PEST ADVISORY LEAFLET NO. 37

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Fruit Flies in Papua New Guinea

Papua New Guinea (PNG) has the greatest diversity of tropical fruit fly species (Diptera: Tephritidae: Dacinae) in the world. One hundred and eighty-eight described species have been recorded, and fifty to sixty new species awaiting description have been discovered in recent years (R.A.I. Drew, pers. comm.). This diversity is also reflected in the number of species known to infest commercial or edible fruits and vegetables; eighteen in total, including four of the most damaging species: Asian papaya fruit fly (*Bactrocera papayae*), melon fly (*B. cucurbitae*), mango fly (*B. frauenfeldi*) and banana fly (*B. musae*).

During their life cycle, fruit flies go through four development stages. The adult female fly lays eggs in batches under the skin of fruits (Figure 1) with a needle-like ovipositor (egg-laying tube at tip of abdomen) (Figure 4). While puncturing the fruit, the fly pushes bacteria from the skin into the flesh. These bacteria cause fruit decay, which results in a substrate in which the larvae feed.

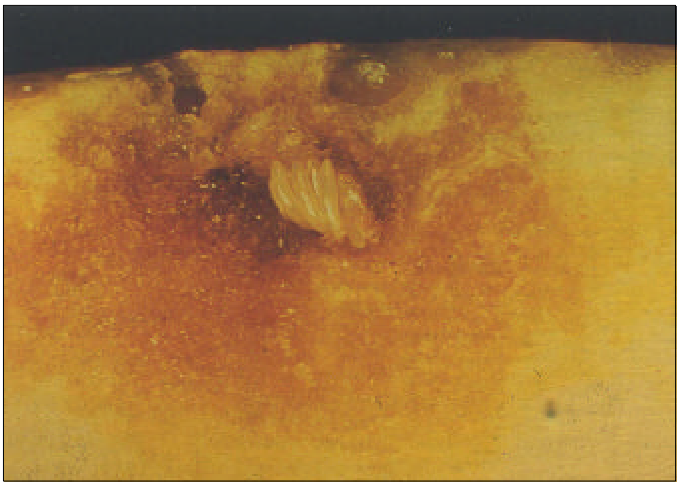


Figure 1: Fruit fly eggs in host fruit flesh.

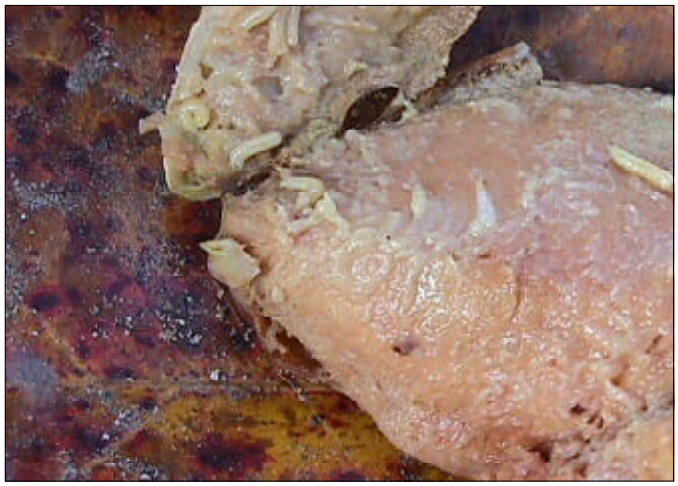


Figure 2: Fruit fly larvae in tropical almond fruit.

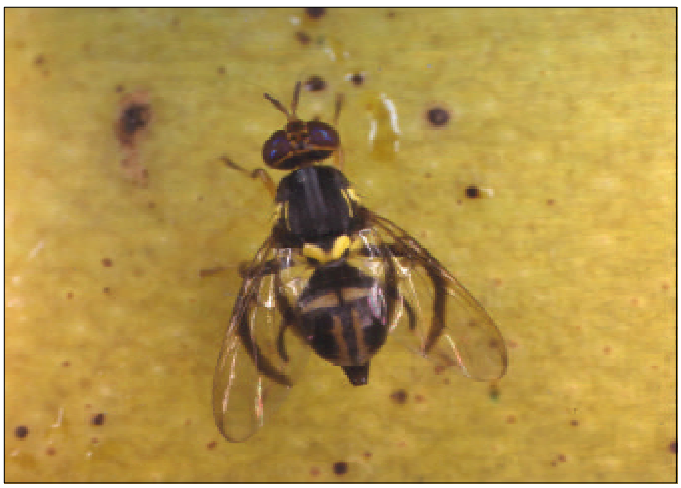


Figure 3: Mango fly (*Bactrocera frauenfeldi*)

Figure 4: Asian papaya fruit fly (*B. papayae*)

Eggs hatch in 1-2 days to produce larvae that feed on the fruit's flesh (Figure 2), causing more decay and, in some cases, premature fruit fall. The larva grows in size by shedding its skin twice, defining three larval stages (instars). When fully grown, the larva escapes from the fruit, drops on the ground, burrows into the soil or organic matter for a short distance and its skin thickens and hardens to form a shell called a puparium, inside which the larva transforms itself into the adult. After 10-14 days, the adult fly emerges from the puparium and digs its way out of the soil or organic matter. Shortly after females emerge, they search for a protein meal to mature eggs. During this phase, flies may disperse quite large distances in search of protein sources. Females mate within 7-10 days of emergence and are ready to lay eggs when these have become mature.

Fruit flies are dependent on the host tree or plant. The host plant

may provide food for the adults and a mating site, in addition to providing the egg laying site and food for the larvae. Therefore, a host plant may be defined as one that allows complete development of the fruit fly. Fruit fly hosts are very diverse. Not only do many species of fruit flies infest fleshy fruits and vegetables, but also some species, such as melon fly, attack buds, flowers or plant stems. Some species, such as mango fly and Asian papaya fruit fly, are generalists and attack a wide range of hosts. Most species, however, have a more restricted range of hosts and some species are specialists feeding on a single or very limited and consistent array of hosts. Banana fruit fly, for instance, attacks almost exclusively bananas.

