIS, PPQ are listed below. The latest version of each form should be used. Others may be prepared to satisfy the requirements of a particular program.

Many of these forms may be found at http://www.aphis.usda.gov/forms/

PPQ Fomrs	Number	Title
SURVEY	PPQ 343	Trapping Record
	PPQ 345	Caution - Do Not Handle or Move (Warning label used on Insect traps)
REGULATORY	PPQ 391	Specimens for Determination
	PPQ 214	Warning Quarantine Labe
	PPQ 244	USDA - APHIS Warning Quarantine (Tag)
	PPQ 254	Disposition of Plants and Plant or Animal Products
	PPQ 287	Mail Interception Notice
	PPQ 468	Caution - Pesticide Treatment in Progress
	PPQ 518	Report of Violation
	PPQ 519	Compliance Agreement
	PPQ 522	Certified Under All Applicable Federal or State—Cooperative Domestic Plant Quarantine (Tag)
	PPQ 523	Emergency Action Notification
	PPQ 524	Issuance Record for Permits or Certificates
	PPQ 527	Certified Under All Applicable Federal or State Cooperative Domestic Plant Quarantine (Package Certificate)
	PPQ 530	Limited Permit
	PPQ 535	Certificate of Treatment—(Fruit - Foreign Site)
	PPQ 537	Limited Permit (Movement of Noncertified Articles)
	PPQ 540	Certificate of Federal/State Domestic Plant -Quarantines
	PPQ 551	Regulated Establishment Record
	PPQ 554	Certified Under All Applicable Federal or State Cooperative Domestic Plant Quarantine (Label)
	PPQ 577	Phytosanitary Certificate
CONTROL	PPQ 213-R	Airplane Inspection Record
	PPQ 431-R	Treatment Test Record
	PPQ 468	Caution - Pesticide Treatment in Progress
	PPQ 552-R	Pesticide Samples for Chemical Analysis
	PPQ 802	Daily Aircraft Record
	APHIS 2060	Environmental Monitoring
	APHIS 2061	Residue Sample for Food or Feed Products

J

Manual Name

Appendix J

Contributors

This Section is reserved for future use.

K

Manual Name

Appendix K

References

Adams, S., 1994. Putting the Bite on Caribbean Fruit Flies. Agricultural Research, 42(7): 14-15.

Aguiar-Menezes, E.L. and Menezes, E.B., 1997. Natural Occurrence of Parasitoids of *Anastrepha* spp. in Different Host Plants in Itaguai (RJ), Brazil. Biological Control, 8(1): 1-6.

Ahmad, R.A., et al., 1975. Note on Breeding Parasites of Fruit Flies in Pakistan. Plant Protection Bull. FAO, 23(5): 146-147.

Albrecht, C.P. and Sherman, M., 1987. Lethal and Sublethal Effects of Avermectin B_1 on Three Fruit Fly Species. J. Econ. Entomol., 80: 344-347.

Alcantara-Licudine, J.P., et al., 1999. Dissipation of Phloxine B and uranine in protein bait sprayed in a coffee field for the suppression of Mediterranean Fruit Fly. Bull. Environ. Contamination and Toxicology, 62(3):344-351.

Ali, Ishtiaq, et al., 1999. Efficacy of Various Insecticides and Trap Heights in Methyl Eugenol Baited Traps Against Fruitflies (Bactrocera spp.). Sarhad J. Agric., 15(6): 589-594.

AliNiazee, M.T., 1985. Opiine Parasitoids of *Rhagoletis pomonella* and *R. zephyria* in the Willamette Valley, Oregon. Canadian Entomologist, 117(2): 163-166.

Allman, S.L., 1939. The Queensland fruit fly: observations on breeding and development. Agric. Gazette NSW, 50(9; 10): 499-501; 547-549.

Aluja, M., et al., 1990. Fruit infesting Tephritids and associated Parasitoids in Chiapas, Mexico. Entomophaga, 35(1): 39-48.

Aluja, M. and Liedo, P., editors, 1993. Fruit Flies: Biology and Management. Springer-Verlag, New York, Inc.: 492 pp.

Aluja, M., 1994. Bionomics and Management of *Anastrepha*. Annu. Rev. Entomol., 39: 155-178.

Amor, T.B., et al., 1998. Prophyrins and Related Compounds as Photoactivatable Insecticides I. Phototoxic Activity of Hematoporhyrin toward *Ceratitis capitata* and *Bactrocera oleae*. Photochemistry and Photobiology, 67(2): 206-211.

Angello, et al., 2002. Effect of High-Carbon Dioxide Atmospheres on Infestations of Apple Maggot in Apples. J. Econ. Entomol., 95(2): 520-526.

Anon., 1993. 85-Beneficial Insect Planes. In New Products. Ag. Consultants, 49(5): p.18.

Anon., 1996. A Description of Papaya fruit fly. <www.dpi.qld.gov.au/aphs/pff/description.html>

Anon., 1998. Pepper Maggot, *Zonosemata electa*. ipm <www.ncsu.edu/AG295/html/pepper_Maggot.htm>: 2 pp.

Anon, 2000. Asian Papaya Fruit Fly. Pacific Fruit Fly Web, www.pacifly.org/Species_profiles/B_papayae.htm>

Anon, 2000b. Becoming a Fruit Fly Fighter. Experiment Zone. Extreme Science, Univ. of Sydney, Faculty of Science. <www.scifac.usyd.edu.au/extreme/fruitfly.html>:2 pp.

Anon., 2000c. Genetics and Rearing of Tephritid Fruit Flies and their Parasitoids. <pwa.ars.usda.gov/hilo/genetic.html>: 4 pp.

Anon., 2000d. New French Polynesian Weapon Against Fruit Fly. Pacific Islands Report, November 7th, 2000: 2pp.

Anon., 2000e. Mediterranean Fruit Fly. Phenology Model Database. Univ. of California, Statewide Integrated Pest Management Project. <www.ipm.ucdavis.edu/PHENOLOGY/medfly.html>: 2 pp.

Anon., 2000f. Oriental Fruit Fly. Phenology Model Database. Univ. of California, Statewide Integrated Pest Management Project. <www.ipm.ucdavis.edu/PHENOLOGY/orientff.html>: 2 pp.

Anon., 2000g. Melon Fly. Phenology Model Database. Univ. of California, Statewide Integrated Pest Management Project. <www.ipm.ucdavis.edu/PHENOLOGY/melonfly.html>: 2 pp.

Anon., 2000h. Serpentine Fruit Fly. Phenology Model Database. Univ. of California, Statewide Integrated Pest Management Project. <www.ipm.ucdavis.edu/PHENOLOGY/serpffly.html>: 2 pp.

Anon., 2003. Fruit Fly Pests in Northwestern Australia: Invasion, Hybridisation or Evolution? The Fruit Fly Research Centre, University of Sydney. <Http://www.bio.usyd.edu.au/fruitfly/pages/research/Project4/project.html>: 1 pp.

APHIS, 1982a. Action Plan, Mediterranean Fruit Fly, *Ceratitis capitata*. Survey and Emergency Response Staff, Plant Protection and Quarantine, USDA, 50 pp. Also: DRAFT Action Plan, February 1993.

APHIS, 1982b. Action Plan, Melon Fly, *Dacus cucurbitae*. Survey and Emergency Response Staff, Plant Protection and Quarantine, USDA, 84 pp.

APHIS, 1982c. Pests Not Known to Occur in the United States or of Limited Distribution. No. 26: Mediterranean Fruit Fly. 1-10.

APHIS, 1982d. Action Plan, Oriental Fruit Fly, *Dacus dorsalis*, Survey and Emergency Response Staff, Plant Protection and Quarantine, USDA, 84 pp.

APHIS, 1984a. Action Plan, Melon Fly, *Dacus cucurbitae*. Survey and Emergency Response Staff, Plant Protection and Quarantine, USDA, 84 pp.

APHIS, 1984b. Action Plan, European Cherry Fruit Fly, *Rhagoletis cerasi*. Survey and Emergency Response Staff, Plant Protection and Quarantine, USDA, 48 pp.

APHIS, 1984c. Action Plan, South American Fruit Fly, *Anastrepha fraterculus*. Survey and Emergency Response Staff, Plant Protection and Quarantine, USDA, 42 pp.

APHIS, 1986. Mexican Fruit Fly Program Manual. M301.64: 13 pp.

APHIS, 1990. Action Plan DRAFT, Mediterranean Fruit Fly, *Ceratitis capitata*. Policy and Program development, Plant Protection and Management Systems, USDA, 100 pp.

APHIS, 1998. Treatment Manual. Interim Edition. 2000+ pages.

APHS, 1999. Winning the war against papaya fruit fly. <http://www.dpi.qld.gov.au.aphs/pff/eradication>: 2pp.

Appel, H.M. & Schultz, J.C., 1994. Oak Tannins Reduce Effectiveness of Thuricide in the Gypsy Moth. J. Econ. Entomol., 87(6): 1736-1742.

Armstrong, J.W. and Couey, H.M., 1984. Methyl Bromide Fumigation Treatments at 30^0C for California Stonefruits Infested with the Mediterranean Fruit Fly. J. Econ. Entomol., 77: 1229-1232.

Armstrong, J.W., 1992. Fruit fly disinfestation strategies beyond methyl bromide. New Zealand Journal of Crop and Horticultural Science, 20(2): 181-191.

Ashley, T.R. and Chambers, D.L., 1979. Effects of Parasite Density and Host Availability on Progeny Production by Biosteres longicaudatus, a parasite of Anastrepha suspensa. Entomophaga, 4(4): 363-369.

