IAEA-TECDOC-1099

Development of female medfly attractant systems for trapping and sterility assessment

Proceedings of a final Research Co-ordination Meeting organized by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and held in Penang, Malaysia, 28 May – 1 June 1998

INTERNATIONAL ATOMIC ENERGY AGENCY IAEA

July 1999

The originating Section of this publication in the IAEA was:

Insect and Pest Control Section
International Atomic Energy Agency
Wagramer Strasse 5
P.O. Box 100
A-1400 Vienna, Austria

DEVELOPMENT OF FEMALE MEDFLY ATTRACTANT SYSTEMS FOR
TRAPPING AND STERILITY ASSESSMENT
IAEA, VIENNA, 1999
IAEA-TECDOC-1099
ISSN 1011–4289

Printed by the IAEA in Austria
July 1999

FOREWORD

Practical application of the sterile insect technique (SIT) against major insect pests will continue to increase as the repeated use of insecticides is recognized as an environmental problem. In the case of the Mediterranean fruit fly (medfly), which attacks over 300 species of fruits and vegetables in tropical, subtropical, and temperate climates on all five continents, control is still largely based on frequent insecticide spraying, often more than 10 sprays per fruiting season.

Methods for population estimation, which accurately reflect changes due to movement, mortality or reproduction, are a prerequisite for effective pest management and in particular for use of SIT. With better monitoring tools medfly populations can be estimated more accurately and compared under different conditions, to guide decisions on alternative (i.e. more effective and more environment-friendly) control strategies. In support of this need in the application of SIT field programmes against medfly, an FAO/IAEA co-ordinated research project (CRP) was carried out which resulted in a TECDOC published in 1996 on Standardization of Medfly Trapping for Use in sterile insect technique Programmes.

Following the development of male only genetic sexing strains at the FAO/IAEA Agriculture and Biotechnology Laboratories in Seibersdorf, Austria, it was recognized that the development of a female medfly targeted trapping system, in conjunction with only male sterile releases, would improve the efficacy of the SIT, reduce costs, and more effectively utilize sterile males.

As a result, a new FAO/IAEA Co-ordinated Research Project on Development of Female Medfly Attractant Systems for Trapping and Sterility Assessment was initiated in 1994 with the objective to develop new synthetic female medfly attractants and to determine their efficacy compared to proteinaceous baits under different weather, host-tree and population density conditions.

Findings obtained during the course of this 5-year CRP are described in this publication. Tests were carried out by researchers in fourteen different countries and climates in northern and southern Africa, southern Europe, Central and South America and the Indian Ocean. The production of fruits preferred by the medfly is important in all countries where tests were conducted.

Results reflect major progress made in achieving the above objectives, which have resulted in a commercial female medfly lure already in use not only in operational SIT control and eradication programmes, but also in conventional monitoring and even mass trapping. It is hoped that this publication will be of help to all plant protection, pest control and quarantine workers in the tropics and subtropics, where the medfly is a major pest or has the potential to become established.

The IAEA officer responsible for this publication is J. Hendrichs of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.

EDITORIAL NOTE

In preparing this publication for press, staff of the IAEA have made up the pages from the original manuscripts as submitted by the authors. The views expressed do not necessarily reflect those of the IAEA, the governments of the nominating Member States or the nominating organizations.

Throughout the text names of Member States are retained as they were when the text was compiled.

The use of particular designations of countries or territories does not imply any judgement by the publisher, the IAEA, as to the legal status of such countries or territories, of their authorities and institutions or of the delimitation of their boundaries.

The mention of names of specific companies or products (whether or not indicated as registered) does not imply any intention to infringe proprietary rights, nor should it be construed as an endorsement or recommendation on the part of the IAEA.

The authors are responsible for having obtained the necessary permission for the IAEA to reproduce, translate or use material from sources already protected by copyrights.

CONTENTS

ANNEXES 1–4

SUMMARY

Introduction

A recent estimate of the number of host or potential host plants for the Mediterranean fruit fly (medfly), *Ceratitis capitata* (Wiedemann), increased their number to 333 species. Medfly host plants grow in tropical, subtropical or temperate climates on all five continents. This impressive polyphagy and destructive ability against so many fruits and vegetables elevates this otherwise beautiful fly to the prominent role of key menace to agricultural commodities in many different countries.

To reduce crop destruction, the control of medfly is usually based on repeated bait spraying with organophosphate insecticides, frequently more than ten sprays per fruiting season, sometimes applied by air. Control measures usually pollute the crop and the environment and can increase the cost of the agricultural products substantially. Also, to export fruits and vegetables to medfly free countries, strict quarantine control treatments are deemed necessary.

In certain geographical regions, the medfly has been eradicated or prevented from becoming established by using the sterile insect technique (SIT). Recently, considerable improvement in the medfly SIT control methodology has been achieved by the development of genetic sexing lines which allow the release of sterilized males only. Rearing facilities for the production of male only sterile medflies are located in Madeira, Portugal; Guatemala City, Guatemala; Mendoza, Argentina and Arica, Chile, with anticipated conversion to the rearing of sexing strains of additional facilities in several other countries.

An effective method for population estimation, which accurately reflects changes due to movement, mortality or reproduction, is a prerequisite for the success of any insect pest control operation. For SIT in particular, efficient and precise methods are needed to monitor the feral pest population before sterile insect releases begin, to monitor the decrease of the pest population during the release campaign, and to survey the area following eradication for possible re-introduction.

Monitoring for adult flies is carried out mainly with the use of traps that attract the insect, usually by olfactory or visual stimuli. With the medfly, because of its importance in so many agroecosystems, many trapping systems have been developed over the years. They combine lures with suitable devices to trap the fly upon landing. The most common lures used are sexual or food odours or colours attractive to the flies, or a combination of these. Odours attract the fly from long distances, while colours attract from short distances usually after arrival at the host tree or a certain part of the tree canopy. Because of the ease of deployment, trimedlure, a male parapheromone, is often used for detecting medflies. Previous efforts for the deployment of proteinaceous baits that capture both male and female medflies have been limited by their short-lived attractiveness in the field and difficulties in maintaining the liquid traps in the field.

With the recognition of the environmental side effects of the continuous use of insecticides, biological technologies to control, and in certain cases eradicate, Mediterranean fruit fly populations affecting commercial food crops will be required. The sterile insect technique (SIT) is one of these methods. The development of male only genetic sexing strains at the FAO/IAEA Agriculture and Biotechnology Laboratories in Seibersdorf, Austria, affords

the opportunity to reduce costs of SIT by rearing only males and in particular increases the efficacy of SIT because of the absence of sterile females that distract the sterile males.