Host fruits are susceptible to attack by fruit flies at different stages of maturity. For example, bananas are not susceptible to most fruit fly species (except banana fruit fly and Asian papaya fruit fly) up to the green mature stage. Therefore, they can be exported without quarantine treatment up to this stage of maturity from wherever the two pest fruit flies cited above do not occur. On the other hand, banana fruit fly will sting the fruits when the bananas are very small and green; the eggs remain dormant until the banana ripens, at which time the eggs hatch and the larvae feed. Similarly, melon fly may infest its hosts at the bud or flowering stage and even infest the stems. Asian papaya fruit fly may infest green fruit such as papaya, citrus and bananas.

Natural enemies that attack fruit flies are diverse, but the most significant ones are parasitic wasps of the family Braconidae, subfamily Opiinae. These lay their eggs inside the eggs or larvae of fruit flies. The wasp's larva lives as an internal parasite inside the fruit fly larva, eventually killing its host. Attempts to introduce and establish such enemies in the Pacific have so far yielded only limited success in reducing the proportion of fruits attacked.

ECONOMIC SPECIES

Eighteen fruit fly species have been bred from commercial or edible host fruits and fleshy vegetables in PNG. Although ten of them cause significant damage to edible fruits, all species have been included here. Distribution records of species are based mostly on adult fly trapping data for monitoring and quarantine surveillance. Permanent trapping sites have been maintained in all provinces except Gulf. Table 1 summarizes known distribution, lure response, number of host plants and pest status of various species. Host records are based on intensive host fruit surveying carried out mostly in Central, Morobe and East New Britain provinces. Most of the data below have been gathered as part of the Papua New Guinea Fruit Fly Project (see acknowledgements).

Diagnostic features are provided primarily to help to identify fruit fly species that emerge from infested fruit samples. Although they may help to identify flies in samples from traps, a complete set of diagnostic features to separate one species from the 187 other PNG species is beyond the scope of this leaflet. To confirm the identification, specimens must be keyed using Drew's monograph (Drew 1989). It is advisable that specimens be forwarded to an experienced fruit fly taxonomist to confirm identification.

Mango fly - *Bactrocera frauenfeldi* (Schiner)

Diagnosis and male lure: See Figure 3. Transverse black band across the wing; predominantly black species; scutellum yellow with a triangular black mark; abdomen terga III-V orange-brown with a broad medial and two broad lateral longitudinal black bands. Males are attracted to Cue-lure.

Table 1: Known distribution and pest status of economic species of fruit flies of the genera *Bactrocera* and *Dacus* in Papua New Guinea. Note that *B. musae* in New Ireland is restricted to Lihir Island.

Genus	Subgenus	Species	Lure	Western	Central	Milne Bay	Oro	Morobe	Madang	East Sepik	West Sepik	E. Highlands	Simbu	W. Highlands	W. New Britain	E. New Britain	New Ireland	Manus	Bougainville	Number of hosts	Pest status
B.	*Bactrocera*	*atramentata*	Cue																	1	+
B.	*Paratridacus*	*atrisetosa*	None																	7	++
B.	*Bactrocera*	*bryoniae*	Cue																	4	++
B.	*Zeugodacus*	*cucurbitae*	Cue																	6	+++
B.	*Bactrocera*	*curvifera*	ME																	1	+
B.	*Paradacus*	*decipiens*	None																	1	++
B.	*Bactrocera*	*frauenfeldi*	Cue																	38	+++
B.	*Bactrocera*	*lineata*	Cue																	1	+
B.	*Bactrocera*	*moluccensis*	Cue																	1	+
B.	*Bactrocera*	*musae*	ME															?		2	+++
B.	*Bactrocera*	*neohumeralis*	Cue																	1	+
B.	*Bactrocera*	*obliqua*	None																	5	++
B.	*Bactrocera*	*papayae*	ME																	6	++
B.	*Sinodacus*	*strigifinis*	Cue																	1	+
B.	*Bactrocera*	*trivialis*	Cue																	9	+
B.	*Bactrocera*	*umbrosa*	ME																	1	++
D.	*Callantra*	*axanus*	Cue																	1	+
D.	*Callantra*	*solomonensis*	Cue																	5	++

Key
+++ = high damage to edible fruits
++ = moderate damage
+ = attacks edible fruits, but low damage

Distribution: Widespread species throughout PNG, Torres Strait Islands, Solomon Islands, Palau, Federated States of Micronesia, Marshall Islands, Gilbert Islands of Kiribati and Nauru. It is present and abundant even on remote atolls. It was introduced and established in northern Queensland (Australia) around 1974, and is now present from Cape York Peninsula south to Townsville. It is very common throughout lowland areas everywhere in PNG, and has been recorded in all provinces (Table 1). Only a few specimens have been collected in the Highlands, where it is not economically important.

Host plants: Mango fly is a polyphagous species that has been recorded from more than 72 host plant species in 45 genera and 29 families. Known host species are mostly commercial or edible fruits. In PNG, it has been bred from 38 species, in 31 genera and 24 families. The 33 species of commercial/edible hosts are noted below.

Mango fly has been bred in large numbers from guava and strawberry guava (*Psidium guajava* and *P. cattleianum*), mango (*Mangifera indica*), mountain and water apples (laulau) (*Syzygium malaccense* and *S. aqueum*), avocado (*Persea americana*), Tahitian chestnut (*Inocarpus fagifer*), cashew apple (*Anacardium occidentale*) and tropical almond (*Terminalia catappa*).

Other commonly though usually less heavily infested hosts are carambola (*Averrhoa carambola*), breadfruit (*Artocarpus altilis*), bukbuk (*Burckella obovata*), canistel (*Pouteria campechiana*), bullock's-heart (*Annona reticulata*), soursop (*A. muricata*), okari nut (*Terminalia kaernbachii*), Pacific lychee (*Pometia pinnata*), ripe papaya (*Carica papaya*), pau nut (*Barringtonia edulis*), *Baccaurea papuana* (Euphorbiaceae), and *Clymenia polyandra* (Rutaceae).