Baker, A.C., et al., 1944. A Review of Studies on the Mexican Fruit Fly and Related Mexican Species. USDA, Miscell. Pub., 531: 155pp.

Baranowski, R., et al., 1993. Biological Control of the Caribbean Fruit Fly. Florida Entomologist, 76(2): 245-251.

Bashiruddin, et al., 1988. Queensland fruit fly virus, a probable member of the Picornaviridae. Arch. Virol., 100(1-2): 61-74.

BASS, undated (a). Recorded Hosts, *Dacus tryoni*. Biological Assessment Support Staff, Plant Protection & Quarantine, USDA, 9 pp.

BASS, undated (b). Host List Lesser Pumpkin Fly, *Dacus ciliatus*. Biological Assessment Support Staff, Plant Protection & Quarantine, USDA, 9 pp.

BASS, 1983. Oriental Fruit Fly, *Dacus dorsalis*. Biological Assessment Support Staff, Plant Protection & Quarantine, USDA, 29 pp.

BASS, 1985. Host List Mediterranean Fruit Fly, *Ceratitis capitata*. Biological Assessment Support Staff, Plant Protection & Quarantine, USDA, 59 pp.

BASS, 1986. Melon Fly, *Dacus cucurbitae*. Biological Assessment Support Staff, Plant Protection & Quarantine, USDA, 19 pp.

Bateman, M.A., 1968. Determinants of abundance in a population of the Queensland fruit fly, Dacus tryoni. Sypm. R. Entomol. Soc. London, 4: 119-131.

Bateman, M.A., 1982. Section III. Chemical methods for Suppression or Eradication of Fruit Fly Populations. In: Economic Fruit Flies of the South Pacfic Region, By Drew, Hooper, and Bateman, Watson Ferguson and Co., Brisbane, Australia, : 115-128.

Bautista, R. and Harris, E.J., 1996. The Influence of Fruit Substrates on the Parasitization Behavior of *Biosteres arisanus*, an Egg-Larval USDA, Report Number:0000043802: 1 pp.

Bellas, T, 1996. The Papaya Fruit Fly - A Failure of Quarantine. Dept. of the Parliamentary Library. Research Paper 29 1995-96. <www.aph.gov.au/library/pubs/rp/1995-96rp29.htm>: 27 pp.

Bess, H.A., et al., 1950. Progress and Status of Two Recently Introduced Parasites of the Oriental Fruit Fly, *Dacus dorsalis* in Hawaii. Proc. Hawaiian Entomol. Soc., 14(1): 29-33.

Bilpin Springs Orchard. Dakpot Products. <www.pnc.com.au/~cl/Products.html> : 2 pp.

Boller, E., 1966. Der Einfluss naturlicher Reducktionsfaktoren auf die Kirschenfliege *Rhagoletis cerasi* in der Nordwestschweiz, unter besonderer Berucksichtigung des Puppenstadiums. Schweizerische Landwirtschaftliche Forschung, 5(2): 154-210.

Bosch, van den, R. and Haramoto, F.H., 1951. *Opius oophilus*, an Egg-Larval Parasite of the Oriental Fruit Fly discovered in Hawaii. Proc. Hawaiian Entomol. Soc., 14(2): 251-255.

Boucek, Z., 1963. A Taxonomic Study in *Spalangia*. Acta Entomologica, Musei Nationalis Pragae, 35: 430-512.

Boucek, Z. and Narendran, T.C., 1981. Indian Chalcid wasps of the genus *Dirhinus* parasitic on synanthropic and other Diptera. Systematic Entomology, *6: 229-251*.

Bressan, S. and Teles, M.C., 1991. Longevidade e Curva de Sobrevivencia de Tres Especies do Genero *Anastrepha* em Laboratorio. Revta. Bras. Ent., 35(4): 685-690.

Bridwell, J.C., 1918. Descriptions of New Species of Hymenopterous Parasites of Muscoid Diptera with Notes on their Habits. Proc. Hawaiian Entomol. Soc., 4(1): 166-179.

Brisbane Organic Growers Inc., 2000. News in 2000. Wild May Fruit Fly Attractant. <www.bog.powerup.com.au/news_2000.htm>: 8 pp.

Broughton, S. and Lima, De C.P.F., 2002. Field Evaluation of Female Attractants for Monitoring *Ceratitis capitata* Under a Range of Climatic Conditions and Population Levels in Western Australia. J. Economic Entomol., 95(2): 507-512.

Brown, V., 1985a. Action Plan for Mexican Fruit Fly, *Anastrepha ludens.* CDFA, Division of Plant Industry, Pest Detection/ Emergency Projects Branch, Sacramento, California, Sept. 15, 1985: 1-40 pp.

Brown, V., 1985b. Action Plan for Caribbean Fruit Fly, *Anastrepha suspensa.* CDFA, Division of Plant Industry, Pest Detection/ Emergency Projects Branch, Sacramento, California, Sept. 15, 1985: 1-41 pp.

Bueno, A.M., 1986. The use of Sex Pheromone for Monitoring and Control of Olive Fruit Fly. II Intern. Symp. Fruit Flies, Crete, Sept.1986: pp. 483-494.

Burditt, A. and White, L.D., 1987. Parasitization of Western Cherry Fruit Fly by *Pachycrepoideus vindemiae*. Florida Entomologist, 70(3): 405-406.

Burns, R.E, et al., 1996. Inundative Release of the Parasitoid *Diachasmimorpha longicaudata* for the control of the Caribbean Fruit Fly *Anastrepha suspensa*. In: Fruit Fly Pests, A World assessment of their Biology and Management. Edited by McPheron and Steck, St. Lucie Press, Delray Beach, Florida: 377-381.

Burns, R.E., et al., 2001. Efficacy of Spinosad Bait Sprays to Control Mediterranean and Caribbean Fruit Flies in Commercial Citrus in Florida. Florida Entomologist, 84(4): 672-678.

CalEPPC, 2000. List B: Wildland Pest Plants of Lesser Invasiveness. California Exotic Pest Plant Council, <www.caleppe.org/info/ 99listb.html>USDA, NRCS, 2001. The PLANTS Database, Version 3.1 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

California Olive Oil Council, 2002. Agricultural Information, <www.cooc.com/gagr.html>: 1-14.

Calkins, C.O.et al., 1994. Fruit Flies and the Sterile Insect Techinque. CRC Press, Boca Raton, Florida: 258 pp.

Cals-Usciati, J., et al., 1985. Adaptations fonctionnelles des structures liees a la prise alimentaire chez la larve primaire de *Trybliographa daci*, endoparasitoide de la Mouche des fruits *Ceratitis capitata.*

Cantrell, B. et al., 2000. Fruit Fly Fighters: Eradication of the Papaya Fruit Fly. CSIRO, SCARM Report 81: 1-200.

Caprio, M.A.,et al., 1991. Model for implementing a genetically improved Strain of a Parasitoid. American Entomologist, 37(4): 232-239.

Carambola Fruit Fly Programme Web Page, 2000. Carambola Fruit Fly, *Bactrocera carambolae,* Taxonomic Status, Biology. <www.carambolafly.com>.

Carey, J.R., 1991. Establishment of the Mediterranean Fruit Fly in California. Science, 253 (5026): 1369-1373.

Carey, J.R., 1993. Recent advances in the demography and invasion biology of fruit flies: a summary. Fruit flies biology and management. New York, Springer-Verlag: 115-117.

Carrejo, N.S. amd González, R.G.O., 1999. Parasitoids reared from species of *Anastrepha* in Valle Del Cauca, Columbia. Florida Entomologist, 82(1): 113-118.

Carrol, L.E., et al., 2002. Pest Fruit Flies of the World: Descriptions, Illustrations, Identification, and Information Retrieval. Version: 8th August, 2002. <http://www.sel.barc.usda.gov/Diperta/tephriti/pests/adults/www/zon_elec.htm>: many separate entries.

Celedonio-Hurtado, H., et al, 1988. Demography of Anastrepha ludens, A. obliqua, and A. serpentina in Mexico. Florida Entomologist, 71(2): 111- 120.

Chen, C.C. & Tseng, Y.H., 1993. Monitoring and survey of insect pests with potential to invade the Republic of China. In Plant quarantine in Asia and the Pacific: Report of an APO Study Meeting, 17-26th March, 1992, Taipei, Taiwan, pp. 42-52.

Christenson, L.D. and Foote, R.H., 1960. Biology of Fruit Flies. Annual Review of Entomology, 5: 171-192.

Chuan, P.O.A., et al., 1981. A compedium of Economic Entomology in Pennsular Malaysia (1887- 1975). Ministry of Agriculture, Malaysia: 1-233.

Clancy D.W., 1952. Notes on Parasites of Fruit Flies. Proceedings, Hawaiian Entomo. Soc., 14(3): 375.

Clausen, C.P., 1956. Biological Control of Fruit Flies. J. Economic Entom., 49(2): 176-178.

Clausen, C.P., 1978. Tephritidae, Fruit Flies. In: Introduced Parasites and Predators of Arthropod Pests and Weeds: A World Review. USDA Handbook # 480: 320-335.

Cline, H., 2002. New olive fruit fly attract/kill traps on horizon. Western Farm Press, July 5, 2003, 1-5. <westernfarmpress.com/ar/farming_new_olive_fruit/>.

Cochereau, P., 1970. Les Mouches des Fruits et Leurs Parasites dans la Zone Indo-Australo-Pacifique et Particulierement en Nouvelle-Caledonie. Cah. ORSTOM, Ser. Biol., 12: 15-50.

Cook, S.P., et al, 1995. Predation of Gypsy Moth Pupae by Invertebrates at Low Small Mammal Population Densities. Environmental Ecology, 24(5): 1234-1238.