The development of female medfly targeted detection and trapping systems, used in conjunction with only sterile male releases, opens the possibility of simpler and more accurate appraisal of the progress of the SIT programmes. Thus, to improve the efficacy of the SIT, reduce costs, and more effectively utilize sterile males, a female attractant system to trap females in the wild population is required. It was envisioned that the development of a synthetic female food attractant could be combined with the male only SIT programme to reduce the number of sterile males captured. This would effectively reduce labor required to discriminate between marked sterile and unmarked wild males. The capture of wild females would enhance the programme since most of the females captured would be wild and their removal would provide an indication of the programme's success and simultaneously reduce the wild female population. In addition, the capability to capture live female flies enables the programme to assess the sterility introduced into the wild female medfly population. By knowing precisely the extent of sterility induced, the sterile males can be more strategically utilized, increasing efficacy and reducing programme costs.

In view of the above, the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, which has long been involved in medfly eradication and/or control activities in different regions, organized a co-ordinated research project (CRP) with the objective to develop new synthetic female medfly attractants and to determine their efficacy compared to proteinaceous baits under different weather, host-tree and population density conditions.

The co-ordinated research project

Fourteen countries participated in this 5-year co-ordinated research project. In all countries except Mexico, field trials were conducted with wild populations. In the case of Mexico, no wild populations existed and the traps were evaluated with populations of mass-reared sterilized flies released continuously along the Mexico/Guatemala border by the medfly SIT campaign to prevent medfly establishment in Mexico and the USA.

Tests in Spain, Portugal, Greece, Turkey, Morocco, Israel and Mallorca were carried out during summer and autumn. Generally, the host trees were citrus and fig. In Turkey, experiments were carried out in mandarin, quince, peach and plum. In Mexico, Guatemala, Honduras and Costa Rica experiments were conducted in late autumn and early summer, where medfly hosts included coffee and citrus. Several participating countries were in the Southern Hemisphere. In South Africa, tests were conducted during December and January in plum and pear. Experiments in Argentina were conducted in mandarin from March through June, and in Mauritius, field trials took place in Indian almond and coffee from October through March.

Common experimental designs were used by all participants. The original protocol was based on recommendations by R. Heath and N. Epsky and subsequent protocols were developed during Research Co-ordination Metings (RCMs) held in Guatemala in May, 1995, and in Portugal in January,1997. The final protocol is presented in Annex 1. The final meeting in Penang in May, 1998 was held in conjunction with the FAO/IAEA International Conference on Area-Wide Control of Insect Pests. This enabled the participants to participate in an international meeting where their results were presented and discussed. These meetings fostered close collaboration and provided a forum for information exchange between the

scientists and the institutions involved, as well as a focused approach for the development and technology transfer of environmentally friendly technologies.

During the course of the CRP, a number of side experiments were conducted by most of the participants. These experiments often resulted in solutions to common problems or explored changes in the trapping systems before larger tests were conducted. The different traps used in the standard protocol by all participants are presented in Annex 2 and the cost of the trapping materials used are given in Annex 3. A tabulated summary of results from the last year of the CRP are given in Annex 4.

Co-ordinated project activities and conclusions

Initial experiments were conducted to evaluate new female trapping systems for Mediterranean fruit flies. The combination of two female attractants (ammonium acetate and putrescine) was tested in different types of traps. Female captures with the new synthetic lures were compared to captures with standard aqueous proteinaceous baits. The male specific para pheromone Trimedlure, was used to provide additional information on population densities. In addition to several standard traps provided by the IAEA, many of the research teams tested the female attractants in traps designed by them or known to be used in their country. In addition to obtaining comparisons of numbers of medflies captured, host availability and environmental conditions were recorded. Preliminary success was obtained in the capture of live wild females that was needed to develop systems for female sterility assessments.

In 1996, it was discovered that a third chemical, trimethylamine, was a potential synergist for the capture of female medflies. At the RCM held in Madeira, the use of the three component lure was strongly endorsed by all scientists, and, participating scientists recommended also that the last part of the CRP should focus on comparing the use of the synthetic lures in traps that were dry versus those that contained water. Additional recommendations included: to begin trapping in low populations; to continue to improve systems to capture wild female flies or collect eggs deposited within egging devices contained in the traps; and to determine the potential for fly suppression by mass trapping of female flies.

Based on the efforts prior to the 1997, and decisions made at the Madeira meeting, a cohesive protocol was developed, resulting in significant advances in female trapping systems for use in SIT programmes, including:

- The two component lure, consisting of ammonium acetate and putrescine, was approximately equal to protein baits for capture of medflies.
- The addition of the trimethylamine lure to ammonium acetate and putrescine lures significantly improved trap capture of female medflies.
- The commercial formulation of the three component lure has a field life of 6–8 weeks, compared to that of protein baits, which should be replaced every week.
- Traps baited with the synthetic lure capture few non target insects. Protein baits capture 4 to 50 times more non target insects, including beneficial insects, than the synthetic lure.
- Traps baited with the three component lure capture 5–40 times fewer sterile flies than TML baited traps.

- Traps baited the synthetic lure captured approximately 75%–77% female medflies. Protein baited traps captured 77% female medflies. TML baited traps captured <1% females.
- Based on results from all countries, the plastic McPhail type traps baited with synthetic lures and insecticide captured 2.2 times more medflies than protein baited plastic McPhail type traps.
- Based on results from countries having very low medfly populations, the plastic traps baited with synthetic three component lure captured approximately 4.1 times more medflies than protein baited plastic traps.
- In low populations, the female food attractant synthetic lures detected the presence of wild Mediterranean fruit flies before the TML baited traps.

This co-ordinated research project has made a major contribution to the development of future strategies for using sterile male releases to suppress or eradicate Mediterranean fruit fly and has led the use of the three component synthetic female food attractant being now globally accepted to assess the effectiveness of SIT programme efforts. Its essential objectives — to develop a trapping system for female medflies which will be used in practical SIT programmes using a genetic sexing strain (i.e. where only sterile males are released), and to develop a female trap from which the eggs of wild females can be obtained to estimate sterility which has been induced into the wild medfly population — were accomplished. The results obtained are indicative of the enthusiasm and dedication of all the scientists involved.

