The Fruit Fly Research Programme in New Caledonia

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An important fruit fly research programme was set up in New Caledonia following the recent ban on ethylene dibromide treatments. It is aimed at revitalizing the fruit and vegetable export sector. A progress report is presented.

introduction

A fruit fly research programme has been set up in New Caledonia (Map p. 362) to address recent quarantine restrictions on the export of local fruits and vegetables, especially to countries such as New Zealand which are free of pest fruit fly species (Diptera: Tephritidae). Exports from New Caledonia to New Zealand were authorized until 31 December 1993 on condition that the produce was pre-treated with ethylene dibromide (EDB). Fruit flies can be efficiently eliminated at different development stages (e.g. eggs, larva) by treatment with this pesticide. However, New Zealand legislation has now set the permissible EDB residue level at 0.1 ppm, thus representing an overall ban on the use of this product.

Only fruits and vegetables with a confirmed non-host status for different fruit fly species, or those that have undergone an authorized alternative treatment (heat, cold, etc.), can currently be exported to New Zealand. The French Territory of New Caledonia has assigned the CIRAD-FLHOR fruit research station at Pocquereux the task of solving this produce export problem.

A 4-year research programme (1993-1996) has been set up under mixed financing (CIRAD/Territory of New Caledonia). The present paper summarizes this programme, with emphasis on the first two well-established phases, i.e. the sexual trapping network and *Bactrocera tryoni* (Froggatt) breeding project.

Tephritidae inventory in New Caledonia

Eleven fruit fly species have been identified in New Caledonia, including seven endemic species (Cochereau, 1970; Drew, 1989; White & Elson-Harris, 1992). All of these species, their known fruit hosts, susceptibilities to different sex attractants, and South Pacific distributions are summarized in Table 1. Two complementary strategies have been developed to certify the detection of all fruit flies and collect further information on the full range of plant hosts, these are: a sexual trapping network and systematic collection of susceptible fruits and vegetables.

sexual trapping network

The sexual trapping network was set up in 1990 and gradually extended throughout New Caledonia; there are now 118 traps at 41 different sites. Each Lynfield trap comprises a plastic container (1 l) with four holes, cotton soaked with a liquid sex attractant and a dichlorvos insecticide strip. The traps are attached at human height under the tree foliage. Three sex attractants are used (Cue-lure, Methyl-eugenol and Trimedlure); the first two are known to effectively attract some fruit fly species present in New Caledonia, and Trimedlure is used to detect accidental introductions of Mediterranean fruit flies (*Ceratitis capitata* Wiedemann).

Although fruit fly captures are not always representative of the actual field situation,

Table 1
Inventory of fruit flies (*Tephritidae*) in New Zealand
(from WHITE & ELSON-HARRIS, 1992; DREW, 1989 and DREW, pers. comm.).

Species	Known host fruit	Attractant	Distribution
Bactrocera tryoni (Froggatt)	very many	Cue-lure	Australia, N.C. Polynesia
Bactrocera psidii (Froggatt)	citrus fruits, guavas, peaches, mangoes, etc.	Cue-lure	endemic N.C.
Bactrocera curvipennis (Froggatt)	citrus fruits, guavas, peaches, mangoes, etc.	Cue-lure	Vanuatu, N.C.
Bactrocera mucronis (Drew)	unknown	Cue-lure	endemic N.C.
Bactrocera umbrosa (Fabricius)	breadfruit, jackfruit	Methyl-eugenol	Vanuatu, N.C., Micronesia, East Asia
Bactrocera ebenea (Drew)	unknown	Methyl-eugenol	endemic N.C.
Bactrocera aneuvittata (Drew)	unknown	unknown	endemic N.C.
Bactrocera perpusilla (Drew)	unknown	Cue-lure (?)	endemic N.C.
Bactrocera fulvifacies (Perkins)	unknown	unknown	endemic N.C.
Bactrocera caledoniensis	unknown	Cue-lure	endemic N.C.
Bactrocera sp.*	*Diospyros fasciculosa* (*Ebenaceae*)	unknown	endemic N.C. (?)
Bactrocera near *xanthodes* *	unknown	Methyl-eugenol	Vanuatu (?), N.C.
Dirioxa pornia (Walker)	citrus fruits, peaches, (secondary pest)	unknown	Australia, N.C.