Cooper, J., 1999. Electronic Pulses Zap Hitchhikers on Citrus. ARS News Service, USDA. <www.ars.usda.gov/is/AR/archive/jan99.tech0199.htm>: 2 pp.

Corcoran, R.J., et al., 1993. Vapor Heat Treatment of Zucchini Infested with *Bactrocera cucumis*. J. Econ. Entomol., 86(1): 66-69.

Cornelius, M.L., et al., 1999. Visual Stimuli and the Response of Female Oriental Fruit Flies to Fruit-Mimicking Traps. J. Econ. Entomol., 92(1): 121-129.

Couey, H.M., et al., 1984. Quarantine Procedure for Hawaiian Papayas Using Heat and Cold Treatments. J. Econ. Entomol., 77: 984-988.

Daiber, C.C., 1966. Notes on two Pumpkin Fly species and some of their Host Plants. S.Afr. J. Agri. Sci., 9: 863-876.

Dakpot Products, 1999. Dakpot Fruit Fly Attractant. <www.pnc.com.au~cl/Products/html>: 2 pp.

D'Amico, V. and Elkinton, J.S., 1995. Rainfall Effects on Transmission of Gypsy Moth Nuclear Polyhedrosis Virus. Environ. Entomol., 24(5): 1144-1149.

Dammerman, K.W., 1929. The Agricultural Zoology of the Malay Archipelago. J.H. de Bussy, LTD, Amsterdam, Netherlands, 109-112.

Debouzie, D. and Mazih, A., 1999. Argan (Sapotaceae) Trees as Reservoirs for Mediterranean Fruit Fly in Morocco. Environ. Entomol., 28(1): 53-60.

Dekker, L. and Messing, R., 2001. Introduction to Managing Fruit Flies in Hawai'i. In: Pest Management Guidelines, HITAR Brief No. 114. <www.extento.hawaii.edu/kbase/reports/fruit_pest.htm> 10 pp.

DirectorateCommunication, 2000. Cultivation of Mangoes. National Department of Agriculture, <http://www.nda.agric.za/docs/mangoA5/mango.htm>: 1-20.

Dimou, I., et al., 2003. Depth of pupation of the wild olive fruit fly, *Bactrocera oleae*, as affected by soil abiotic factors. Journal of applied entomology, 27(1): 12-17.

Drew, et al., 1982. Economic Fruit Flies of the South Pacific Region. Queensland Dept. of Primary Industries, Brisbane: 139 pp.

Drew, R.A.I. and Allwood, A.J., 1985. A new family of Strepsiptera parasitizing fruit flies in Australia. Systematic Entomology, 10(2): 129-134.

Drew, 1989. The tropical fruit flies of the Australasian and Oceanian regions. Memoirs of the Queenland Museum, 26, 1-521.

Drew, R.A.I. and Hancock, D.L., 1994. The *Bactrocera dorsalis* complex of fruit flies in Asia. International Institute of Entomology, supp. 2: 68pp.

Dow AgroSciences, 1999. Success; Supplemental Labeling. DO6-065-015. EPA-accepted 09/23/99, CA-accepted 03/01/00. Dow AgroSciences LLC, Indianpolis, Indiana: 2 pp.

Dubois, J., 1965. La mouche des fruits malgache (*Ceratitis malagassa* Munroe) et autres insectes de agrumes, pechers et pruniers a Madagascar. Fruits, 20(9): 435-460.

Duyck, P.F. and Quilici, S., 2002. Survival and development of different life stages of three *Ceratitis* spp. reared at five constant temperatures. Bull. Entomol. Res., 92(6): 461-469.

Economopoulos, A.P., 2002. Mediterranean Fruit Fly: Attraction/Trapping for Detection, Monitoring and Control. Phytoparasitica, 30(2): 115-118.

EPA, 1989. Avermectin (Agri-Mek, Affirm) E.P.A. Pesticide Fact Sheet 9/89: 7pp.

EPA, 1999. Section 18 - Pesticides beginning with an "S". EPA Office of Pesticides Programs. www.epa.gov/opprd001/Section18/page_s.htm: 3 pp. (updated 2/3/00).

Eskafi, F.M. and Cunningham, R.T., 1987. Host Plants of Fruit Flies of Economic Importance in Guatemala. Florida Entomologist, 70(1): 116-123.

Eskafi, F.M. and Kolbe, M.M., 1990. Predation on Larval and Pupal *Ceratitis capitata* by the Ant *solenopsis geminata* and Other Predators in Guatemala. Environ. Entomol., 19(1): 148-153.

Eskafi, F.M. and Kolbe, M.M., 1990b. Infestation Pattern of Commonly Cultivated, Edible Fruit Species by Ceratitis capitata and Anastrepha spp. in Guatemala and Their Relationship to Environmental Factors. Environ. Entomol., 19(5): 1350-1380.

Espky, N.D., et al., 1996. Attraction of Aastrepha suspensa to volatiles from Avian Fecal Material. Tektran, ARS, USDA, Report # 0000070704: 1 pp.

Etienne, J., 1973. Lutte biologique et apercu sur les Etudes Entomologiques Diverses Effectuees ces Dernieres Annees a la Reunion. L'Agronomie Tropicale, 6-7: 683-687.

Fabre, F., 2003. comparison of the Efficacy of Different Food Attractants and Their concentration for Melon Fly. J. Econ. Entomol., 96(1): 231-238.

FAO/IAEA, 2002. Development of Improved Attractants and their Integration into Fruit Fly SIT Management Programmes. Insect Pest Control Newsletter, 59: p. 22.

Fisher, K., 1994. The eradication of the Queensland Fruit Fly, *Bactrocera tryoni*, from Western Australia. *In*: Fruit Flies and the Sterile Insect Technique by Calkins, et al., 1994: pp. 237-245.

Fitt, G.P., 1980. New Records of *Dacus* (Austrodacus) *cucumis* from the Northern Territory, Australia. J. Aust. ent. Soc., 19(3): 240.

Fitt, G.P., 1983. Factors Limiting the Host Range of Tephritid Fruit Flies, with particular emphasis on the influence of *Dacus tryoni* on the Distribution and abundance of *Dacus jarvisi*. PhD Thesis, Univ. of Sydney: pp. 1-260.

Fitt, G.P., 1986. The roles of adult and larval specialisations in limiting the occurrence of five species of *Dacus* in cultivated fruits. Oecologia, 69(1): 101-109.

Fletcher, B.S., 1986. Some Issues in Fruit Fly Ecology. NATO ASI Series Vol. G11. In: Fruit Fly Management. Springer-Verlag, Berlin: 117-133.

Flitters, N.E. and Messenger, P.S., 1965. Effect of Temperature and Humidity on Development and Potential Distribution of the Mexican Fruit Fly in the United States. USDA, ARS, Tech. Bull. # 1330: 36pp.

Frochlich, G. and Rodewald, W., 1970. Pests and Diseases of Tropical Crops and Their Control. Permgamon Press, New York.

Fry, J.M., 1987. Natural Enemy Databank. A catalogue of natural enemies of arthropods derived from records in the CIBC Natural Enemy Databank. CAB International, pp. 34-35.

Fullaway, D.T., 1950. Fruit Fly Parasites Collected in Queensland by N.L.H. Krass in 1949. Proc. Hawaiian Entomol. Soc., 14(1): 65-67.

Fullaway, D.T., 1951. Review of the Indo-Australasian Parasites of the Fruit Flies (Tephritidae). Proc. Hawaiian Entomol. Soc., 14(2): 243-250.

Garcia, A.T.E., et al., 1989. Patogenicicade de *Metarhizium anisopliae* nas diferentes fases de desenvolvimento de *Ceratitis capitata.* Revta bras. Ent., 33(1): 17-23.

Garcia, J., 2001. A Better Fruit Fly Trap. Agricultural research, 49(5): 14-15.

Gaskins, M.H., 1968. Letter to Mr. M.J.A. Brouers, Organizacion de las Maclones Unidas, Para La Agricultura y la Allmentacion, Mexico. Reference to nutmegs in Puerto Rico grown from seeds imported from Granada (Southern Spain). O-I-C, USDA, Crops Research division, Federal Experiment Station, Mayaguez, Puerto Rico: 1pp.

Gaul, S.O., et al., 2002. Integrated Pest Management of *Rhagoletis mendax* in Lowbush Blueberry using Vegetative Field Management. J. Econ. Entomol., 95(5): 958-965.

Geddes, P.S., et al., 1987. The buleberry maggot, *Rhagoletis mendax*, in eastern North America. Revue D'Entomologic du Quebec, 37(1-2): 16-24.

Ghani, M.A., 1972. Final Report: Studies on the Ecology of some Important species of Fruit Flies and their Natural Enemies in West Pakistan. Pakistan Station, CIBC, Rawalpindi, Pakistan, 1-42.

Gingrich, R.E., 1993. Biological Control of Tephritid Fruit Flies by Inundative Releases of Natural Enemies. *In:* Fruit Flies: Biology and Management, edited by M. Aluja and P. Liedo, Springer-Verlage, New York, Inc.: pp. 311-318.

Gomes, P.J., 2000. Action Plan, Peach Fruit Fly, *Bactrocera zonata.* FAO, IAEA, CAB International: 1-50.

Gonzalez-Hernandez, A. and Tejada, L.O., 1979. Fluctuacion de la Poblacion de *Anastrepha ludens* y de sus enemigos naturales en *Sargentia greggii*. Folia Entomol. Mexicana, 41: 49-60.