MEDITERRANEAN FRUIT FLY FEMALE ATTRACTANT STUDIES IN SUPPORT OF THE STERILE INSECT TECHNIQUE: TRAPPING EXPERIMENTS CONDUCTED ON THE ISLAND OF CHIOS, GREECE

B.I. KATSOYANNOS, N.T. PAPADOPOULOS, N.A. KOULOUSSIS
Laboratory of Applied Zoology & Parasitology,
Department of Agriculture, University of Thessaloniki,
Thessaloniki, Greece

Abstract

This paper contains information on a four-year research programme co-ordinated by the International Atomic Energy Agency. The main objective of the programme was to develop a trapping system for females of the Mediterranean fruit fly (medfly), *Ceratitis capitata* (Diptera: Tephritidae), for practical use in Sterile Insect Technique (SIT) programs and to design and evaluate a trap to obtain eggs from wild female medflies in order to estimate sterility induction in the field population. The experiments were conducted from July to September 1994 -1997 on the island of Chios, Greece, in citrus orchards with low to medium medfly populations. Different trap types and several trap treatments consisting of sex and food based attractants were tested, following a standard coordinated experimental protocol. The most extensively tested were three food based "female" attractants (FA-3), namely ammonium acetate (AA), 1,4 diaminobutane (putrescine) and trimethylamine, all formulated in dispensers lasting one month. These attractants were evaluated in combinations of two (AA + putrescine, termed FA-2) or three (FA-3) dispensers in various traps, including dry (provided with DDVP) or wet (provided with water and 0.01% surfactant) plastic International Pheromone's McPhail traps (IPMT). Among the various traps and treatments tested, the most effective for medfly capture was the wet IPMT, baited with FA-3 attractants. This treatment captured predominantly females and was relatively selective for medflies. In dry IPMT traps, the FA-3 were as effective as the standard 300 ml aqueous solution of 9% of the protein NuLure and 3% borax, but much more medfly selective. Dry IPMT traps were also more selective than wet ones. FA-3 baited wet Tephri traps (a Spanish modification of the McPhail trap), performed somewhat poorer than IPMT traps. Other dry trap types tested were not effective. Additional experiments showed that certain insecticide formulations used in dry traps may have a repellent effect to the flies. Slightly modified wet or dry IPMT traps baited with the FA-3 could be readily used to capture live medfly females. The fertility of these females could later be assessed in cages with appropriate oviposition devises to measure the degree of sterility induced in the field populations by SIT programs.

1. INTRODUCTION

Although several trapping systems have been developed for the Mediterranean fruit fly (medfly), *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) [cf. 1, 6, 8, 19], a system selective for females has been unavailable until recently. Such a system could be used for mass trapping and also for capturing females to assess their fertility as a control method to verify effectiveness of Sterile Insect Technique (SIT) through induction of sterility in the wild population. To develop such a system, a research programme co-ordinated by the International Atomic Energy Agency (IAEA) was initiated in 1994. The program included extensive trapping experiments in several countries, using various trap types baited with promising female-targeted attractants.

Here, we report on the standard co-ordinated trapping experiments and on certain results of side experiments which were conducted. The full results are contained in the Annual Reports submitted to the Agency [10-13] and/or have been published elsewhere [16, 17].

2. MATERIALS AND METHODS

2.1. Generalities, experimental area and orchards

The experiments were conducted from July to September 1994- 96 on the island of Chios, Greece. Chios is located in the central Aegean sea, about 10 km off the west coast of Turkey and has a typical Mediterranean climate (Table I). During experimental months, the weather was characterized by moderate to high temperature and humidity, slight to moderate winds usually blowing from the north, and an almost total lack of rainfall (a single rainfall occurred in September 1996). The experiments were conducted in an area located approximately 1 km west of the eastern coast of the island at an altitude of 1-2 m, in the middle of a 20 km^2 area cultivated mostly with various *Citrus* spp. trees, especially mandarin (*Citrus nobilis* Lour.), orange (*Citrus sinensis* Osbeck) and bitter orange (*Citrus aurantium* L.). In the same area were other medfly host trees such as apricot (*Prunus armeniaca* L.), pear (*Pyrus communis* L.), and fig (*Ficus carica* L.). Bitter oranges are the most preferred and severely attacked host during June to early July, while figs constitute a much preferred host in which the fly breeds from mid August to late October [15]. More detailed information on the climate, hosts and medfly phenology on Chios have been reported in recent publications [8, 15].

The co-ordinated experiments were conducted in two citrus farms each year (Site 1 and Site 2) which were approximately 100 m long and 100 m wide. The farms were located about 0.5 km apart (in 1994 and 1995) or were adjacent to one another (in 1996 and 1997). Both farms contained mandarin trees as the main culture and a few to several orange, bitter orange and lemon (*Citrus limon* Burm.) trees planted mostly between the mandarin trees. On the margins of the farms were a few other host trees, such as fig, and certain non host trees. The side experiments were mainly conducted in two other farms: Site 3 having similar size and tree species composition to Sites 1 and 2 and located 0.5 km from them; and Site 4 located about 1 km to the south. Site 4 was smaller (90 m long, 20 m wide) but had a tree species composition similar to the other sites. It is owned by the senior author and has been used extensively in the past for medfly trapping and other studies [e.g. 7, 8, 9, 15, 18].

High populations of adult medflies are usually present in the area from the end of June to early December [15]. The year 1996 was exceptional in that *C. capitata* adult populations remained at undetectable levels during early to mid July and at low levels during August. This was most probably due to the unfavorable weather conditions observed during February and March of that year [15].

During the period of experimentation, the mandarin, orange, and bitter orange trees on all farms bore mostly unripe fruits unsuitable for oviposition and these remained uninfested. Only in the first weeks of July did sweet and bitter orange trees bear a small number of ripe or ripening fruits which were infested by *C. capitata*. The figs in the area matured and were highly infested from early to mid August. Hence, from July to early August the adult population originated from citrus fruits and from August to September from figs.

2.2. Treatments tested and experimental procedures

The trap types and materials used were purchased or provided by the co-ordinating Agency. The co-ordinated experiments were conducted according to a standard experimental protocol. In brief, the experiments consisted in comparing trap catches for each year for eight weeks in up to six trap treatments, in five experimental blocks per site, in a completely randomized block design.