It has also been bred a few times from abiu (*Pouteria cainito*), ripe bananas (*Musa x paradisiaca*), black sapote (*Diospyros digyna*), mandarin (*Citrus reticulata*), pomelo (*Citrus maxima*), mangosteen (*Garcinia mangostana*), passionfruit (*Passiflora edulis*), ripe betel nut (*Areca catechu*), santol (*Sandoricum koetjape*), sapodilla (*Manilkara zapota*), star apple (*Chrysophyllum cainito*) and *Garcinia xanthochymus* (Guttiferae).

Biology: Adult flies mate during the day. Egg laying starts when the female is about two weeks old. One female can lay an average of 25 eggs or more in 24 hours. Egg incubation takes about two days. Laboratory studies of rate of development on papaya-based diet at 25.9° C have shown that larvae complete their development in 10.5 days and pupal stage duration lasts 11 days. Mean total development time from egg to adult is therefore 21.5 days. This species is very common in village situations, where host trees abound, and much less common in rainforests.

Asian papaya fruit fly - *Bactrocera papayae* Drew and Hancock

Diagnosis and male lure: See Figures 4 and 5. The Asian papaya fruit fly belongs to the Oriental fruit fly species complex, which includes 52 described species in Asia and seven species in PNG. Members of the complex are recognized by clear wings without transverse bands, a predominantly black thorax (dorsal side) and a characteristic 'T'-shaped black band on the orange-brown abdomen. Because all species are very similar to each other, specimens suspected to be *B. papayae* should be sent to a fruit fly taxonomist for confirmation. Males are attracted to methyl eugenol.

Distribution: This very destructive fruit fly is native to and widespread in southeast Asia (Thailand, Peninsular Malaysia, East Malaysia, Singapore, Indonesia and Kalimatan). It invaded PNG from Asia through West Papua and was detected in 1992 in the Western Province. For many years, it was trapped only in the Western and West Sepik Provinces, but was later detected in Port Moresby (May 1998), Morobe Province (September 1998), and the Highlands (Eastern Highlands, Simbu, Western Highlands) (November 1998). It has also been trapped in Madang and East Sepik, and is assumed to be present in Gulf, and possibly also in Oro and Milne Bay Provinces. It has not yet been detected in the island provinces. It is commonly trapped in the Highlands.

From PNG, it spread to the Torres Strait islands in early 1993 and was detected in Cairns (northern Queensland, Australia) in October 1995, but may have been introduced about two years earlier. It was eradicated from Queensland by implementing a large-scale eradication programme involving male annihilation, protein bait spraying and restriction of fruit movement outside of 75,000 km^2 quarantine zone. Male annihilation involved blocks made of caneite (compressed fibreboard) soaked in a solution of methyl eugenol to attract male flies and these were nailed to trees and malathion was used to kill them, resulting in death of males and disruption in mating.

Host plants: This polyphagous pest species was bred in South-east Asia from 193 host species, from 114 genera and 50 families. In Australia, it was bred from 35 host species in Australia and caused considerable damage to coffee berries. Not enough data are presently available to establish a comprehensive host list for Papua New Guinea, but it has been bred from carambola, cashew, papaya, pomelo, mango and guava. No infestations of coffee berries have been observed or reported so far in PNG, even though *B. papayae* is commonly trapped in the Highlands.

Biology: In its native range this very destructive pest readily attacks most species of edible fruits and fleshy vegetables. Females lay eggs even in green papayas and citrus and in very young bananas. Female *B. papayae* has an exceptionally long ovipositor (Figure 4), allowing it to penetrate past the sap layer of green fruits such as papaya.

Banana fly - *Bactrocera musae* (Tryon)

Diagnosis and male lure: See Figure 6. Clear wings without transverse bands; dorsal side of thorax predominantly black; abdomen terga III-V vary from uniformly orange-brown to orange-brown with fuscous to black medial longitudinal band and fuscous to black anterolateral corners on tergum III. Males are attracted to methyl eugenol.

Distribution: Widespread and very common along the east coast of Queensland, from Townsville north to Torres Strait islands, and in mainland Papua New Guinea, where it is as common in the Highlands as at low elevations (Table 1). In early 1999, it was trapped and bred from bananas in East New Britain, and is widespread over most of the Gazelle Peninsula. It may have been introduced with infested bananas brought from mainland PNG as food relief after the devastating 1994 volcanic eruption but this has not been confirmed. Breeding populations also occur on Lihir Island (New Ireland Province). A few specimens have been occasionally trapped on Manus, but it is not confirmed whether breeding populations occur there. Early literature has recorded its presence in Solomon Islands and Vanuatu, but it was never trapped or reared from banana samples in these countries in recent years.

Host plants: In Papua New Guinea it causes severe damage to eating and cooking bananas (*Musa x paradisiaca*) and was once bred from papaya (*Carica papaya*). In Australia, 12 host species have been recorded, from 10 genera and 9 families, but the majority of records are from banana.

Biology: Adults mate at dusk. Female flies lay 7-12 eggs per fruit. They often oviposit in green and young bananas, and egg hatching may be delayed for up to 11 days while the host fruit is maturing.

Bactrocera trivialis (Drew)

Diagnosis and male lure: See Figure 7. Clear wings without transverse bands; dorsal side of thorax predominantly black; abdomen with tergum II with wide orange-brown band and terga III-V black with median longitudinal orange-brown band. Males are attracted to Cue-lure.

Distribution: This fruit fly is widespread in mainland PNG, (Table 1). It is less common in the Highlands than at low elevations. It is also present in the Torres Strait islands and in Indonesia (West Papua, Sulawesi).

Host plants: Eleven host species are known, in 9 genera and eight families. In PNG, it has been regularly bred from guavas and *Syzygium*, and there are also records from Tabasco chilli (Solanaceae: *Capsicum frutescens*), mango, grapefruit (*Citrus x paradisi*), orange (*C. sinensis*), tropical almond, peach (Rosaceae: *Prunus persica*) and *Baccaurea sp.*

Lesser Queensland fruit fly - *Bactrocera neohumeralis* (Hardy)

Diagnosis and male lure: See Figure 8. Clear wings without transverse bands; dorsal side of thorax dark red-brown with dark fuscous to black pattern; humeral calli (anterolateral lighter colored spots on thorax) dark brown to fuscous; abdomen with tergum II with wide orange-brown band and terga III-V dark fuscous to dull black and tending red-brown medially. Males are attracted to Cue-lure.