Gonzalez, B., et al, 1971. Estudios Sorbe la Aplicacion de la Tecnica de Machos Esteriles en el control de la Mosca Sudamericana de la Fruta, *Anastrepha fraterculus*. Rev. Peru. Entomol., 14(1): 66-86.

Gowdey, C. C., 1913. Report by the Entomologist of the Uganda Protectorate. Annual Report of the Dept. of Agric. for the year ended 31st March, Kampala, 1913: pp. 29-39.

Greany, P.D., 1989. Host plant resistance to tephritids: an under-exploited control strategy. In: A. S. Robinson & G. Hooper, Fruit flies, their biology, natural enemies and control, Elsevier, Amsterdam: pp.353-362

Greany, P.D. et al., 1991. Improvement in Efficacy of Gibberellic Acid Treatments in Reducing Susceptibility of Grapefruit to attack by Caribbean Fruit Fly. Florida Entomologist, 74(4): 570-580.

Greathead, D.J., 1972. Notes on coffee Fruit-Flies and their Parasites at Kawanda. Commonwealth Inst. Biological Control, CAB, 13: 11-18.

Greve, J.E. van S. and Ismay, J.W., 1983. Crop Insect Survey of Papua New Guinea from July 1st 1969 to December 31st 1978. Papua New Guinea Agric. J., 32(1-4): 120 pp.

Gurney, W.B., 1910. Fruit Flies and other Insects Attacking Cultivated and Wild Fruits in New South Wales. Agric. Gazette NSW, 22: 722-727.

Gut, L.J. and Brunner, J.F., 1994. Parasitism of the Apple Maggot, *Rhagoletis pomonella*, infesting Hawthorns in Washington. Entomophaga, 39(1): 41-49.

Hagley, E.A.C., et al., 1993. Effect of Age of the Puparium of the Apple Maggot, *Rhagoletis pomonella*, on Parasitism by *Phygadeuon wiesmanni*. The Canadian Entomologist, 125(4): 721-724.

Hajek, A.E., et al, 1996. Host Range of the Gypsy Moth Pathogen *Entomophaga maimaiga* in the field Versus Laboratory. Environ. Entomol., 25(4): 708-721.

Hallman, G.J., 1999. Ionizing radiation quarantine treatments against tephritid fruit flies. Postharvest Biology and Technology, 16(2): 93-106.

Handler, A.M., et al, 1998. The Lepidopteran transposon vector, *piggyBac*, mediates germ-line transformation in the Mediterranean fruit fly. Proc. Natl. Acad. Sci. USA, 95: 7520-7525.

Haniotakis, G., et al., 1986. Sex-specific Activity of (R)-(-)- and (S)-(+)-1,7-Dioxaspiro[5.5]Undecane, the major Pheromone of *Dacus oleae. Journal of Chemical Ecology, 12(6): 1559-1568.*

Haniotakis, G., el al., 1991. An Effective Mass Trapping Method for the Control of *Dacus oleae.* J. Econ. Entomol., 84(2): 564-569.

Hardie, D.C., 1982. A Review of Mediterranean Fruit Fly Parasites with Special Reference to Western Australia. Biology Project 301/302, Western Australian Institute of Technology: 1-43.

Hardin, B., 2000. Biodegradable Decoy Reduces Insecticide Use. Agricultural Research, 48(1): 12-14.

Hardy, D.E., 1974. The Fruit Flies of the Philippines. Pacific Insects monograph, 32: p. 35.

Hazen, S.B., 1999. Letter to Carl Busch, APHIS, from EPA of 20th May, 1999, covering quarantine exemptions for the use of spinosad and diazinon against fruit fly species. File: 99-DA-09; 99-DA-01: 4 pp.

Heath, R.R., et al., 1996. Improved Pheromone-Based Trapping Systems to Monitor *Toxotrypana curvicauda.* Florida Entomologist, 79(1): 37-46.

Heather, N.W., et al., 2002. A heated air quarantine disinfection treatment against Queensland fruit fly for tomatoes. Australian Journal of Experimental Agriculture, 42(8): 1125-1129.

Hendrichs, J., 1996. Action Programs Against Fruit Flies of Economic Inportance: Session Overview. In: Fruit Fly Pests, A World assessment of their Biology and Management. Edited by McPheron and Steck, St. Lucie Press, Delray Beach, Florida: 513-519.

Hennessey, M.K. & Knight, R.J., 1996. Resistence to Caribbean Fruit Fly in Carambola Tektran, ARS, USDA, 03/24/1996: 1 pp.

Hennessey, M.K., 1998. Predation on Carribean Fruit Fly Prepupae and Pupae in Guava and Carambola Grove. Tektran, ARS, USDA, 12/18/88: 1 pp.

Hernández-Ortez, V., et al., 1994. Native Parasitoids Associtated with the Genus *Anastrepha* in Los Tuxtlas, Veracruz, Mexico. Entomophaga, 39(2): 171-178.

Higgins, M., 2000. Fruit flies rock the evolutionary clock. Environmental News Network. <www.enn.com/news/enn-stories/2000/01/01272000/fruitfly_9457.asp>: 3 pp.

Hogmire, H.W., 1995. Mid-Atlantic Orchard Monitoring Guide. Northeast Regional Agricultural Engineering Service, Ithaca, New York: pp.63.

Horsefall, M., 1995. Organic Fruit Fly Control. Canberra Organic Growers Society. Grass Roots, 112: 4 pp.

Howitt, A., 1993. Apple Maggot. Fruit IPM Fact Sheet. Michigan State Univ. Extension. NCR 63, Common Tree Fruit Pests, Michigan State Univ.: 1-5 pp.

Hoy, M.A., 1990a. Genetic Improvement of Arthropod Natural Enemies: becoming a Conventional Tactic? Proceedings of a UCLA Colloquium held at Frisco Colorado, 1989. Alan R. Liss, New York, 112: 405-417.

Hoy, M.A., 1990b. Genetic Improvement of Parasites and Predators. FFTC-NARC International Seminar on the use of parasitoids and predators to control Agricultural Pests, Tukuha Science City, Japan,: 15 pp.

Hu, X.P., et al.,1998a. Controlled Release of Sugar and Toxicant form a Novel Device for Controlling Pest Insects. Journal of Controlled Release, 50(1-3): 257-265.

Hu, X.P., et al.,1998b. Effects of Sugar/flour Spheres Coated with Paint and Insecticide on Alighting Female *Ceratitis capitata* Flies. Florida Entomologist, 81(3): 318-325.

Hukuhara, T., 1999. Boosting Insect Biocontrol. Nature Biotechnology, #3. < www.newswise.com/articles/1999/10/INSECT/NBT.html> 2 pp.

Huque, H. and Ahmad, C.R., 1969. Studies on the Control of *Dacus ciliatus* by Sterile Male Release Technique. Int. J. Appl. Radiat. Isotop., 20(11): 791-795.

Hull, et al., 1995. Apple Maggot. In: Mid-Atlantic Orchard Monitoring Guide, NRAES-75. Northeast Regional Agricultural Engineering Service: 370 pp.

Husain, T., 1985. A catalogue of family Chalcididae of India. Centre for Studies on Science: 82 pp.

HYPPZ, 1998a. Olive Fruit Fly. <www.inra.fr/HYPPZ/RAVAGEUR/6dacole.htm>: 2 pp.

HYPPZ, 1998b. Cherry maggot; European cherry fruit fly. <www.inra.fr/HYPPZ/RAVAGEUR/6dacole.htm>: 2 pp.

Ibrahim, A.G., et al., 1994. Biology of *Diachasmimorpha longicaudata*, A Parasitoid of Carambola Fruit Fly. Pertanika J. Trop. Agric. Sci., 17(2): 139-143.

Insect Science, 2002. Pheromones and their Traps. <http://www.insectscience.co.za/phertraps.htm>: 1 pp.

Insect Science, 2002a. Attract and Kill. Last Call FF. <http://www.insectscience.co.za/labelff.htm>: 3 pp.

Investigator, P., 1999. Interactions Between a Parasitic Wasp and its Insect Host: A Molecular Study of Wasp Virus. WorkPage, <http://www.workpage.com/f/83/145f.htm>

Ito, P.J., et al., 1979. Transmission of Mucor rot of guava fruits by three species of fruit flies. Tropical Agriculture, 56(1): 49-52.

Jacobson, M., 1983. Insecticides, Insect Repellants, and Attractants from Arid/Semiarid-Land Plants. In Plants; The Potential for Extracting Protein, Medicines, and Other Useful Chemicals. Workshop Proceedings, September, 1983,Office of Technology Assesment, OTA-BP-F-23: 138-146.

Jang, E.B., 1990. Fruit Fly Disinfestion of Tropical Fruits using Semipermeable Shrinkwrap Film. Acta Horticulturae, 269: 453-458

Jarvis, H., 1925. The Fruit Fly. Report on Measures of possible Control. Queensland Agricultural Journal, 26(1): 48-52.

Jarvis, H., 1927. Notes on the Breeding of Certain Fruit Flies in Captivity. Queensland Agricultural Journal, 28(4): 451-452.

Jiron, L.F. and Mexon, R.G., 1989. Parasitoid Hymenopterans of Costa rica: Geographical Distributions of the Species Associated with Fruit Flies. Entomophaga, 34(1): 53-60.

Johnson, M.W., 2002. Managing Olive Fly-Monitoring and Control-(Power Point Presentation). <http://fruitsandnuts.ucdavis.edu/crops/JohnsonOliveFly.pdf>: 24pp.

Jones, O.T., et al., 1983. Development of a monitoring trap for the olive fly, *Dacus oleae*, using a component of its sex pheromone as lure. Bull. ent. Res., 73: 97-106.