TABLE I. MONTHLY AIR TEMPERATURE, PRECIPITATION, AND RELATIVE HUMIDITY RECORDED DURING THE YEARS 1991 - 93 AT A METEOROLOGICAL STATION LOCATED AT A DISTANCE OF ABOUT 1 - 2 KM FROM THE EXPERIMENTAL ORCHARDS

Month	Temperature °C			Mean Precipitation	Mean R.H. %
	Avg.	Avg. Min.	Max	mm	
Jan.	8.7	7.7	9.2	57.0	74.0
Feb.	8.4	5.0	11.2	66.3	72.3
Mar.	11.0	6.8	14.3	57.7	75.0
Apr.	14.2	9.3	18.0	48.3	77.0
May	17.5	13.1	21.3	19.0	74.7
June	22.9	17.8	27.0	0.0	69.3
July	24.8	20.4	28.8	0.0	57.3
Aug.	24.5	22.0	29.8	0.0	57.3
Sept.	20.7	17.0	26.0	0.0	63.3
Oct.	17.2	14.4	23.4	16.3	69.3
Nov.	13.7	10.0	16.9	102.3	73.0
Dec.	9.9	7.0	12.1	121.3	71.0

2.2.1. 1994 experiments

Site 1 and Site 2 (Co-ordinated experiments): The experiments were conducted from July 7 to September 9. At each site, twenty traps were deployed in five blocks of four traps each. Each block consisted of the following two treatments, replicated two times within each block. 1) Trimedlure (TML) baited Jackson traps (JT). These traps contained a white sticky insert and were baited with a TML impregnated plug ("Magnet" Trimedlure 70-0 Plug, 2 g active, supplied by AgriSense Ltd., Fresno, CA 93722, USA), placed in a special plastic basket hung inside the trap, in the middle of the horizontal wire hanger (JT, TML). 2) Closed Bottom Dry Trap (CBDT), FA-2. The CBDT [2, 4], was a dry trap consisting of a fluorescent green painted plastic sheet that formed a 15 cm long, 9 cm diameter, cylindrical container having three 2 cm diameter holes for insect access. The bottom and the top of the trap consisted of two removable plastic petri dishes. The traps were baited with two dispensers containing two synergistically acting, food based females attractants (FA-2), one dispenser with ammonium acetate (AA)(BioLure,Consep Inc., Bend, OR, USA), and the other with 1,4 diaminobutane (putrescine, P), prepared using a polyethylene membrane system [2]. The traps also contained a small toxicant strip of the insecticide methomyl to kill the attracted insects. (CBDT, FA-2, dry).

Site 3 (Side experiment 1): At this site, a total of 40 traps in five blocks (lines) of eight traps each were deployed on July 7, and were checked twice per week until September 9. Each block consisted of the following four treatments replicated twice within each block: 1) JT, TML; 2) CBDT, FA-2, dry; 3) CBDT, FA-2, wet (The CBDT traps, in addition to the FA-2 dispensers, were provided with a small plastic container filled with water and replaced as needed. This container was about 0.5x2x4 cm and was provided with a 3 mm diameter hole for the evaporation of water); and 4) IPMT, NU+B (International Pheromone's McPhail traps, baited with the standard 300 ml of an aqueous solution of 9% NuLure and 3% borax).

Site 4 (Side experiment 2): Field cage experiments [13] showed that wet (provided with water) IPMT traps baited with FA-2 were much more effective than dry IPMT or CBDT traps baited with the same attractants [13]. Apparently the presence of water in this trap enhanced its effectiveness. Other field cage experiments demonstrated a strong attraction of female medflies to orange juice [13, 14].

The purpose of this experiment was to compare the attractiveness of the FA-2 attractants in IPMT traps provided with water to a known effective attractant, NuLure, and with orange juice. The selectivity of these attractants and their impact to certain beneficial insects was also evaluated.

The experiment was conducted between July 28 and August 6. Two blocks of four different treatments each, were deployed in mandarin and orange trees. The distance between the traps was about 15 m. We tested the following treatments: 1) IPMT, NU+B; 2) IPMT, NU+B and FA-2 (in addition to the NU+B, two dispensers with the FA-2 were attached on the interior sides of the upper part of the trap); 3) IPMT, FA-2, wet (the trap bottom was filled with water); and 4) IPMT, orange juice (the bottom of the trap was filled with 300 ml of commercial pure orange juice of the local trade name "Amita").

The traps were checked daily and their position within each block re-randomized. NU+B and orange juice were renewed every 2-3 days. The total daily captures of the two traps of each treatment were considered a replicate.

2.2.2. 1995 experiments

Because, during the 1994 experiments the CBDT, FA-2 proved ineffective under the conditions of Chios, this trap type was excluded from the 1995 experiments.

Site 1 and Site 2 (Co-ordinated experiments): The experiments were conducted from July 7 to September 1. At both sites, the following five treatments were tested: 1) JT, TML; 2) OBDT, FA-2 (the OBDT trap was an opaque, green, open-bottom cylinder (similar to CBDT), provided with a yellow sticky paper insert with a pre-applied new, special adhesive instead of the standard Bird Tanglefoot [5]); 3) IPMT, FA-2, dry (the IPMT was baited with FA-2 and included two small strips impregnated with the insecticide methomyl as a killing agent.); 4) IPMT, FA-2, wet (in the bottom part of the IPMT trap, 300 ml of water were added to enhance the effectiveness of the attractants and kill the attracted insects). In the first trap check, we observed that many insects did not drown into the water. To break the surface tension of the water and facilitate insect drowning, during each of the following trap services 0.01% of the surfactant Agral-90 (alkylphenolethoxylate, Prometheus Ldt. Greece) was added in each trap.); and 5) IPMT, NU+B.

Site 4 (Side experiment). The initial trap catch data from the coordinated experiments showed that treatments 4 and 5 were the best. To gain more data on these treatments, a two-choice test was conducted in Site 4 between July 27 and August 2 involving five pairs of traps of the treatments 4 and 5 described above. The two traps in a pair were suspended at about 5 m from one another and at 5-10 m from other pairs. They were checked every second day (3 times in total).

2.2.3. 1996 experiments

Data from the 1995 experiments showed that the OBDT was ineffective under the conditions of Chios, and this trap type was excluded from the 1996 experiments. This year we mainly evaluated the FA-2 attractants alone or in combination with trimethylamine (TMA). This compound acts synergistically with the FA-2 attractants and is formulated in dispensers

lasting one month (BioLure Consep Inc., Bend, OR, USA). The attractants were evaluated in combinations of two (FA-2) or all three (FA-3).