Distribution: Common pest in Australia along the east coast of Queensland south to northeastern New South Wales, and in isolated areas west of Cape York Peninsula. Common, in mainland PNG, where it has been collected mostly in Central Province but also in small numbers in Morobe and Western Provinces.

Host plants: In Australia, it is a polyphagous pest species recorded from 158 host species in 95 genera and 44 families. In Papua New Guinea, it has only been occasionally bred from guava. The species referred to as *B. neohumeralis* in PNG may, in fact, be a new species in the *tryoni* complex, very similar to *B. neohumeralis* but with a more restricted host range.

Biology: Unlike Queensland fruit fly (*B. tryoni*), its sibling species, *B. neohumeralis* mates during the day rather than at dusk.

Bactrocera obliqua (Malloch)

Diagnosis and male lure: See Figure 9. Wing with narrow dark transverse band along crossveins; dorsal side of thorax black; scutellum yellow with very broad medial black band; abdomen entirely black. This species does not respond to male lures. It can only be adequately monitored through host fruit surveying.

Distribution: This species is known only from East New Britain, Bougainville and Manus Provinces. Its actual range is probably more extensive, but host fruit surveying is required to detect the species.

Host plants: This species has been bred from five host species, in four genera and three families. It is commonly bred from and is a significant pest of guava, mountain apple and water apple, and has also been bred from *Baccaurea papuana* and *Celastrus* sp.

Melon fly - *Bactrocera cucurbitae* (Coquillett)

Diagnosis and male lure: See Figure 10. Thorax and abdomen predominantly orange-brown; a median and two lateral longitudinal yellow bands on dorsal side of thorax; characteristic wing band pattern with dark expanded area at the wing apex and minor darkening on crossveins. Males are attracted to Cue-lure.

Distribution: Melon fly is native to tropical Asia, as far west as Pakistan. It is present and common in Papua New Guinea. It was discovered in Solomon Islands in 1984, and is now widespread in all provinces, except in Makira, Rennell-Bellona and Temotu Province. It has been introduced and occurs in Hawai'i (first detected in 1895), Guam (1936), Commonwealth of Northern Mariana Islands (detected in 1943, eradicated by sterile insect release in 1963, but reestablished, from neighboring Guam, in 1981), and Nauru (detected in 1982 and eradicated in 1999 by male annihilation and protein bait spraying). It is also present in some parts of Africa (Kenya and Tanzania) and the Indian Ocean islands of Mauritius and Réunion. In PNG, it is present in virtually every provinces, but is absent from Manus and has been collected from Western Highlands Province only once (Table1). It is less common in the Highlands than at lower altitude.

Host plants: In South-east Asia, it has been reared from 41 host species, in 26 genera and 12 families. Plants in the family Cucurbitaceae are, however, the usual hosts. Nine species of cucurbit hosts have been recorded in the Pacific. In PNG, it has been bred from flowers and fruits of watermelon (*Citrullus lanatus*); buds, flowers, and fruits of local and Queensland Blue pumpkins (*Cucurbita pepo*); and fruits of cantaloupe (*Cucumis melo*), honeydew melon (*C. melo*), rockmelon (*C. melo*), cucumber (*C. sativus*), luffa (*Luffa cylindrica*) and bitter gourd (*Momordica charantia*).

Biology: Adults mate at dusk. Egg laying starts when female adults are 11-12 days old. Eggs are laid in batches of 1-40 eggs primarily on cucurbits, but secondarily on a wide range of other fruits and fleshy vegetables. Not only young to ripe fruits are infested, but also flowers, buds and even leaf stalks and stems of host cucurbits. One female may lay over 1000 eggs during her life. Oviposition peaks occur in the morning and late afternoon. Eggs hatch in about 24 hours. Development time varies from 4 to 17 days (larva) and 7-13 days (pupa), depending on temperature and host. Adults are long-lived, typically up to 150 days, but 240-460 days under cooler temperatures. This species is uncommon in the forest.

Bactrocera atrisetosa (Perkins)

Diagnosis and male lure: See Figure 11. Wings without transverse bands; whole body color predominantly orange to orange-brown; dorsal side of thorax has a median and two lateral yellow bands. This species does not respond to male lures. It can only be adequately monitored through host fruit surveying.

Distribution: This species is restricted to mainland Papua New Guinea. Because it is not attracted to male lures, limited distribution records are based on flies bred from collected fruits in Central, Oro, Morobe and Eastern Highlands Provinces.

Figure 5: Asian papaya fruit fly (*B. papayae*).

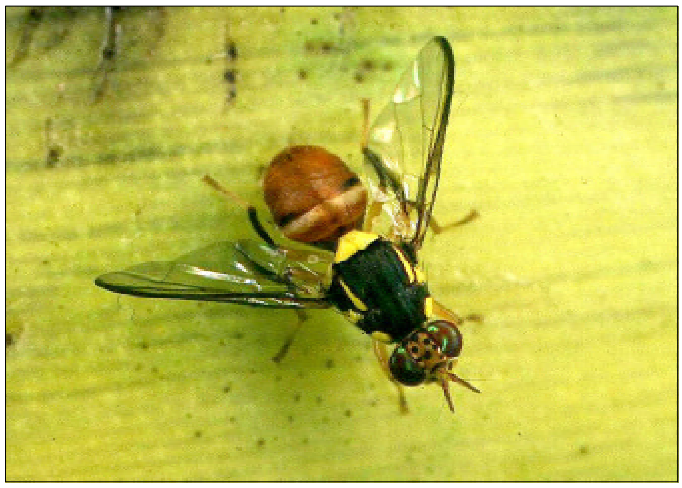


Figure 6: Banana fly (*B. musae*).

Figure 7: *Bactrocera trivialis*.