* identification in progress.

the sexual trapping network provides information on the distributions and relative population densities of different fruit fly species (Fig. 2). *B. tryoni* (Froggatt) and *B. psidii* (Froggatt) are often trapped in high numbers, i.e. 55% and 39% respectively; note that these trapping figures are means for all sites, but there are marked between-site variations. *B. tryoni* seems to be spreading rapidly as it was captured in 98% of cases in Nouméa; nevertheless, only a few have been trapped on the Loyalty Islands (Maré, Lifou) which are still relatively free of this species. The *B. tryoni* risk potential should be stressed in the light of its rapid spread subsequent to an accidental introduction from Australia in 1970 (COCHEREAU, 1970).

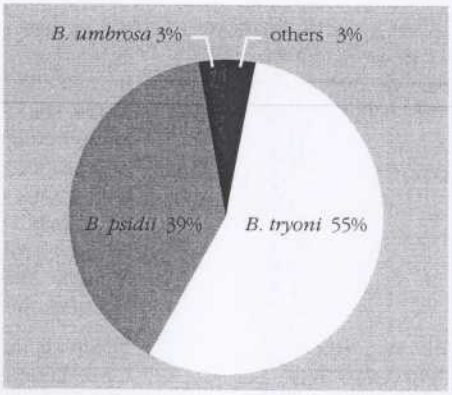

Figure 2
Percentages of fruit flies trapped in New Caledonia (mean of 108 traps).

The bimonthly collections also provide data on fruit fly population dynamics. Trapping results at the Pocquereux station are summarized in Figure 3, highlighting the clear correlations between population peaks and summer heat spells. The curves are similar for each region, except for the urban zone around Nouméa where fruit fly populations remain high throughout the year. This could be explained by the island-like location of Nouméa and the fact that climatic variations are not as extreme as elsewhere in New Caledonia. All 11 characterized fruit fly species are captured regularly in the traps, even though there are very few specimens of some species, i.e. *B. fulvifacies* (Perkins) and *Dirioxa pornia* (Walker). A few flies of a species close to *B. xanthodes* (Broun) have been trapped in the network set up on Maré Island. It is now being fully identified with the assistance of the entomology laboratory of the

Queensland Department of Primary Industries (Dr. R.A.I. Drew).

fruit and vegetable collection

The trapping network provides a relatively easy means for drawing up a partial fruit fly inventory. However, the list obtained should not be considered exhaustive since species that do not respond to the different sex attractants used are not detected. This shortcoming was highlighted by the fact that some specimens of a seemingly new *Bactrocera* species (Drew, pers. comm.) were collected separately on *Diospyros fasciculosa* (Ebenaceae) fruits, but they have never been found in the traps.

Wild and cultivated fruits and vegetables thus have to be collected at all sites throughout the year. They are placed in "hatching boxes" on a wet bed of sawdust. The sawdust is sifted regularly to collect fruit fly pupa and adults, which are then identified.

This campaign to detect fruit fly species that are not attracted by the sexual traps is also useful for determining different species of host plants. The fruit hosts of six fruit fly species are still completely unknown.

This list is being drawn up in collaboration with the New Zealand Ministry of Agriculture and Fisheries (MAF). Economically important fruit fly species, i.e. those that infest exportable fruits and vegetables, are thus being identified. In practice, MAF considers that all fruit species belonging to the same plant family as a known fruit host could be infested and thus should be tested. For instance, *B. umbrosa* (Fabricius) has been observed on *Momordica* sp., which means that it should be tested on all other Cucurbitaceae species present (e.g. zucchini, squash).

The list is needed as a basis for discussions on the exclusion of some species from future host status studies. *B. tryoni* (Froggatt), *B. psidii* (Froggatt), *B. curvipennis* (Froggatt) and *B. umbrosa* (Fabricius) are so far the only species chosen; a programme has thus been set up to rear these pests.

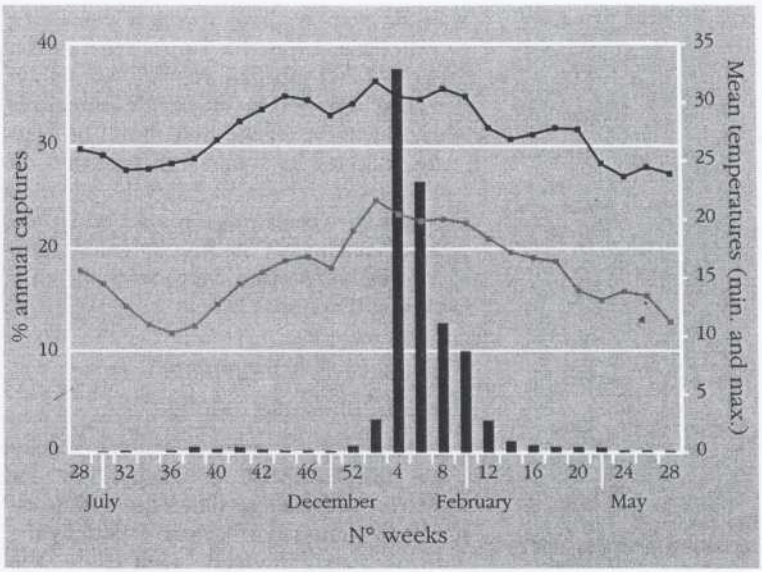

Figure 3
Variations in fruit fly trapping rates at the Pocquereux research station (July 1993-June 1994; mean of 3 traps).