The co-ordinated experiments were conducted from July 23 to September 17. The following treatments were tested: 1) JT (TML); 2) IPMT, FA-2, wet (in wet traps, 0.01% of a wetting agent (Triton X -100, Union Carbide, Danbury, Connecticut, USA) was added); 3) IPMT, FA-3, wet (water and surfactant were added as described above); 4) IPMT, NU+B; 5) IPMT, FA-2 and NU+B; 6) Tephri, NU+B (The Tephri trap, a Spanish trap, was a cylindrical, smaller modification of the McPhail trap (Agro Alcoy, Alcoy, Spain). Apart from having a bottom opening, it has four lateral holes of 2 cm diameter in the upper part. It was baited with 250 ml aqueous solution of NU+B.); and 7) Frutect (The Frutect trap (RonPal Ltd., Rishpon, Israel), was a yellow sticky coated 40x40 cm panel with a dark red, 12.5 cm diameter sphere, attached in the center of the panel. The sphere was pre-baited with a long lasting (evaporating) proteinaceous attractant placed in its interior, which was dispersed to the exterior via a sponge which formed a 1.0 cm band on the outside periphery of the sphere.)

The treatments tested were not the same in the two sites of the standard coordinated experiment.

Site 1. The following six of the above treatments were tested: 1) JT, TML; 2) IPMT, FA-2, wet; 3) IPMT, FA-3, wet; 4) Tephri, NU+B; 5) IPMT, NU+B; and 6) Frutect trap.

Site 2. The following five of the above treatments were tested: 1) JT, TML; 2) IPMT, FA-2, wet; 3) IPMT, FA-3, wet; 4) IPMT, NU+B and FA-2; and 5) IPMT, NU+B.

Site 4 (Side experiment). The FA-2 and FA-3 treatments, which were the best in the co-ordinated experiments, were further evaluated in a two-choice test conducted between August 25 and September 15 at Site 4, using five pairs of traps. The traps in a pair were suspended at about 5 m from one another and 5-10 m from other traps. They were checked every 2-3 days (8 times in total). After a check, the positions of the traps in a pair were interchanged. Two trap-checks of a pair were considered as replicate.

2.2.4. 1997 experiments

The FA-3 attractants in McPhail type traps provided with water were found to be the most effective treatments during 1996 [3, 16]. To gain more information on the effectiveness of these attractants we tested them again in wet and dry IPMT and Tephri traps in the standard coordinated experiments conducted from July 7 to September 1. In the water of IPMT traps, 2 drops (concentration about 0.01%) of the surfactant Triton were added. In the dry traps as well as in the wet Tephri traps, we placed a 15x25x5 mm piece of a DDVP plug (Biological Control Systems, provided by IAEA). The following treatments were tested in both Sites: 1) JT, TML (only two such traps at Site 2); 2) IPMT, NU+B; 3) IPMT, FA-3, wet (as in 1996); 4) IPMT, FA-3, dry with DDVP; 5) Tephri, FA-3, dry with DDVP (the DDVP plug was placed in the special basket of upper part of the trap); and 6) Tephri, FA-3, wet with DDVP (250 ml of water was placed in the bottom of the trap).

2.2.5. Experimental procedures

At all sites and in all years, the traps were hung on citrus trees (mostly mandarin), at a distance of about 10-20 m between the lines (blocks) and 10-20 m within blocks (the distance depending on the number of treatments), with all treatments randomly distributed within each block. They were checked twice a week in a regular schedule for eight consecutive weeks. In each check, the position of the traps within each block was re-randomized.

TML dispensers were renewed every 15 days whereas the FA-2 and FA-3 dispensers and the plugs with the DDVP were renewed only once, one month after the initiation of the

experiment. Frutect traps (used in 1996) were replaced by new ones after one month. After every second check, the liquid in the IPMT and Tephri traps was replaced with fresh solution. Sticky inserts were renewed as often as needed. The pH of the NuLure solution was checked several times at the beginning and the end of each two-check periods, and was always found to be about 8.0.

At each check, we recorded the number and sex of medflies captured and the total number of other insects captured. In certain treatments, we also recorded the number of individuals of certain other important insect species. These included: the olive fruit fly, *Bactrocera oleae* (Gmelin); the celery fly, *Euleia (Philophylla) heraclei* L.; a leaf miner of celery (Tephritidae); *Chrysopa* sp. (Chrysopidae); and yellowjacket wasps, *Vespula germanica* (F.). Evidence of medfly predation by yellowjackets was recorded. At regular intervals (usually every second trap check) samples of medfly females from certain treatments were dissected and the presence of mature oocytes determined. The few females showing degenerated or otherwise decomposed oocytes were not considered.

Data from the co-ordinated experiments are given in the tables as mean numbers of captures per trap per day. However, for the statistical analysis, data were grouped in captures of two weeks per trap per treatment (N=20), transformed to ln (x + 0.5) and submitted to Analysis of Variance. Means were separated according to Tukey's HSD test. When two treatments were compared, data were analyzed using Student's t test.

3. RESULTS AND DISCUSSION

3.1. 1994 experiments

The numbers of medflies captured during the entire experimental period in Sites 1 and 2 of the co-ordinated and in Site 3 of the side experiment 1, are given in Table II. CBDT traps with or without a water reservoir captured about twelve times fewer medflies than the NU+B baited IPMT traps, and in a similar sex ratio (about two times more females than males). Compared to the JT, TML, the CBDT traps were about 30-40 times less effective in total captures.

These results may not reflect the actual efficacy of the FA-2 attractants because the attracted insects in the CBDT traps were subjected to extremely high predation by ants and especially by yellowjacket wasps. However, in the very first replicates, no apparent signs of predation were observed, probably because the wasps had not located the traps yet or had not learned to find and predate them easily. If we exclude predation by taking into account the results pertaining to the first trap check only (Table III), then the CBDT traps again prove to be much less efficacious than the traditional traps.

The addition of a water reservoir to enhance humidity inside the CBDT traps had no effect on trap captures (Tables II and III). However, it should be considered that the water reservoir used had a very small (3 mm diameter) opening, allowing only a limited amount of water to evaporate. This was obvious by the fact that water replenishment in the reservoirs was usually not necessary during most of the trap checks. In additional experiments conducted in field cages using the FA-2 attractants in IPMT traps, the presence of water vapor enhanced the efficacy of the FA-2 attractants considerably [13]. Concerning the medfly selectivity of the traps, no conclusions can be made from the results of Table II, since the treatments tested are not comparable.