Figure 8: Lesser Queensland fruit fly (*B. neohumeralis*).

Figure 9: *Bactrocera obliqua.*

Figure 10: Melon fly (*B. cucurbitae*).

Host plants: This species has been reared from 7 host species in 6 genera and 3 families, and is primarily associated with cucurbits. It has been bred from fruits of watermelon, honeydew melon, rockmelon, local and Queensland Blue pumpkins, zucchini (*Cucurbita pepo*), luffa (*L. cylindrica*), tomato (*Lycopersicon esculentum*) and *Aglaia sapindina* (Meliaceae).

Pumpkin fruit fly - *Bactrocera decipiens* (Drew)

Diagnosis and male lure: See Figure 12. Wings with characteristic dark band pattern; dorsal side of thorax red-brown with a medial and two lateral yellow stripes and two narrow black stripes; abdomen orange. This species does not respond to male lures, but can easily be detected by sampling pumpkins.

Distribution: Pumpkin fruit fly has so far only been recorded from East New Britain Province.

Host plants: It is commonly bred from pumpkin. Its larvae can co-exist with melon fly larvae within the same pumpkin, but its rate of development is much slower than that of melon fly.

Bactrocera strigifinis (Walker)

Diagnosis and male lure: See Figure 13. Wings clear with narrow dark band along dm-cu crossvein, as illustrated on photo; dorsal side of thorax yellowish brown with a medial and two lateral yellow stripes; abdomen yellowish brown. Males are attracted to Cue-lure.

Distribution: Eastern coastal rainforests of north Queensland, as far South as Ayr District, Papua New Guinea and Solomon Islands. In PNG it is known from Central, Oro, Morobe, Madang, East Sepik, and Eastern Highlands Provinces. In Solomon Islands, it has been trapped a few times in Guadalcanal and Western Provinces.

Host plants: This species has been bred from flowers of pumpkin and zucchini (both *Cucurbita pepo*) in Central Province.

Dacus solomonensis Malloch

Diagnosis and male lure: See Figure 14. Large wasp-like species; color predominantly red-brown to orange-brown; abdomen tergite V with a large protruding hump well visible in lateral view. Males are attracted to Cue-lure.

Distribution: Bougainville Province in Papua New Guinea and throughout Solomon Islands except Rennell-Bellona and Temotu provinces.

Host plants: There are no records from Bougainville, but in Solomon Islands, it is a significant cucurbit pest regularly bred from cucumber, pumpkin, luffa or spongy gourd (*Luffa aegyptiaca*) and snake gourd (*Trichosanthes cucumerina*).

Biology: Life history studies have been done on laboratory colonies in Solomon Islands, where larvae are reared in whole fruits. At 25° C, eggs start hatching after 46 hours and larval development takes about 12 days in pumpkin and snake gourd. Pupal period lasts about 9 days and adult mating starts about 16 days after adult emergence.

Dacus axanus (Hering)

Diagnosis and male lure: See Figure 15. Large wasp-like species; color predominantly orange to orange-brown; abdomen tergite V without a large protruding hump. Several other species look similar to *D. axanus* and may be distinguished using Drew's Monograph (Drew 1989). Males are attracted to Cue-lure.

Distribution: This is a common species throughout northeastern and northwestern parts of Australia, Torres Strait islands and most of PNG, except for the Highlands and Bougainville (Table 1).

Host plants: This potential pest of cucurbits was once bred from luffa or spongy gourd (*Luffa aegyptiaca*) in the Central Province and has also been bred from angled luffa (*Luffa acutangula*) and snake gourd (*Trichosanthes cucumerina*) in Australia.

Breadfruit fly - *Bactrocera umbrosa* (Fabricius)

Diagnosis and male lure: See Figure 16. This very common species is immediately recognised by the characteristic wing pattern with the three transverse broad dark bands. Males are attracted to methyl eugenol.

Distribution: Widespread and very common in Malaysia, southern Thailand, Philippines, Indonesia, Palau, Papua New Guinea, Solomon Islands, Vanuatu, and New Caledonia. In PNG, it is much less abundant in the Highlands. It has been collected in all provinces except Gulf, Enga and Southern Highlands (Table 1).It undoubtedly occurs in these provinces as well.

Host plants: Its hosts include species of *Artocarpus* (Moraceae). In PNG it commonly attacks breadfruit (*A. altilis*).

Biology: Adults mate at dusk. Populations peak in December-January, which corresponds to the main breadfruit season.

Bactrocera curvifera (Walker)

Diagnosis and male lure: See Figure 17. Large species; characteristic wing with dark band pattern; abdomen terga III-V dark colored. Males are attracted to methyl eugenol.

Distribution: Widespread and common in PNG at low elevations (Table 1), and present but uncommon in the Highlands.

Host plants: It has been bred a few times from breadfruit in East New Britain, Central and Morobe Provinces.

Bactrocera bryoniae (Tryon)

Diagnosis and male lure: See Figure 18. Wing with very broad costal dark band (along wing fore-margin); dorsal side of thorax black; abdomen terga II-V orange-brown with a medial and 2 lateral longitudinal dark bands joined along anterior margin of tergum III. Males are attracted to Cue-lure.

Distribution: Common almost all over PNG, except Bougainville and Manus (Table 1). It is, along with *B. musae* and *B. papayae*, one of the few economic species common in the Highlands. It is also widespread in Australia (coastal areas of northern part of Western Australia, Northern Territory, east coast south to Sydney, and the Torres Strait islands).

Host plants: Surveys in Australia and PNG have identified at least 9 host species in 8 genera and 5 families. In PNG, it commonly infests 'Birdseye' and 'Tabasco' chilli (*Capsicum frutescens*) and wild passionfruit (*Passiflora foetida*), and has also been bred from banana and *Bryonopsis affinis* (Cucurbitaceae).

Biology: Adults mate at dusk. Damage on 'Birdseye' chilli is significant, and is as high as 80% in Morobe.

Bactrocera moluccensis (Perkins)

Diagnosis and male lure: See Figure 19. Wings without transverse bands; thorax dorsally red-brown with brown markings; abdominal terga III-V red-brown with a narrow black transverse band along anterior margin of tergite III and a narrow median longitudinal dark band over all three terga. Males are attracted to Cue-lure.