B. tryoni, B. psidii, B. curvipennis and *B. umbrosa* rearing

A rearing programme for the above-mentioned pest species was considered necessary to produce enough flies for year-round reproducible and fully-controlled experiments.

Fruit fly colonies were created from infested peaches (*Prunus persica*) for *B. tryoni* and *B. curvipennis*, guavas (*Psidium guajava*) for *P. psidii* and jackfruit (*Artocarpus heterophyllus*) for *B. umbrosa*.

B. tryoni rearing conditions

About 2 000 adults/cage were kept in a temperature-controlled room (25°C ± 1°C) at about 70% relative humidity, under natural lighting with supplementary strong artificial lighting. The flies had a regular supply of water, sugar, yeast hydrolysate and the bacterial strain *Klebsiella oxytoca*. This latter enterobacterium is commonly used in rearing *Tephritidae* fruit flies (Lloyd, pers. comm.); it provides a protein supplement which promotes the production of high quantities of viable eggs and sexual maturation (Drew & Lloyd, 1989).

Eggs are collected on artificial oviposition domes made of perforated plastic cylinders (photographic film capsules), coated

inside with a larval medium containing fresh banana (88.6%), Torula yeast extract (11.1%) and nipagine (0.25%), an antimicrobial agent that effectively stimulates egg laying in female fruit flies. The eggs are collected in water and deposited on this larval medium. Larval pupation occurs in wet sawdust spread under the larval containers. The fruit fly rearing procedures were extensively described in a manual (CLARE and LEMONTEY, 1994).

B. psidii, B. curvipennis and *B. umbrosa* rearing

Conditions for rearing these three species are not as well established as for *B. tryoni*. There are differences with respect to a number of factors, especially the yeasts used to feed adult flies, the potato/dehydrated carrot-based larval medium used for *B. umbrosa*, and the lighting conditions in the rearing rooms.

B. curvipennis and *B. umbrosa* rearing conditions are gradually being perfected and functionalized. So far very few *B. psidii* flies have been successfully reared in the laboratory. Nevertheless, mass numbers of these fruit flies should be collected from infested fruit during the next hot season; further rearing trials could then be undertaken.

B. Tryoni life cycle

Fruit fly life cycles have to be fully understood in order to meet specific needs for insects at different development stages. Three thousand eggs that had been oviposited in 2 h were thus deposited on 600 g larval medium. After hatching, 100 larvae were randomly collected from the medium every 12 h for 2 weeks and their development stages were specified (1st, 2nd and 3rd instars). Changes in the mean composition of the different larval stages on the nutrient medium are shown in Figure 4. Table 2 provides various biological data on *B. tryoni*.

Control of *B. tryoni* rearing and critical information that has been obtained on its life cycle will facilitate further studies with this species. The same biological studies will be conducting with other species once they can be efficiently reared.

Figure 4
Bactrocera tryoni *life cycle at 25°C ± 1°C (on banana medium).*

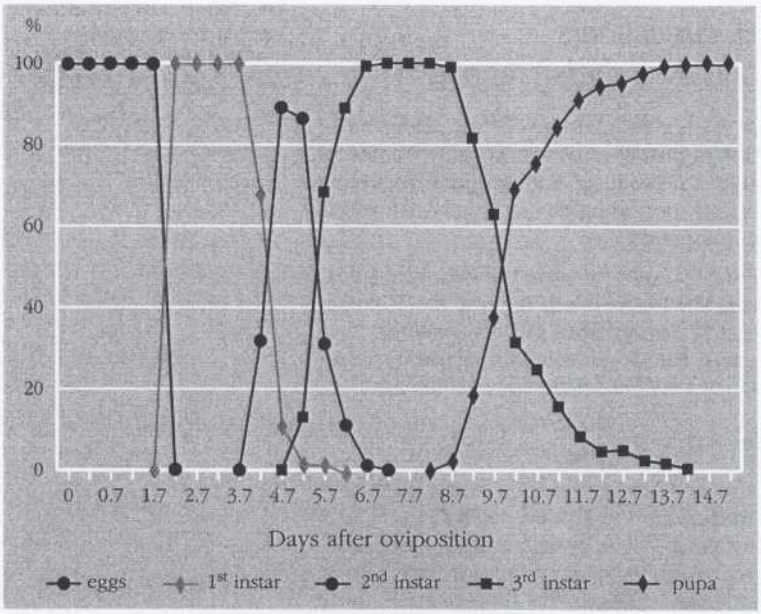

Table 2
Biological characteristics of *B. tryoni* (at 25°C ± 1°C).