Jones, S.C., 1937. The Currant and Gooseberry Maggot or Yellow Currant Fly (Epochra canadensis). Agric. Exp. Station Circular 121, Oregon Agri. Exp. Station, Oregon State College, Corvallis, Oregon, March 1937; 1-11.

Joo, L.C., et al., 1996. Identification of the volatile components of E802Mazoferm Steepwater, a Condensed Fermented Corn Extractive Highly Attractive to the Mexican Fruit Fly. USDA, ARS, Tektran, 08/13/1996. <DIPTERA/http://www.nal.usda.gov/tektran/data/000007/38/0000073850.html>: 2pp.

Kaiser, C. and Sheard, A.G., 2001. Integrated Pest & Disease Management (IPDEM) of Cherries in Kwazulu-Natal. KZN Department of Agriculture and Environmental Affairs. KZN AgriReport NA-2001-06: 1-33.

Kandybina, M.N., 1977. Larvae of Fruit Flies. Opredeliteli Po Faune SSSR, Leningrad: Nauka, Leningradskoe otd-nie, 114: 212 pp. (Translated in 1987 by G. Saad, OICD, LGU, USDA, Ag TT 85-10-1779, 298 pp.)

Kapatos, et al., 1977. The Release of *Opius concolor* and *O. concolor* var. *siculus* against the spring generation of *Dacus oleae* on Corfu. Entomophaga, 22(3): 265-270.

Kapoor, 1993. Indian Fruit Flies. Oxford & IBH Pub. Co., New Dehl, India, 1-228 pp.

Katiyar, K.P., et al., 1995. Parasitoides hymenopteros de moscas de las frutas en la region occidental de Venezuela. Rev. Fac. Agron. (LUZ), 12: 303-312.

Katiyar, et al., 2000. Fruit Flies Infesting Fruits of the Genus Psidium and their altitudinal Distribution in Western Venezuela. Florida Entomologist, 83(4): 480-486.

Katsoyannos, B.I. and Papadopoulos, N.T., 2003. Comparison of Different Trapping Systems for *Bactrocera oleae* in Chios, Greese.In: 1st European Meeting of the IOBC/WPRS Study Group “Integrated Control in Olives”, Crete, Hellas, May 29-31, 2003: p. 10.

Kirkpatrick, S., 2002. Growers eagerly await another tool for olive fruit fly control. AG Alert, August 14, 2002: 1 pp.

Knowles, N.J., 1998. Invertebrate Picorna-like Viruses. <http://iah.bbsrc.ac.uk/virus/picorna-like/VirusList.htm>: 7 pp.

Kroening, M.K., 1989. New Host and Distributional Records for *Rhagoletis* in Colorado. Southwestern Entomologist, 14(2): 147-152

Laiti, F. T., et al., 2002. Fruit Flies in Samoa. Plant Protection Service, Secretariat of the Pacific Community. Pest Advisory Leaflet # 32: 4 pp.

Landolt, P.J., 1984. Behavior of the Papaya Fruit Fly Toxotryphana cruvicauda, in relation to its Host Plant, *Carica papaya*. Folia Entomologica Mexicana, no. 61: 215-224.

Landolt, P.J., 1994. Fruit of *Morrenia odorata* as a Host for the Papaya Fruit Fly, *Toxotrypana curvicauda*. Florida Entomologist, 77(2): 287288.

Larsen, T., 1999. Pers. com. (e-mail) on fruit fly lures. Consep Corporation: 1 pp.

Leblanc, L., 1997. Fruit Fly fauna in federated states of Micronesia, Guam, Palau, Kiribati, Northern Marianas and Marshall Islands. Managment of fruit flies in the Pacific, a Regional Symposium, Nadi, Fiji, 28-31, October, 1996. Canberra, ACT: Australian Centre for International Agricultural Research, 1997: pp. 64-67.

Leffingwell, J.C., 1999. Osmanthus: A review by John C. Leffingwell, PhD. <www.leffingwell.com/osmanthus.htm>

Leonel, F.L., et al., 1995. Distribution and tephritid hosts of braconid parasitoids in Brazil. International J. Pest Management, 41(4): 208-213.

Lewis, J.A., et al., 1988. Volatile Compounds from the Flowers of *Spathiphyllum cannaefolium*. Phytochemistry, 27(9): 2755-2757.

Lewis, J.V., 1999. Torula Yeast Pellets. Commerce Business Daily Issue of November 4, 1999. 1-2.

Lindegren, J.E., 1990. Proc. and Abstracts, V International Colloquium on Invertebrate Pathology and Microbial Control, Adelaide, Australia. Department of Entomology, Univ. of Adelaide: p. 223.

Liquido, N.J., 1991. Effect of Ripeness and Location of Papaya Fruits on the Parasitization Rates of Oriental Fruit Fly and Melon Fly by Braconid Parasitoids. Environ. Entomol., 20(6): 1732-1736.

Liquido, N.J., et al., 1991. Host Plants of the Mediterranean Fruit Fly: an Annotated World Review. Miscellaneous Publications, 77: 1-52.

Liquido, N.J., et al., 1994. Ecology of *Bactrocera latifrons* Populations: Host Plants, Natural Enemies, Distribution, and Abundance. Ann. Entomol. Soc. Am., 87(1): 71-84.

Lindegren, J.E. et al, 1990. Response of Mediterranean Fruit Fly to the Entomogenous Nematode Steinernema feltiae in Field Tests in Hawaii. Environ. Entomol., 19(2): 383-386.

Loiacono, M.S., 1981. Notas sobre Diapriinae Neotropicales. Rev. Soc. Argentina, 40(1-4): 237-241.

Lopez, M., Aluja, M., and Sivinski, J., 1999. Hymenopterous Larval-Pupal and Pupal Parasitoids of Anastrepha Flies in Mexico. Biological Control, 15(2): 119-129.

MacCollom, G.B., 1987. Decrease Pesticide Costs by Using Traps. American Fruit Grower, 107(4): 42-43 and online at: <http://www.laddresearch.com/Traps/Apple_Maggot_Fly/AMF_Study/amf_trap_study.html>

Maitland, D.P., 1992. Locomotion by jumping in the Mediterranean fruit-fly larva *Ceratitis capitata*. Nature, 355(6336): 159-161.

Manousis, T., et al., 1987. An inapparent infection with a probable picornavirus in several stocks of laboratory reared and naturally-occurring populations of *Dacus oleae* pupae in Greece. Microbios, 51: 81-88.

Manousis, T. and Moore, N.F., 1987. Cricket Paralysis Virus, a Potential Control Agent for the Olive Fruit Fly, *Dacus oleae*. Applied and Environmental Microbiology, 53(1): 142-148.

Martinez, A.J. and Moreno, D.S., 1991. Effect of Cyromazine on the Oviposition of Mexican fruit Fly in the Laboratory. J. Econ. Entomol. 84(5): 1540-1543.

Marucci, P.E., 1952. Notes on Parasites of Fruit Flies. Proceedings, Hawaiian Entomo. Soc., 14(3): 371.

Marwat, N.K., et al., 1988. Suppression of Population and Infestation of Dacus Spp. by Male Annihilation in Guava Orchard. Pakistan J. Zool. Vol., 24(1): 82-84.

Mason, A.C., 1922. Biology of the Papaya Fruit Fly, *Toxotrypana curvicauda*, in Florida. USDA, Bull. No. 1081: 1-9.

May, A.W.S., 1946. Pests of Cucurbit Crops. Queenland Agricultural Journal, 62(3): 137-150.

May, A.W.S. and Kleinschmidt, R.P., 1954. Some Native Parasites of Dacinae in Queensland. Queensland J. Agric. Science, 11(3): 107-113.

Mazomenos, B.E., et al., 2002. Attract and kill of the olive fruit fly Bactrocera oleae in Greece as a part of an integrated control system. IOBC wprs Bulletin, 25(*): 1-11.

McBride, J. and Wood, M., 2000. A Better Bait for Medfly. Agricultural Research, 48(10): 20-21.

McPhail, M. and Bliss, C.I., 1933. Observations on the Mexican Fruit Fly and some related species in Cuernavaca, Mexico, in 1928 and 1929. USDA, Circular # 255: 24 pp.

McPheron, B.A. and Steck, G.J. (eds.), 1996. Fruit Fly Pests: A world Assessment of their Biology and Management. St. Lucie Press, Boca Raton: xxii + 586 pp.

Menezes, E., et al, 1998. Development of *Coptera haywardi* in irradiated and Unirradiated Pupae of the Caribbean Fruit Fly and the Mediterranean Fruit Fly. Florida Entomologist, 81(4): 567-570.

Messing, R.H., et al., 1993. Quality Control Parameters of Mass-reared Opiine Parasitoids Used in Augmentative Biological Control of Tephritid Fruit Flies in Hawaii. Biological Control, 3: 140-147.

Meyer, J.R. and Cline, W.O., 1997. Blueberry Maggot. In: Blueberry Pest Management; A Seasonal Overview. <ipmwww.ncsu.edu/small_fruit/maggot.html>: 2 pp.

Miller, N.C.E.,1940. Fruit Flies. The Malayan Agricultural Journal, 28(3): 112-121.

Mitchell., W.C., and Saul, S.H.,1990. Current control methods for the Mediterranean fruit fly, *Ceratitis capitata*, and their application in the USA. Review of Agricultural Entomology, 78(9): 924-940.

Molineros, J., et al., 1992. Diagnosis of the Present Situation of the Fruit Fly Problem in Ecuador. Ecuatorian commission of Atomic Energy. Quito, Sept., 1992, 53pp.