Distribution: Widespread in Indonesia, lowland PNG (Table 1) and Solomon Islands.

Host plants: It has been consistently bred from Tahitian chestnut (Caesalpinaceae: *Inocarpus fagifer*), though its actual host range is probably more extensive.

Biology: Contrary to mango fly that infests only the outer fleshy part of Tahitian chestnut, *B. moluccensis* larvae damage the entire fruit, including the inner nut.

Bactrocera atramentata (Hering)

Diagnosis and male lure: See Figure 20. Wings without transverse

Figure 11: *Bactrocera atrisetosa*.

Figure 12: Pumpkin fruit fly (*Bactrocera decipiens*).

Figure 13: *Bactrocera strigifinis.*

Figure 14: *Dacus (Callantra) solomonensis*.

Figure 15: *Dacus (Callantra) axanus*.

Figure 16: Breadfruit fly (*Bactrocera umbrosa*).

bands; thorax and abdomen pitch black; scutellum yellow with narrow median black band. Males are attracted to Cue-lure.

Distribution: This species is known from West New Britain, East New Britain, New Ireland and Manus Provinces.

Host plant: Pacific lychee (*Pometia pinnata*).

Bactrocera lineata (Perkins)

Diagnosis and male lure: See Figure 21. Wings without transverse bands; thorax and abdomen pitch black; scutellum entirely yellow. Males are attracted to Cue-lure.

Distribution: Restricted to mainland PNG (Table 1), but only a few specimens have been collected in the Highlands.

Host plants: Pacific lychee (*Pometia pinnata*).

FRUIT FLY DAMAGE IN PNG

The impact of pest fruit flies in PNG has been assessed on selected commercial or edible fruits and cucurbits by incubating, over moist sawdust (Figure 24), fruits from field collected samples. The procedure is explained in detail under the quarantine surveillance section. This generates data on the proportion or percentage of infested fruits and the number of fruit fly larvae infesting individual

fruits. Levels of infestation data are actually based on the number of puparia recovered from each fruit, and data are summarized in Table 2.

FRUIT FLY SURVEILLANCE

Quarantine surveillance against fruit flies involves maintaining a network of male lure traps and regularly sampling high-risk host commodities to assist in the early detection of unwanted exotic fruit flies or any other pests and diseases. It constitutes an early warning system to detect exotic fruit flies newly introduced to PNG or to a province where they do not yet occur. It allows authorities to mobilise resources quickly to deal with the incursion or establishment of the pest before it becomes widely distributed. An effective quarantine surveillance system gives importing countries confidence in data on the presence (or absence) and economic importance of fruit fly species that already exist in each country. It is a necessary prerequisite for developing quarantine protocols for overseas trade in fresh fruits and vegetables.

Trapping

The use of traps baited with a chemical lure that attract male flies is the easiest way to maintain quarantine surveillance. Of the various male lures available, two are used for trapping in PNG: methyl eugenol and Cue-lure. Methyl eugenol attracts 38 of the described species in PNG. It may attract flies from a distance of up to 500 metres. Cue-lure attracts 99 of the described PNG species. Its range of attractiveness is much less than that of ME - up to 300 metres. The remaining 49 described PNG species are not attracted to Cue-lure or ME and can only be adequately sampled through host fruit surveying. These include three PNG pest species: *B. atrisetosa*, *B. decipiens* and *B. obliqua*. Major pests to be kept outside PNG and that do not respond to male lures include cucumber fruit fly (*Bactrocera cucumis* (French)), a pest of cucurbits, tomato and papaya in Australia, and solanum fruit fly (*B. latifrons* (Hendel)) a pest of tomato, eggplant, capsicum and chilli in Asia and Hawai'i.

Of the numerous male lure trap models, the modified Steiner trap

Table 2: Assessment of fruit fly damage to edible host species in Papua New Guinea.

Host	Stage of maturity	Province	Mean% infestation	Range in % infestation in different samples	Mean number of puparia per infested fruit	Maximum number of puparia in one fruit	Fruit Fly species
Banana	Mature to ripe	Central	22.9	0-75	22.4	154	*B. musae*
Banana	Mature to ripe	E. New Britian	0.3	0.3	25.0	25	Infestation of *B. frauenfeldi* in 1 fruit only. (samples from area free from *B. musae)*
Banana	Mature to ripe	Marobe	17.6	17.6	38.6	130	*B. musae*
Banana	Ripe	Oro	-	10-40	-	-	*B. musae* (data from Smith, 1977)
Breadfruit	Ripe	E. New Britian	75.3	75.3	115.3	324	*B. umbrosa* (72.6%), *B. frauenfeldi* (11.0%), *B. curvifera* (1.4%)
Carambola	Ripe	E. New Britian	13.8	0.8-38	5.1	20	*B. frauenfeldi*
Carambola	Ripe	Central	18.7	0-74	6.6	41	*B. frauenfeldi,* except a few *B. papayae* bred from 3 fruits.
Carambola (Malaysian)	Ripe	Central	82.0	10-98	22.5	96	*B. frauenfeldi*
Cashew Apple	Ripe	E. New Britian	5.2	6-66	5.0	51	*B. frauenfeldi*
Guava	Ripe	Central	75.0	17-92	14.3	69	*B. frauenfeldi* (54.3%), *B. trivialis* (44.7%)
Guava: Vietnam White	Ripe	E. New Britian	64.2	28-96	29.4	179	Mostly *B. frauenfeldi* but also *B. obliqua*
Guava: Vietnam White	Ripe	Marobe	61.5	59-84	16.4	85	*B. frauenfeldi* (32.5%), *B. trivialis* (13%)
Guava: Large with pink flesh	Ripe	E. New Britian	74.1	52-82	13.9	57	*B. frauenfeldi* (66.2%), *B. obliqua* (19.4%)
Manadarin	Ripe	E. New Britian	0.6	0.6	3.0	5	*B. frauenfeldi*
Mango	Fallen	E. New Britian	50.8	50.8	9.8	126	*B. frauenfeldi*
Orange	Ripe	Highlands	2.6	0-9	1.4	2	*B. trivialis*
Pumpkin	Flower	Central	25	25	9.5	70	*B. cucurbitae* mostly but a few *B. strigifinis* and *B. atrisetosa*
Pumpkin	Mature fruits	E. New Britian	24	24	36.6	114	*B. cucurbitae* (5.6%), *B. decipiens* (14.1%)
Pumpkin	Mature fruits	Central	14.5	0-66	29.0	61	*B. cucurbitae* and a few *B. atrisetosa*
Tahitian Chestnut	Ripe or fallen	Central	34.4	26-42	24.6	121	*B. frauenfeldi* in 25% of fruits/*B. moluccensis* in 6% of fruits
Tropical Almond	Fallen fruits	Central	33.2	22-80	8.0	34	*B. frauenfeldi* in 29.6% of fruits/*B. trivialis* in 2.8% of fruits
Watermelon	Flower	Central	31.9	31-35	6.6	65	*B. cucurbitae*
Watermelon	Young fruits	Central	26.0	26.0	12.5	62	*B. cucurbitae*