N° eggs/female/24 h	about 15 (15-30 days after oviposition)
Hatching rate	about 70%
Hatching	41-53 h after oviposition
Pupation	8-14 days after oviposition
Emergence of adults	21-29 days after oviposition
Sexual maturity	about 15 days after emergence
Length of the life cycle	about 40 days

host and non-host status of plants

MAF drew up a list of different fruits and vegetables to test on the basis of data collected through the sexual trapping network and from collected wild and marketed fruit (Table 3).

Tests concerning *B. tryoni* and *B. curvipennis* were staggered to coincide with the November 1994-February 1995 fruiting period so as to obtain high numbers of available gravid adult females. For the two other species, the number of tests carried out was dependent on the rearing success rates. Details on the studies conducted for each fruit and vegetable with each fruit fly species are given in Figure

5; they met with the MAF specifications for the determination of fruit fly host status (ANONYMOUS, 1991).

Fruits and vegetables that were found to be non-hosts for all concerned fruit fly species can be exported again without any type of postharvest treatment. Alternative nonchemical treatments will be required for those that host fruit flies, e.g. mango was found to be a host for *B. tryoni, B. psidii* and *B. curvipennis.*

heat-treatment of mango

The efficiency of hot-air and vapour heat treatments to eliminate various fruit fly stages that infest fruit has been investigated with several different fruit species. ARMSTRONG *et al.* (1989) thus demonstrated the effect of high-temperature forced-air treatments of papayas infested with *Ceratitis capitata* (Wiedemann), *Dacus cucurbitae* (Coquillett) and *D. dorsalis* (Hendel) in Hawaii. Similar disinfestation studies with *Bactrocera xanthodes* (Broun) and *B. melanotus* (Coquillett) were carried out in the Cook Islands and led to a lifting of the ban on papaya exports to New Zealand (WADDELL *et al.*, 1992 and 1993). In mangoes (cv Kensington), HEARD *et al.* (1992) demonstrated the efficiency of vapour heat treatment of *B. tryoni* in Australia. In New Caledonia, disinfestation studies should be carried out with *B. tryoni, B. psiddi* and *B. curvipennis* infesting cv Kensington mango; *B. umbrosa* should also be assessed in this context if the host status of mango for this fruit fly is found to be positive.

The first phase in the heat-treatment research involved comparing the resistances of different fruit fly species at all development stages (i.e. egg, larva, 1st, 2nd and 3rd instars) over an increasing temperature gradient. This was carried out by immersing eggs and larvae in hot water baths for increasing periods of time, thus obtaining 0-100% mortality.

MAF considers that the vapour heat treatment developed in Australia could be used without modification, whereas our preliminary tests indicated high resistance of *B. tryoni.* The treatment has not yet been checked for effectiveness, but this will soon be done. Further analyses should be carried out if any of the other three species shows higher resistance. There are several phases to these analyses:

– confirming lethal hot water bath treatment temperatures and times with artificially infested fruits;
– checking that the temperatures used are not phytotoxic to the treated fruit;
– checking treatment efficiency in large-scale tests. This involves exposing high numbers of insects (30 000) to heat to certify that lethal temperatures established in previous tests actually cause 100% fruit fly mortality.

Our research is now focused on determining comparative resistances and the completed results for *B. tryoni* will be published later.

Table 3
MAF list of fruits and vegetables for testing.

Fruits and vegetables (varieties)	Species to test
lime (Tahiti SRA 58)	*B. tr., B. cur., B. ps., B. um.*
litchi (local variety)	*B. tr., B. cur., B. ps.*
mango (Kensington)	*B. um.*
pineapple (Queen Tahiti)	*B. tr., B. cur., B. ps., B. um.*
zucchini (Diamant)	*B. um.*
eggplant (Black beauty, Zébrina)	*B. tr., B. cur., B. ps.*
squash (New Zealand variety)	*B. um.*

B. tr.: Bactrocera tryoni — *B. cur.: Bactrocera curvipennis*
B. ps.: Bactrocera psidii — *B. um.: Bactrocera umbrosa.*

conclusion

In New Caledonia, postharvest treatments are essential for export fruit and vegetable crops because of the presence of fruit flies in this country. Fruit fly pest research carried out at the Pocquereux station (New Caledonia) is fully in line with current world trends to develop alternative nonchemical postharvest treatment techniques. Scientific collaboration with the Horticulture and Food Research Institute of New Zealand (Hort+Research,