The results of the side experiment 2 conducted at Site 4, are given in Table IV. Medfly captures were similar in all treatments, except for the combination of NU+B with FA-2. In that case the captures were higher (although not statistically different) indicating a possible synergistic effect of NU+B with the FA-2 attractants. Remarkable, also, was the high

TABLE II. MEAN NUMBERS OF MEDFLIES AND OTHER INSECTS CAPTURED PER TRAP CHECK IN THE 10 TRAPS OF EACH TREATMENT (5 BLOCKS X 2 TRAPS OF EACH TREATMENT/BLOCK), DURING THE ENTIRE EXPERIMENTAL PERIOD OF 1994, IN THE STANDARD, CO-ORDINATED EXPERIMENTS AND IN THE SIDE EXPERIMENT 1. THE NUMBER OF TRAP CHECKS WAS 22 PER SITE FOR THE STANDARD CO-ORDINATED EXPERIMENT AND 20 FOR THE SIDE EXPERIMENT.

Treatments[a]	Number of medflies captured[b]			Other
	Males	Females	Total	Insects[c]
Standard experiment				
Site 1				
JT, TML	14.2	0.006	14.3	-
CBDT, FA-2	0.14	0.3	0.43	1.99
Site 2				
JT, TML	12.4	0.01	12.41	-
CBDT, FA-2	0.1	0.29	0.4	4.2
Side experiment 1				
JT, TML	7.8	0.007	7.8	-
CBDT, FA-2	0.08	0.2	0.3	5.8
CBDT, FA-2, wet	0.08	0.2	0.3	5.9
IPMT, NU+B	1.1	2.2	3.3	16.2

[a] For treatments see text.
[b] Because of high predation in CBDT, statistical analysis was not possible.
[c] The few other insects captured by Jackson traps were not counted.

TABLE III. NUMBER OF MEDFLIES AND OTHER INSECTS CAPTURED IN THE 10 TRAPS OF EACH TREATMENT DURING THE FIRST TRAP CHECK OF 1994, IN THE STANDARD CO-ORDINATED EXPERIMENTS (JULY 12), AND IN THE SIDE EXPERIMENT 1 (JULY 11). PREDATION BY YELLOWJACKET WASPS WAS NOT APPARENT DURING THE FIRST CHECK.

Treatments	Number of medflies captured[a]			Other
	Males	Females	Total	insects[b]
Standard experiment				
Site 1				
JT, TML	144.2a	0.0a	144.2a	-
CBDT, FA-2	3.9b	6.1b	9.7b	83.0
Site 2				
JT, TML	105.0a	0.1a	105.3a	-
CBDT, FA-2	1.4b	2.8b	4.2a	118.2
Side experiment 1				
JT, TML	65.7a	0.0b	65.7a	-
CBDT, FA-2	0.4c	0.6b	1.0c	119.9b
CBDT, FA-2, wet	0.5c	0.4b	0.9c	130.1b
IPMT, NU+B	5.3b	6.9a	12.2b	272.9a

[a] For statistical analysis see text.
[b] The few other insects captured by Jackson traps were not counted.

attractiveness of commercial orange juice, which was comparable to both that of NU+B and FA-2. Orange juice is inexpensive and readily available for implementation in medfly trapping. However, it was quite unselective, attracting a very large number of a wide variety of other insects species, including beneficials such as chrysopid predators. Isolation of the attractive compounds of orange juice could possibly lead to the detection of more selective medfly attractants. The rather high number of other insects captured by FA-2 baited traps in this experiment was due to the fact that these traps captured large numbers of an unidentified brown colored fly species. When used in IPMT traps provided with only water, the FA-2 attractants were of similar effectiveness with NU+B. Concerning female selectivity of the FA-2, this did not differ from NU+B or orange juice baited traps, the sex ratio being about 1:1.

TABLE IV. MEDFLIES AND OTHER INSECTS CAPTURED IN IPMT TRAPS, AVERAGE NUMBER OF INSECTS CAPTURED/DAY DURING TEN CONSECUTIVE DAYS (10 REPLICATES) BY TWO TRAPS OF EACH TREATMENT, IN THE SIDE EXPERIMENT 2 - 1994

Treatments	Number of medflies captured[a]			Other
	Males	Females	Total	insects
NU+B	8.9a	9.6a	18.5a	95.6a
NU+B & FA-2	11.6a	18.0a	29.6a	254.4a
FA-2, wet	10.1a	11.3a	21.4a	197.5a
Orange juice	10.5a	12.8a	23.3a	619.8b

[a] Means in each column followed by the same letter are not significantly different at the 0.05 level, Tukey's HSD test.

3.2. 1995 experiments

3.2.1. Medfly captures

The mean numbers of medflies and other insects captured during the entire experimental period in the co-ordinated experiments and the side experiment are given in Table V. The OBDT traps were ineffective, but showed somewhat higher captures than the dry, FA-2 baited IPMT traps.In contrast, the captures of medflies (especially of females) were quite high in the treatments IPMT, FA-2, wet, and IPMT, NU+B. At Site 1 and in the side experiment, female captures in treatment IPMT, FA-2, wet, were somehow higher than in IPMT, NU+B, whereas at Site 2 the captures in IPMT, NU+B, were about 40% higher than in IPMT, FA-2, wet. Apparently, the presence of humidity inside the IPMT traps is a decisive factor affecting effectiveness.

IPMT, FA-2, wet, traps were generally more female selective than IPMT, NU+B traps. The lack of humidity inside the dry traps, either the OBDT or the IPMT, FA-2, dry, is apparently one of the reasons for their inefficiency. In 1994 experiments, the sex ratio in NU+B baited or FA-2 baited IPMT traps was about 1:1 or slightly in favor of females. In 1995, however, more females were captured.

Dissections of samples of females captured in the side experiment (July 27 to August 2) showed that from a total of 168 females captured by the IPMT, FA-2,wet traps, 76.2% contained mature oocytes as compared to 68.5% out of 149 females captured by the IPMT, NU+B traps. In samples of 75 females per treatment from the standard coordinated

TABLE V. MEAN NUMBERS OF MEDFLIES AND OTHER INSECTS CAPTURED/TRAP/DAY IN THE TWO SITES OF THE CO-ORDINATED EXPERIMENT AND IN THE SIDE EXPERIMENT DURING 1995. IN THE STANDARD CO-ORDINATED EXPERIMENTS, THERE WERE FIVE TRAPS PER SITE PER TREATMENT AND THEY WERE CHECKED 16 TIMES DURING THE ENTIRE EXPERIMENTAL PERIOD. IN THE SIDE EXPERIMENT, FIVE TRAPS OF EACH TREATMENT WERE USED AND THEY WERE CHECKED THREE TIMES.