Figure 17: *Bactrocera curvifera*.

Figure 18: *Bactrocera bryoniae.*

Figure 19: *Bactrocera moluccensis*.

Figure 20: *Bactrocera atramentata*.

Figure 21: *Bactrocera lineata.*

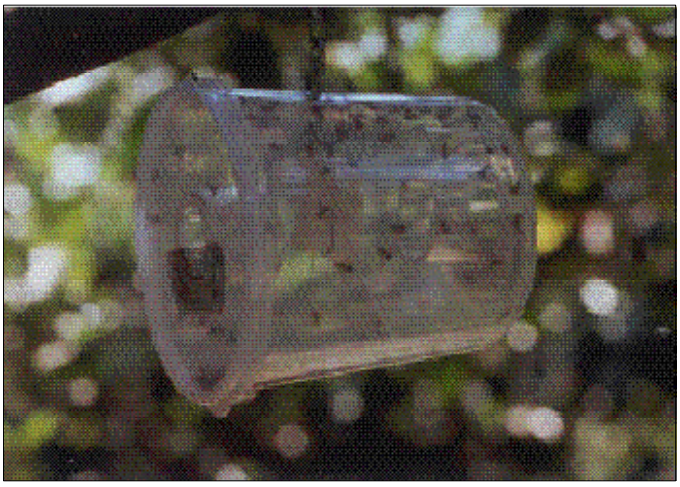


Figure 22: Modified Steiner trap.

(Figure 22) is used throughout the Pacific. It is a horizontal plastic cylinder with an opening at each end; one end is removable. Cotton dental wicks treated with the lure solution are suspended inside the trap. The solution is a mixture of 4 parts lure to 1 part Malathion (50% emulsifiable concentrate). Flies, attracted to the lure, enter the trap through the openings at the ends, feed on or come in contact with the lure and are killed by the insecticide. The trap is attached to a tree branch within the canopy, two metres above the ground, with a wire that must be coated with a non-drying adhesive, such as Tanglefoot, that prevents ants, other insects, spiders and lizards from entering the trap and eating the flies.

Two traps (one Cue-lure and one ME) are usually set at each trapping site. Trapping sites may be located at agriculture stations, commercial plantations, villages, towns and primary forests. For quarantine surveillance against unwanted exotic species, traps should be placed in suburban areas, tourist resorts, refuse dumps, near diplomatic missions, at education institutes that cater to overseas students, and ports of entry, to detect foreign species that may be introduced through contaminated exotic fruits brought in by travelers. Special emphasis must be placed on maintaining traps along the West Papua-PNG border in Western and West Sepik provinces.

Only one lure must be used per trap. To avoid cross contamination of lures, two operators are required for trap clearance, one

responsible for handling and emptying the contents of traps with Cue lure and the other person responsible for servicing the ME trap. Traps are emptied weekly (Figure 23) in easily accessible sites, otherwise every two weeks or monthly for sites that are a far away. The lure mixture in the cotton wick is renewed every three months, using a dropper.

Trapped flies from one sample are placed inside a small cardboard box with strips of tissue paper to prevent flies from moving and getting damaged during transport and storage. Each box must be accurately labeled with trap number, type of lure (Cue or ME), location, date of emptying and collector's name. Samples must be kept in a dry place that cannot be reached by ants. A few grains of thymol should be added to each specimen box to prevent build-up of mould on specimens.

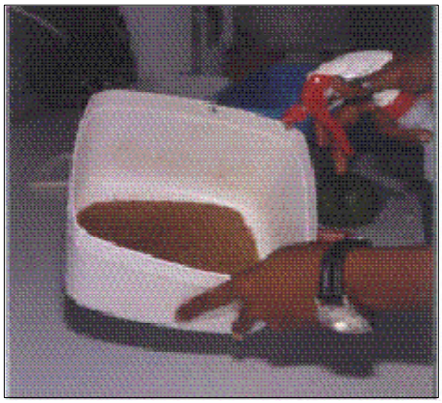
Host fruit surveys

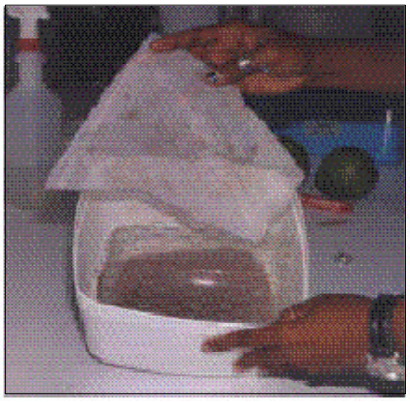
Host fruit surveys involve collecting samples of commercial/edible and wild fruits and incubating them in containers for two to three weeks to determine whether flies emerge from the fruits. They yield information on the range of hosts attacked by each fly species, levels of infestations (number of larvae per fruit and percentage of fruits infested) in each commodity, the stage of maturity when attacked, and diversity and impact of natural parasitoids. They complement trapping for quarantine surveillance and help in sampling species that are not attracted to male lures.