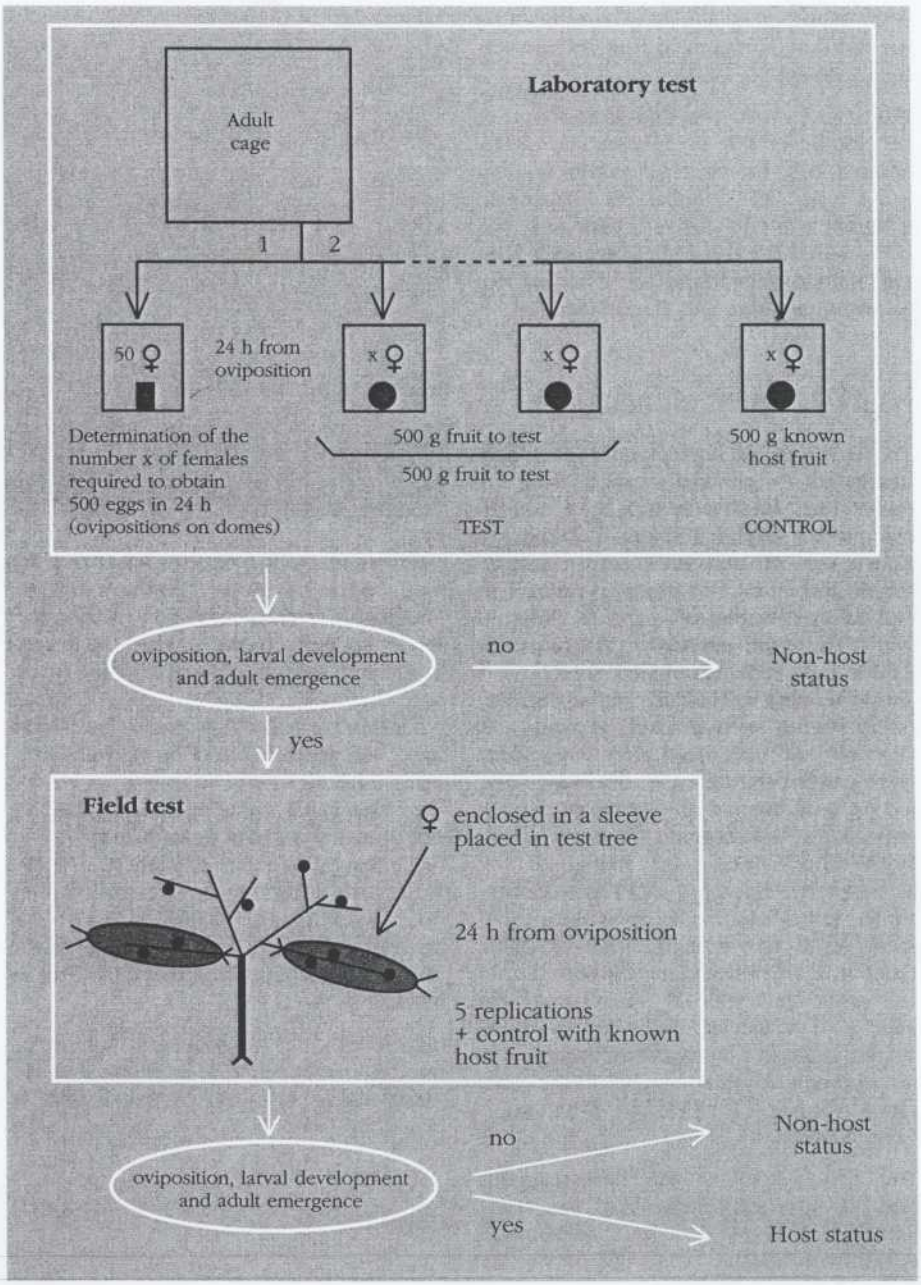

Figure 5
Procedure for determining the fruit fly host status of various fruits and vegetables.

ex-DSIR) will enable CIRAD-FLHOR to benefit from their research experience in a similar disinfestation programme on papayas in the Cook Islands.

Official policies in New Caledonia and economic imperatives have prompted fruit and vegetable producers to export their crops to other markets in the South Pacific region. The know-how acquired through the present research and the credibility obtained by penetrating the renowned demanding market of New Zealand should facilitate future exports of various fruits and vegetables to other markets in the region, especially Japan. ●

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