Monaco, R., 1984. L'*Opius magnus* Fischer, parassita di *Rhagoletis cerasi* su *Prunus mahaleb*. Entomologica, 19: 75-80.

Monteith, L.G., 1977. Additional Records and the Role of the Parasites of the Apple Maggot *Rhagoletis pomonella*. Proc. Entomol. Soc. Ontario, 108: 3-6.

Moore, I. and Nadel, D., 1961. A bacterium present within the eggs of the Mediterranean fruit fly, *Ceratitis capitata*. Ktavim, 11: 133.

Moreno, D.S. and Mangan, R.L., 2000. Potential Use of Reduced Risk and Safer Pesticides in the Eradication and Suppression Programs of Exotic Fruit Flies. Citrus Research Board 2000 Annual Report, Summary of Research Programs: 2 pp.

Moussa, A.Y., 1978. A new Cytoplasmic Inclusion Virus from Diptera in the Queensland Fruitfly, *Dacus tryoni*. J. Invert. Pathol., 32(1): 77-87.

Muesebeck, C.F.W., 1980. The Nearctic Parasitic Wasps of the Genera *Psilus* Panzer and *Coptera* Say. USDA, SEA, Tech. Bull., 1617: 71pp.

Narayanan, E.S. and Chawla, S.S., 1962. Parasites of fruit fly pests of the world. Beitrage zur Entomologie, 12(3/4): 437-476.

Neuenschwander, P., et al., 1983. Natural enemies of preimaginal stages of *Dacus oleae* in Western Crete. I. Bionomics and phenologies. Boll. del Lab Entomol. AGr. F. Silvestri Portici, 40: 3-32.

Newell, I.R. and Haramoto, F.H., 1968. Biotic Factors Influencing Populations of *Dacus dorsalis* in Hawaii. Proc. Hawaiian Entomol. Soc., 20(1): 81-139.

Nixon, G.E.J., 1930. The Ethiopian Representatives of the Genus *Galesus*, with descriptions of new Species. Ann. & Mag. N. Hist. Ser. 10, 6: 399-414.

NPAG, 1998. *Bactrocera oleae*, Olive Fruit Fly. NPAG Data. November 19, 1998: 1-10.

Oakley, R.G., 1950. Manual of Foreign Plant Pests for Fruit Flies. Part III. USDA, ARA, Bureau of Entomology and Plant Quarantine, Division of Foreign Plant Quarantine. 169-246.

Ohta, A.T., et al., 1989. Gamma Radiation and Cold Treatments for the Disinfestation of the Mediterranean Fruit Fly in California-Grown Oranges and Lemons. Pacific Science, 43(1): 17-26.

Ooi, P.A., 1984. A Fruit Fly Survey in a Starfruit Orchard in Serdang, Selangor. J. Pl. Prot. Tropics, 1(1): 63-65.

Orian, A.J.E. and Moutia, L.A., 1960. Fruit Flies of Economic Importance in Mauritius. Revue Agricole et Sucriere de L'Ile Maurice, 39(3): 142-150.

Osman, G.Y., et al., 1990. Zur Wirkung verschiedener Beutearten auf die rauberische Kapazitat des Nematoden *Diplogaster* sp. Anz, Schadlingskde, Pflanzenschutz, Umweltschutz, 63(4): 65-67.

Ovruski, S.M., 1994. Comportamiento en la Deteccion del Huesped de *Aganaspis pelleranoi*, Parasitoide de Larvas de *Ceratitis capitata*. Rev. Soc. Entomol. Argent., 53(1-4): 121-127.

Pacific Fruit Fly Web, 2000a. Protein Bait Sprays for Control of Fruit Flies. <www.pacifly.org/Control/Bait_spraying_1.htm>

Pacific Fruit Fly Web, 2000b. Fruit Flies Eradicated From Nauru. <www.pacifly.org/Success_stories/Nauru_erad 1.htm>

Pearson, G.A., et al, 1995. Insect Note #B-2, The Blueberry Maggot, *Rhagoletis mendax*, in Fruit Insect Pest Management, Dept. Ento. Insect Note, www.ces.ncsu.edu/depts/ent/notes/Fruits/ fruitb2.html>, 3pp.

Pelekassis, C.E.D., et al., 1988. Preliminary Studies of the field movement of the Olive Fruit Fly by labelling a Natuarl Population with Radioactive Phosphorus (P32). Radiation and Radiosioptes applied to Insects of Agricultural Importance: Proceedings of the symposium on the use and application of Radioisoscopes and radiation in the control of plant and animal insect pests: 105-114.

Permalloo, S., et al., 2002. An Area Wide control of Fruit Flies in Mauritius. Food & Agricultural Research Council, Mauritius, AMAS 97: 27-34. <http://farc.gov.mu/amas97/html/p27.htm>

Piedra, E., et al., 1993. Note: New Host Plant and Parasitoid Record in Mexico for Anastrepha alveata. Proc. Entomol. Soc. Wash., 95(1): 127.

Pike, N. and Meats, A., 2003. Tendency for upwind movement in the sibling fruit fly species, *Bactrocera tryoni* and *B. neohumeralis* and their hybrids: influence of time of day, sex and airborne pheromone. Bulletin of Entomological Research, 93(2): 173-178.

Plus, N., and Cavalloro, R., 1983. The viruses of *Ceratitis capitata, in vivo and in vitro.* In: Fruit flies of economic importance. Rotterdam, Netherlands: 106-112.

Purcell, M.F., 1998. Effect of Silwet L-77 and Dizainon on Three Tephritid Fruit Flies and Associated Endoparasitoids. Tektran, ARS, USDA, Report # 0000071104: 1 pp.

Pelekasis, C.E.D., et al. 1988. Preliminary Studies of the Field Movement of the Olive Fruit Fly by labelling a Natural Population with Radioactive Phosphorus. Radiation and Radioisotopes applied to Insects of Agricultural Importance. Proc. of the Symposium on the use and Application of Radioisotopes and Radiation in the Control of Plant and Animal Insect Pests: 105-114.

Quilici, S., 1999. La monche mediterraneenne des fruits ou ceratite. CIRAD, <http://fruit-fliesnetfirms.com/french.2f-ceratitis.htm>: 4 pp.

Quilici, S. and Franck, A., 1999. La Mouche du Natal. CIRAD, <http://fruit-fliesnetfirms.com/french.3f-ceratitis.htm>: 4 pp.

Qureshi, Z.A., et al., 1974. Relative abundance of *Dacus cucurbitae* and *Dacus ciliatus* in common Hosts. Pakistan J. Sci. Ind. Res., 17(4-5): 123-124.

Qureshi, Z. A., et al., 1981. Population suppression of fruit fly, Dacus zonatus by male annihilation technique and its impact on fruit infestation. Z. ang. Ent., 91(5): 521-524.

Qureshi, Z.A., et al., 1986. Screening of Lures for Ethiopian Melon Fly. II Intern. Symp. Fruit Flies/Crete, Sept. 1986: 463-467.

Ranganath, H.R. and Veenakumari, 1996. Report of new fruit fly on guava on the Nicobar Islands, India. Tropical Agriculture, 73(2): p.165.

Remund, U. and Boller, E., 1973. Kirschenfliegenfallen fur Prognosewesen und biotechniseche Bekampfung im Vormarsch. Schweiz Z Obst Weinbau, 114(9): 229-232.

Rice, R.E., 2000. Bionomics of the Olive Fruit Fly *Bactrocera (Dacus) oleae*. UC Plant Protection Quarterly, 10(3): 1-5.

Robacker, D.C., 1999. Attraction of Wild and Laboratory-Strain Mexican Fruit Flies to Two Synthetic Lures in a Wind Tunnel. Florida Entomologist, 82(1): 87-94.

Robacker, D.C., 2000. Development of a Long-Lasting Formulation of AMPu, An Attractant for the Mexican Fruit Fly. Citrus Research Board 2000 Annual Report: 2 pp.

Robacker, D.C., 2002. Attraction of Meican fruit flies to grapefruit enhancement by mechanical wounding of and experience with grapefruit. Journal of Insect Behavious, 15(3): 399-413.

Rogers, K., 1997. Test cut fly ID from 30 days to three. News Release, Cooperative Research Centre for Tropical Pest Management, 24 November, 1997: 2 pp. < www.ctpm.uq.edu.au>.

Rogg, H.W. and Camacho, E., 2003. History of Fruitflies and their control in Bolivia. MAAPRAE/e-PHY, <http://e-phy.agriculture-gouv.fr/wiphy/speciali/07600426.htm>: 1-11pp.

Rossler, Y. and Greany, P.D., 1990. Enchancement of Citrus resistance to the Mediterranean Fruit Fly. Entomol. exp. & appl., 54(1): 89-96.

Rull, J., 2003. Trap position and fruit presence affect visual responses of apple maggot flies to different trap types. J. Appl. Ent., 127(2): 85-90.

Sakovich, N., 2000, A Research Summary of Mediterranean Fruit Fly. Cooperative Extension Ventura County Citrus Publications <http://ucceventura.xirn.uscb.edu/Citrus/Publications/Medfly.htm>: 4 pp.

Saul, S. and Seifert, J., 1990. Methoprene on Papayas: Persistence and Toxicity to Different Developmental Stages of Fruit Flies. J. Econ. Entomol., 83(3): 901-904.

Selman, H.L., and Heppner, J.B.,1998 (Revised, 2001). Papaya Fruit Fly. In: Featured Creatures, University of Florida, Dept. of Entomology and Nematology, Pub. # EENY-21. <www/ifas.ufl.edu/~insect/fruit/tropical/papaya_fruit_fly.htm>: 1-6.