Traps and Treatments[a]	Mean number of medflies captured[b]			Sex ratio (F:M)	Mean no.[c] other insects captured
	Females	Males	Total		
Site 1					
JT, TML	0.007c	11.171a	11.178d	-	-
OBDT, FA-2	0.011c	0.000c	0.011c	-	0.451c
IPMT, FA-2, dry	1.454b	0.033c	1.487b	44.4	2.687b
IPMT, FA-2, wet	11.444a	0.956b	12.407a	11.9	12.400a
IPMT, NU+B	10.153a	1.258b	11.411a	8.1	14.535a
Site 2					
JT, TML	0.105d	29.571a	29.676ab	-	-
OBDT, FA-2	0.429c	0.007e	0.436d	-	0.382d
IPMT, FA-2, dry	5.116b	0.135d	5.250c	35.2	4.433c
IPMT, FA-2, wet	18.069a	1.553c	19.622b	11.7	21.451b
IPMT, NU+B	29.418a	4.855b	34.273a	6.1	37.462a
Side experiment					
IPMT, FA-2, wet	12.00a	4.60a	16.60a	2.6	18.73b
IPMT, NU+B	10.56a	6.13a	16.70a	1.7	38.43a

[a] For treatments, see text.
[b] For statistical analysis, see text.
[c] The few other insects captured by Jackson traps were not counted.

experiment (Site 2) taken at August 25, 47.2% of those captured by the IPMT, FA-2,wet traps contained mature oocytes, as compared to 32.4% of those captured in the IPMT, NU+B traps. These results suggest that
both treatments capture mature as well as immature females, in relative proportions that change with the season according to the composition of the adult population.

3.2.2. Other insects captured

As shown in Table V, the IPMT, FA-2, wet traps were slightly to much more medfly selective than the IPMT, NU+B ones. Also, they captured lower numbers of the beneficial *Chrysopa sp.*, the generalist predator *V. germanica*, and the very important olive pest, *B. oleae* (olive fruit fly), which was present in high numbers in the citrus orchards, most probably foraging for adult food. These results show that the FA-2 attractants are more medfly selective than NU+B, attracting fewer non-target insect species.

The results concerning maturity of captured females in treatments FA-2, FA-3 and NU+B showed, respectively, 80.8, 80.7 and 73.5% females with mature oocytes and were not statistically different (c^2). These results were similar to those obtained in 1995 for FA-2 and NU+B.

3.3. 1996 experiments

3.3.1. Medfly captures

The mean numbers of medflies and other insects captured during the entire experimental period at the two sites of the coordinated experiment and the one side experiment are given in Table VI. As can be seen from these results, in all cases and for females as well as for total captures, wet IPMT traps baited with FA-3 were, by far, the most attractive, followed by FA-2 baited traps. In contrast to the findings of previous year, FA-2 baited traps were more attractive than IPMT, NU+B traps. The increase in captures by the combination of NU+B and FA-2 suggested by our 1994 side experiments was only in part confirmed (Site-2, Treatment 4).

Tephri traps without insecticide, baited with NU+B (Site 1, treatment 4) were 3 - 4 times inferior to similarly baited IPMT traps, whereas Frutect traps (Site 1, treatment 6) captured as many medflies as the NU+B baited IPMT traps. However, this trap type has several disadvantages (laborious service, capture of large numbers of beneficial insects) which render it unsuitable for use and maybe even dangerous for the agro-ecosystem. Jackson traps baited with TML were slightly more attractive for males than FA-3 baited IPMT traps.

In addition to being highly attractive, FA-3 traps (as also FA-2 baited ones), were more female selective than the other trap systems tested, capturing 2 - 4 times more females than

TABLE VI. MEAN NUMBERS OF MEDFLIES AND OTHER INSECTS CAPTURED PER TRAP PER DAY AT THE TWO SITES OF THE STANDARD, CO-ORDINATED EXPERIMENTS, AND IN ONE SIDE EXPERIMENT DURING 1996

Traps and Treatments[a]	Mean number of medflies captured[b]			Sex ratio (F:M)	Mean no.[c] other insects captured
	Females	Males	Total		
Site 1					
JT, TML	0.003e	1.13a	1.14bc	0.003	0.9a
IPMT, FA-2, wet	0.69b	0.33ab	1.01ab	2.13	14.2c
IPMT, FA-3, wet	1.69a	0.77a	2.46a	2.19	4.3b
Tephri, NU+B	0.06d	0.08c	0.15d	0.75	5.3b
IPMT, NU+B	0.32c	0.19c	0.51c	1.73	10.8c
Frutect	0.29c	0.26c	0.55c	1.2	4.7b
Site 2					
JT, TML	0.00d	0.35a	0.35c	0.0	0.05c
IPMT, FA-2, wet	0.41ab	0.09b	0.51b	4.5	12.3a
IPMT, FA-3, wet	0.98a	0.24a	1.21a	4.1	4.3b
IPMT, NU+B & FA-2	0.42c	0.12ab	0.54b	3.6	15.3a
IPMT, NU+B	0.12c	0.05b	0.18c	2.3	9.1a
Side experiment					
IPMT, FA-2, wet	2.15a	0.85a	3.0a	2.5	10.5a
IPMT, FA-3, wet	6.66b	2.15b	8.8b	3.1	4.7b

[a] For treatments, see text.
[b] For statistical analysis, see text.
[c] Many small insects (parasitoids etc.) captured by Frutect traps were not counted.

males. These sex ratios are inferior to those observed in 1995 (for FA-2) but the same is true for NU+B. This discrepancy might be due to the differences in the population size and composition between the two years. FA-3 baited traps performed better than FA-2 baited ones throughout the experimental period in all experiments and apparently are suitable also for early detection of the population presence as shown by the trap captures in the first check days, when the population was very low. For example, during the first trap check, FA-3 baited traps captured 5 - 7 times more medflies than the JT, TML.