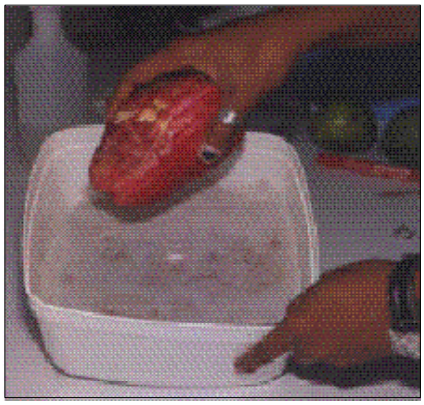
Two approaches may be used in fruit surveys. In general or broad host surveys, commercial/edible and wild fruits are collected and set up in bulk. In damage assessments, large samples (e.g., 50-100 fruits) of commercially important fruits are collected and fruits are set up and incubated individually in separate containers (Figure

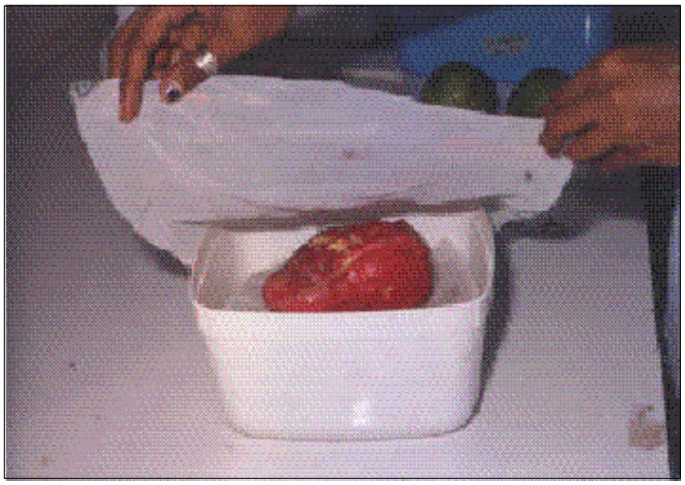
Figure 23: Trap servicing.

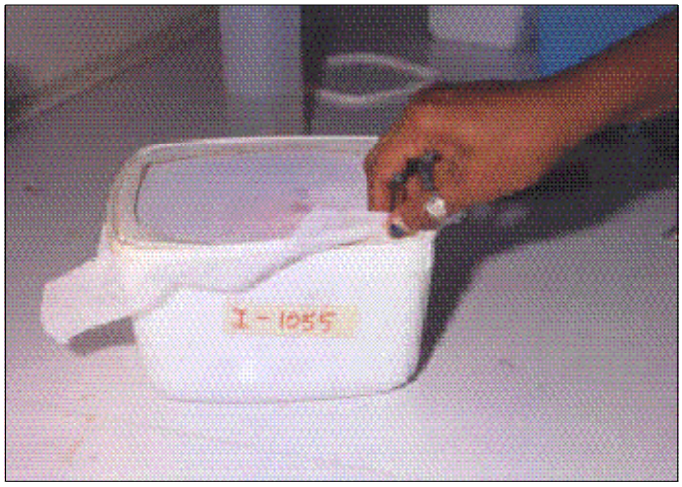
Figure 24: Damage assessment on guava.











Figures 25 to 29: Steps in setting up fruit sample.

24). Alternatively, fruits may be held in bulk for 5 days, dissected and examined, and those infested are transferred to individual containers and held for a further 7-9 days. Damage data presented in Table 2 were based on damage assessments.

Mature and ripe fruits are collected from the tree and/or from the ground and stored in paper bags, not plastic bags. The bag is labeled with the following information: sample number, precise location, date of collection, collector's name, host plant name (scientific or at least common or local name), state of fruit collected (on tree or fallen; green, mature green, ripe; damaged or undamaged). In the laboratory, fruits from each sample are weighed and counted and data sheets are filled in with the following information: sample number, location, date collected, plant species and common name, state of fruit, weight in grams and number of fruits.

Fruit samples are incubated in containers over moist, finely sieved sawdust from untreated timber for at least two weeks (Figure 25 to 29). Sawdust must be sterilised, before and after use, by placing it in an oven (120°C) for two hours or by freezing overnight. Small fruits not likely to release juice may be placed directly on top of sawdust in a plastic container whose top is covered with fine gauze fabric for ventilation. Fruits likely to release lots of juice while breaking down are placed on fine gauze fabric over chicken wire fixed to the top of a plastic container into which juices will drain. The plastic container is placed inside a larger plastic box or a cardboard box whose bottom is lined with a newspaper layer tightly taped to the box bottom and covered with sawdust. The cardboard box top is tightly secured with masking tape to prevent entry of small flies.

Fruits from trees and fallen fruits and fruits of different stages of maturity must be set up in separate containers and be assigned separate sample numbers. For damage assessments, each fruit is assigned a separate sample number.

After 10-12 days of incubation, check samples by slicing open fruits to make sure that all larvae have left the fruit and by sieving the sawdust with a strainer to separate puparia from sawdust. The number of puparia from each sample is noted on the data sheet. Puparia from each sample are placed in a petri dish on a piece of tissue paper lining the bottom of the dish and covered with sterilized sawdust moistened with a hand spray bottle. Petri dishes are placed in a small plastic container with top covered with fine gauze fabric for ventilation and labeled with sample number.

Adult flies that emerge from puparia must be kept them alive for at least 5 days by providing them with sugar and a wet sponge that is moistened daily, placed on the fine gauze top covering the plastic emergence container. Small parasitoids may also emerge, often several days after all flies have emerged. When all flies and parasitoids have emerged, they are killed by placing the container in a freezer for at least one hour. Flies and parasitoids are stored in small cardboard boxes labeled with sample number and host fruit name. A data sheet, indicating fly species (if known), number of male and female flies, parasitoid species (if known), number of parasitoids and any extra observations, must be completed. A small amount of thymol is added to prevent mould.

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Consult the WEB site on fruit flies in the Pacific: http://www.pacifly.org

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