Serit, M., et al., 1986. Parasitism of *Dacus dorsalis* (Hendel) in a Village Ecosystem in Tanjung Bungah, Penang, Malaysia. Fruit Flies: Proc. 2nd International Symposium: 441-448.

Serit, M. and Tan, K.H., 1990. Immature life table of a natural population of *Dacus dorsalis* in a village ecosystem. Tropical Pest Management, 36(3): 305-309.

Sharp, J.L. and King, J., 1997. Methyl Iodide as a Quarantine Treatment for Caribbean Fruit Fly. Technical Report. Agric. Res. Service, 3(4): 2 pp.

Shellie, K.C. and Mangan, R.L., 2002. Hot Water Immersion as a Quarantine Treatment for Large Mangoes: Artificial versus Cage Infestation. J. Amer. Soc. Hort. Sci., 127(3): 430-434.

Shelly, T.E. 1994. Consumption of Methyl Eugenol by Male Bactrocera dorsalis: Low Incidence of Repeat Feeding. Florida Entomologist, 77(2): 201-208.

Shelly, T.E., 2001. Feeding on Papaya Flowers Enhances Mating Competitiveness of Male Oriental Fruit Flies, *Bactrocera dorsalis*. Proc. Hawaiian Entomol. Soc., 35: 41-47.

Shelly, T.E. and Villalobos, E.M., 1995. Cue Lure and the Mating Behavior of Male Melon Flies. Florida Entomologist, 78(3): 473-479.

Shelly, T.E. and Pahio, E., 2002. Relative attractiveness of enriched giner root oil and trimedlure to male Mediterranean fruit flies. The Florida Entomologist, 85(4): 545-551.

Shields, R.E., 2003. California Authorization for Pesticide Use Under U.S. EPA Section 18 Quarantine Exemption for Distribution and Use only within California. Department of Pesticide Regulation. Section 18 No. 00-13, NAF-550 - Label. <www.cdpr.ca.gov/docs/sec 18/pdf/00-13.html>: 5pp.

Shields, R.E., 2002. California Authorization for Pesticide Use Under U.S. EPA Section 18 Specific Exemption for Distribution and Use only within California. Department of Pesticide Regulation. Section 18-02-21, Olive Fruit Fly Attract and Kill (A&K) Target Device - Label. <www.cdpr.ca.gov/docs/sec18/pdf/02-21.html>: 5pp.

Silva, J.G. and Malavasi, A., 1996. Life Cycle of *Anastrepha grandis*. In: Fruit Fly Pests - A World Assessment of their Biology and Management. St. Lucie Press, Delray Beach, Florida: 347-351.

Silva, M.T., et al., 1985. Mating behavior of some Fruit Flies of the Genus *Anastrepha* in the Laboratory. Revta. bras. Ent., 29(1): 155-164.

Silvestri, F., 1914. Report of an Expedition to Africa in search of the Natural Enemies of Fruit Flies with descrptions, observations and biological notes. Bull. Terr. Hawaii Board of Agric. and Forestry, 3: 176 pp., many plates.

Silvestri, F., 1939. La lotta biologica contro le Mosche dei frutti della famiglia Trypetidae, 7th Internationaler Kongress Fur Entomologie, 4: 2396-2418.

Simmonds, H.W., 1935. Fruit Fly Investigations, 1935. Bull. Dept. Agric. Fiji, 1-17.

Singh, M.P., 1989. Biosteres vandenboschi - A new Braconid paraste of Carpomyia vesuviana from the Indian Desert. Entomon, 14: p. 169.

Sivinski, J.M., et al., 1996. Suppression of a Caribbean Fruit Fly (*Anastrepha suspensa*) Population through Augmented Releases of the Parasitoid *Diachasmimorpha longicaudata*. Biological Control, 6(2): 177-185.

Sivinski, J. M., 1996. The Past and Potential of Biological Control of Fruit Flies. In: Fruit Fly Pests, A World assessment of their Biology and Management. Edited by McPheron and Steck, St. Lucie Press, Delray Beach, Florida: 369-375.

Sivinski, J., et al., 1997. Spatial and Temporal Distributions of Parasitoids of Mexican *Anastrepha* Species within the Canopies of Fruit Trees. Ann. Entomol. Soc. Am., 90(5): 604-618.

Sivinski, J., et al., 1998. The Bionomics of *Coptera haywardi* and Other Pupal Parasitoids of Tephritid Fruit Flies. Biological Control, 11(3): 193-202.

Smart, P., et al., 1976. Chemosterilization of the Queensland Fruit Fly, *Dacus tryoni*. Aust. J. Agric. Res., 27(1): 85-94.

Smart, P. and Gilmour, D., 1976. Chemosterilant as a Booby-trapping Agent for the Queenland Fruit Fly. Aust. J. Agric. Res., 27(1): 95-100.

Smith, E.S.C., 1977. Studies on the Biology and Commodity Control of the Banana Fruit Fly, *Dacus musae*, in Papua New Guinea. Papua New Guinea Agric. J., 28(2,3,4): 47-56.

Snowball, G.T., et al., 1962. The Utilization of Parasites of Oriental Fruit Fly against Queensland Fruit Fly. Aust. J. Agric. Res., 13: 443-460.

Snowball, G.J., 1966. Status of Introduced Parasites of Queensland Fruit Fly, 1962-1965. Aust. J. Agric. Res., 17: 719-739.

Solter, et al, 1997. Host Specificity of Microsporidia from European Populations of *Lymantria dispar* to Indigenous North American Lepidoptera. J. Invert. Pathology, 69(2): 135-150.

Sonda, M. and Ichinohe, F., 1984. Eradication of the Oriental Fruit Fly from Okinawa Island and Its Adjacent Islands. Japan Pestic. Infr., 44(40): 3-6.

Soria, F. and Yana, A., 1959. Contribution a l'etude de la Bio-Ecologie de la Mouche des Capres (*Capparimyia savastanii*) et du Parasitisme de cette Trypetide par *O. concolor* en Tunisie. Annales de l'Institut National de la Recherche Agronomique de Tunisie, 32: 125-158.

Sorygar, 2003. Tephri - Trap. <http://www.esorygar.com/> : 1 pp.

Soule, M.E., 1987. Viable populations for conservation. Cambridge University Press, New York: 189 pp.

Soultanopoulos, C.D., 1983. Protein hydrolyzate bait spray applied in ULV from the ground for *Dacus oleae* control. Annls. Inst. Phytopath. Benaki,(N.S.), 14: 11-18.

Soultanopoulos, C.D., 1986. Evaluation of attractants and certain modifications of McPhail traps for *Dacus oleae.* Annls Inst. Phytopath. Benaki, (N.S.), 15(1): 35-40.

Stanley, D., 1998. Lychees and Longans--No Host for Carib Fly. Agricultural News, 46(1): 8-9.

Steck, et al., 1986. Braconid Parasitoids of Tephritidae infesting Coffee and other Fruits in West-Central Africa. Entomophaga, 31(1): 59-67.

Steck, G.J., 2000. *Ceratitis cosyra.* Florida Dept. Agric. & Consumer Services. Entomology Circular No, 403, November/December, 2002: 2pp.

Steffens, R.J., 1982. Ecology and approach to integrated control of *Dacus frontalis* on the Cape Verde Islands. In: Fruit Flies of Economic Importance. Edited by R. Cavalloro. Commission of the European Communities, IOBC, Rotterdam, Netherlands: 632-638.

Steiner, et al., 1965. Oriental Fruit Fly Eradication by Male Annihilation. Jour. Economic Entomol., 58(5): 961-964.

Steiner, L.F. and Mitchell, S., 1966. Tephritid fruit flies. In Insect colonization and mass production. Academic Press, New York: 555-583.

Stibick, J.N.L., 1988. Action Plan, Peach Fruit Fly, *Dacus zonatus.* Policy and Program Development, Plant Protection and Quarantine, USDA, 58 pp.

Stibick, J.N.L., 1989. Action Plan, Oriental Fruit Fly, *Bactrocera dorsalis*. Policy and Program Development, Plant Protection and Quarantine, USDA, 66 pp.

Stibick, J.N.L., 1990. Action Plan, Queensland Fruit Fly, *Bactrocera tryoni*. Policy and Program Development, Plant Protection and Quarantine, USDA, 74 pp.

Stibick, J.N.L.,1993. Action Plan, Malaysian Fruit Fly, *Bactrocera latifrons*. Planning and Design, Plant Protection and Quarantine, USDA, 54 pp.

Stibick, J.N.L., 1993. Action Plan Draft, Mediterranean Fruit Fly, *Ceratitis capitata*, Planning and Design, Plant Protection and Quarantine, USDA, 60 pp. + appendixes.

Stibick, J.N.L., 2002. The Economic Fruit Flies, Family Tephritidae. New Pest Response Guidelines. USDA, APHIS, Plant Protection and Quarantine: 1-1,000 pp. (In preparation).

Steyskal, G.C., 1982. A Second Species of *Ceratitis* Adventive in the New World. Proc. Entomol. Soc. Wash., 84(1), 165-166.

Stonehouse, J., et al., 2002. Farmfield assessments of fruit flies in Pakistan: distribution, damage and control. Crop Protection, 21(8): 661-669.

Stonehouse, J., et al., 2002a. "Single-killing-point" field assessment of bait and lure control of fruit flies in Pakistan. Crop Protection, 21(8): 651-659.

Sutton, B.D. and Steck, G.J., 1994. Discrimination of Carabbean and Mediterranean fruit fly larvae by Cuticular Hydrocarbon Analysis. Florida Entomologist, 77(2): 231-237.

Syed, R.A., 1970. Studies on Trypetids and their Natural Enemies in West Pakistan. *Dacus* species of lesser Importance. Pakistan Jour. of Zoology, 2(1): 17-24.

Syed, R.A., M.A. Grant and M. Murtaza, 1970b. Studies on Trypetids and their Natural Enemies in West Pakistan. III. *Dacus* (Strumeta) *zonatus*. Tech. Bull., 13(1-16)

Tan, K.H., 1984. Description of a New Attractant Trap and the Effect of Placement Height on Catches of Two Dacus Species. J. Pt. Prot. Tropics, 1(2): 117-120.

Teal, P.E.A., 2002. Letters from Customers Regarding Importance of Hormone Supplement Therapy. USDA, Univ. of Florida. <http://cmave.usda.ufl.edu/researchunits/lettersfromcustomers.pdf>: 4pp.

Tedeschini, J., et al., 2002. Attract and Kill of Olive Fruit Fly, *Bactrocera oleae* (Gmelin) in Albania as Part of an Integrated Control System. Presented at the 27th Balkan Regional Meeting of Plant Protection; Nov. 12-16, 2002; Skopje, Macedonia; from the IPMCRSP Albania site: 1p.

Tenakanai, D., 1996. Fruit Fly Fauna in Papua New Guinea. In: Management of Fruit Flies in the Pacific. ACIAR Proceedings, No. 76: 87-94.

Thomas, D.B., 1993. Survivorship of the Pupal Stages of the Mexican Fruit Fly *Anastrepha ludens*, in an Agricultural and a Nonagricultural Situation. J. Entomol. Sci., 28(4): 350-362.

Thomas, D.B., 1995. Predation on the Soil Inhabiting Stages of the Mexican Fruit Fly. Southwestern Entomologist, 20(1): 61-71.

Thompson, G.D., et al., 1999. Development of Spinosad and Attributes of A New Class of Insect Control Products. Univ. of Minnesota National IPM Network, CICP, <http://ipmworld.umn.edu/chapters/hutchins2.htm>: 1-12.

Thompson, W.R., 1943. A Catalogue of the Parasites and Predators of Insect Pests. Parasites of the Dermaptera and Diptera, Imperial Agricultural Bureaux, Slough, UK, 2: 99pp.

Thuy, N.N. and Duc, H.T., 1999. Fruit Fly Management at the Preharvest Stage: Problems and Progress. In Quality Assurance in Agricultural Produce. 19th ASEAN/1st APEC Seminar on Postharvest Technology, Ho Chi Minh City, Vietnam, 9-12 Nov., 1999. Oral Papers, #20: p. 11.

Tseng, Y.-H. and Chen, C.-C., 1992. The Fruit Flies, Genus *Dacus* of Taiwan. J. Taiwan Mus., 45(2): 15-91.

University of California, 1998. Apple Maggot. Phenology Model Database. Statewide Integrated Pest Management. <axp.ipm.ucdavis.edu/PHENOLOGY/applemag.html>: 2 pp.

Uchoa-Fernandes, M.A. 2002. Species diversity of frugivorous flies from host in the cerrado of the state of Mato Grosso do Saul, Brazil. Neotropical entomology, 31(4): 515-524.

Vera, M.T., et al., 2002. Factors affecting Female Remating Frequency in the Mediterranean Fruit Fly. Florida Entomologist, 85(1): 156-164.

Vagalo, M., et al., 1997. Fruit Fly Fauna in Solomon Islands. Managment of fruit flies in the Pacific, a regional symposium, Nadi, Fiji, 28-31 Oct. 1996. Canberra, ACT: Australian Centre for International Agricultural Research : 81-86.

Vijaysegaran, S., 1984. The Occurrence of Oriental Fruit Fly on Starfruit in Serdang and the Status of its Parasitoids. J. Pl. Prot. Tropics 1(2): 93-98.

Villachica, H., 1996. Frutales y hortalizas Promisorios de la Amazonia. SPT-TCA. No. 44: 1 - 450.

Vioryl S.A., 2001. Press Release, 31st May, 2001. ECO-TRAP, New Advanced Product for Olive Fly Control. <http://www.vioryl.gr/english/english_news/news-en_31-05-2001.html>1pp.

Vogel, W., 1950. Untersuchungen uber parasitische Hymenopteren der Kirschenfliege. Bull. Soc. Entomol. Suisse, 23(2): 195-199.

Wang.H. and Zhang, H., 1994. Fruit Fly Problems in China and Prospects for using the Sterile Insect Technique. *In*: Fruit Flies and the Sterile Insect Technique by Calkins, et al., 1994: pp. 123-129.

Warm Earth, 2000. Peach and Nectarine. <www.powerup.com.au/~warmearth/peach_and_nectarine.htm>: 1-4 pp.

Weaver, T., 1998. USDA Scientists Develop Alluring Bait for Mexican Fruit Flies. Agricultural Research News,<http://www.ars.usda.gov/is/pr/1998/981119.htm>: 2 pp.

Weems, H.V., 1965a. *Bactrocera tryoni* (Froggatt). Entomology Circular No. 34, Contribution # 54, Entomology Section, July 1965. Fla. Dept. of Agr., Div. of Plant Industry: 2 pp.

Weems, H.V., 1965b. *Anastrepha suspensa* (Loew). Entomology Circular No. 38, Contribution # 62, Entomology Section, July 1965. Fla. Dept. of Agr., Div. of Plant Industry: 4 pp.

Weems, H.V., 1966. Natal Fruit Fly, *Ceratitis Rosa* Karsch. Entomology Circular No 51, Contribution # 86, Entomology Section, July 1965. Fla. Dept. of Agr., Div. of Plant Industry: 2 pp.

Weseloh, R.M., 1994. Forest Ant Effect on Gypsy Moth Larval numbers in a Mature Forest. Environmental Entomology, 23(4): 870-877.

Wharton, R.A. and Marsh, P.M., 1978. New World Opiinae Parasitic on Tephritidae. J. Wash. Acad. Sci., 68(4): 147-167.

Wharton, R.A., et al., 1981. Hymenopterous egg-Pupal and Larval-Pupal Parasitoids of *Ceratitis capitata* and *Anastrepha* spp. in Costa Rica. Entomophaga, 26(3): 285-290.

Wharton, R.A. and Gilstrap, F.E., 1983. Key to and Status of Opiine Braconid Parasitoids Used in Biological control of *Ceratitis* and *Dacus s. l.* Ann. Entomol. Soc. Am., 76(4): 721-742.

Wharton, R.A., 1989. Chapter 9.1 Classical Biological Control of Fruit-infesting Tephritidae. In: Fruit Flies, Their Biology, Natural Enemies and Control. World Crop Pests, 3B, 303-311.

Wharton, R.A., 1999. A Review of the Old World Genus *Fopius*, with Description of Two New Species Reared from Fruit-infesting Tephritidae. J. Hymenoptera Res., 8(1): 48-64.

White, I.M. and Elson-Harris, M.M., 1992. Fruit Flies of Economic Significance; Their Identification and Bionomics. CAB International: 601pp.

Wilson, W.T., et al., 1997. Honey Bee Colony Development Following Exposure to Suredye Bait in Guatemala. American Bee Journal, 137(3):228-229.

Wong, T.T.Y., 1984. Predation of the Mediterranean Fruit Fly by the Argentine Ant in Hawaii. J. Econ. Entomol., 77(6): 1454-1458

Wong, M.A. and Wong, T.T.Y., 1988. Predation of the Mediterranean Fruit Fly and the Oriental Fruit Fly by the Fire Ant in Hawaii. Proc. Hawaiian Entomo. Soc., 28: 169-177.

Wong, T.T.Y., et al., 1991. Augmentative Releases of *Diachasmimorpha tryoni* to suppress a Mediterranean Fruit Fly Population in Kula, Maui, Hawaii. Biological Control, 1(2): 2-7.

Wong, T.T.Y., et al., 1992. Suppression of a Mediterranean Fruit Fly Population with Concurrent Parasitoid and Sterile Fly Releases in Kula, Maui, Hawaii. Journal of Economic Entomology, 85(5): 1671-1681.

Wood, M., 1989. The Perfume Fruit Flies Just Can't Resist. Agricultural Research, 37(5): 19.

Wood, M., 1996. Red Dye, Updated Traps. Agricultural Research, 44(1): 20-22.

Wood, M., 1998a. Heated Air Blasts Papaya Pests. Agricultural Research, 46(1): 4-6.

Wood, M., 1998. Tactics Simplify Wasp-rearing. Agricultural Research, 46(7): 8-9.

Wood, M. 1999. Improved Lure for Malaysian Fruit Flies. Agricultural Research, 47(9): 17.

Wood, M. and Hardin, B., 2000. Spinosad battles Crop Pests. Agricultural Research, 48(4): 10-12.

Yao, An-Ly, 1989. Recovery survey of small scale field Releases of *Biosteres longicaudatus* in Bai-Chi area, Taiwan. Bull., Inst. Zool., Academia Sinica, 28(3): 211-214.

Zucchi, R.A., 1979. Novas Especies de Anastrepha. Rev. bras. Ent., 23(1): 35-41.

Zucchi, R.A., et al., 1999. La Mosca Sudamericana de las Frutas, *Anastrepha fraterculus* (Wiedemann) en el Brasil. In: The South American fruit fly, *Anastrepha fraterculus* (Wied.); advances in artificial rearing, taxonomic status and biological studies.IAEA-TECDOC-1064, Jan., 1999: 7 pp.

Bigleaf Mahogany

Index

A

B

R

S

T

U

V

W