3.3.2. Other insects captured

The results concerning other insects captured (Table VI) clearly show that from the most promising treatments, the FA-3 baited IPMT traps were, by far, the most medfly selective, capturing up to 4 times fewer non-target insects than the FA-2 baited traps which were the next less selective. Tephri traps (without insecticide), baited with NU+B captured not only fewer medflies than NU+B-baited IPMT traps, but also fewer non-target insects. The Frutect trap, apart from the numbers given in the tables, captured a large number of small insects (probably parasitoids), as well as several lady beetles (Coccinellidae) which are predators of the citrus scale and other harmful homopterans. Hence, this trap type can be considered as detrimental to the citrus agro-ecosystem and its use should be avoided in citrus plantations.

3.4. 1997 experiments

3.4.1. Medfly captures

The mean numbers of medflies and other insects captured during the entire experimental period in the two sites of the coordinated experiment are given in Table VII. At both sites and for females as well as for total captures, wet IPMT traps baited with FA-3 were the most attractive followed by FA-3 baited wet Tephri traps. Since, in FA-3 baited wet IPMT traps stronger yellowjacket predation was observed than in other treatments, the real effectiveness of this treatment is actually higher than that appearing in the table. Similar was the situation for the males, with the exception of the JT, TML which, this year, captured many more males than the other treatments. Large differences in male captures were observed during the first four weeks of experimentation, whereas, later in the season, the differences in male captures between FA-3 baited IPMT wet traps and JT traps converged. In 1996, FA-3 baited IPMT traps captured slightly fewer males than TML baited JT traps. This may be due to the fact that, in 1996, trap installation coincided with the beginning of the fly activity, whereas, in 1997, by the time the experiments were initiated, the population was already high. Dry traps (IPMT or Tephri), captured similar numbers of medflies but represented about half of those captured by wet traps. NU+B baited IPMT traps captured almost as many flies of both sexes as did dry traps. In additional experiments [12], we found that the DDVP used in the traps of the coordinated experiments had a certain repellency to the flies. Hence, the real effectiveness of dry traps was actually higher than that shown in the table. Other side experiments conducted without using insecticide showed that FA-3 baited dry IPMT traps actually captured about 74% of the females compared to similarly baited wet ones [12]. It is interesting to note that wet Tephri traps at both sites captured fewer, but not significantly different, numbers of medflies than did wet IPMT traps.

FA-3 baited wet IPMT traps this year captured significantly more mature females (79.4%) (c^2 test) than did NU+B baited traps (71.7%), but the difference between the two treatments was not high (7.7%).

TABLE VII. MEAN NUMBERS OF MEDFLIES AND OTHER INSECTS CAPTURED PER TRAP PER DAY IN THE TWO SITES OF THE STANDARD, CO-ORDINATED EXPERIMENTS DURING 1997

Traps and Treatments[a]	Mean number of medflies captured[b]			Sex ratio	Mean no. other insects captured
	Females	Males	Total	F:M	
Site 1					
JT, TML	0.003d	6.8a	6.8a	0.0005	0.11f
IPMT, NU+ B	1.3c	1.2c	2.5c	1.1	49.2a
IPMT, FA-3, wet	3.0a	1.9b	4.9a	1.6	10.2b
IPMT, FA-3, dry	1.4b	0.9c	2.3bc	1.5	2.3d
Tephri, FA-3, dry	1.4b	0.8c	2.2bc	1.7	1.2e
Tephri, FA-3, wet	2.4ab	1.7bc	4.1ab	1.4	6.3c
Site 2					
JT, TML[c]	(0.0)	(9.1)	(9.1)	-	(0.07)
IPMT, NU+ B	2.7d	2.2c	4.5c	1.2	24.4a
IPMT, FA-3, wet	5.3a	3.2a	8.5a	1.6	5.9b
IPMT, FA-3, dry	2.9bc	2.1ab	5.1ab	1.4	1.5d
Tephri, FA-3, dry	2.1cd	1.3bc	3.4bc	1.6	0.7e
Tephri, FA-3, wet	3.1ab	1.9bc	5.0b	1.6	3.4c

[a] For treatments, see text.
[b] For statistical analysis, see text.
[c] Data derived from only two traps (results not included in the statistical analysis).

3.4.2. Other insects captured

The results concerning other insects captured are presented in Table VII and clearly show that the FA-3 baited IPMT traps were much more medfly selective than NU+B baited traps, and dry traps were much more selective than wet traps. NU+B baited IPMT traps were, by far, more attractive to the olive fruit fly, and FA-3 baited IPMT traps and NU+B baited ones captured similar numbers of celery flies. During spring and early summer of this year, citrus trees were highly infested by aphids and, as a result, high populations of beneficials such as *Chrysopa sp.* were present in the orchards. NU+B baited IPMT traps captured large numbers of these beneficials, hence were detrimental to the biological equilibrium of the agro-ecosystem, while FA-3 baited traps were not. Large to moderate numbers of yellowjackets were captured only by NU+B baited traps.

4. CONCLUSIONS

Our findings show that the newly developed, dry CBDT and OBDT traps [2, 4, 5] baited with the two synergistically acting attractants, (FA-2), were ineffective, at least under the summer field conditions of Chios (moderate to high temperature, moderate to strong wind, low to moderate relative humidity, high predation). In contrast, when the FA-2 attractants were used in appropriate traps (such as wet IPMT traps) they were as attractive and female selective as the traditional NU+B baited traps but more medfly selective. Effectiveness of FA-

2 was increased considerably by addition of TMA, a third synergistically acting attractant. The IPMT trap baited with all three attractants, water, and a surfactant was found to be the most effective, female targeted trapping system existing today. In comparison to other traps tested, it captured the highest total number of medflies, the lowest total number of other insect species, and the highest female to male ratio. The wet Tephri trap baited with FA-3 and provided with a DDVP plug followed in efficacy. Dry IPMT traps baited with the FA-3 were about 20% less effective than wet ones but much more medfly selective. Dry traps, in general, are much easier to service (no need to replace the water) and are considered more practical to use than wet ones, especially for mass trapping purposes. Special attention should be directed to the selection of a proper insecticide for dry traps, since our results showed that some formulations may be repellent to the flies. Wet or dry IPMT traps, with slight modifications [17], could be readily used to capture live females in order to assess their fertility as a method of verifying success of SIT programs.

ACKNOWLEDGEMENTS

This work was conducted within the framework of the research co-ordinated program "Medfly female attractant studies in support of the Sterile Insect Technique." Part of the co-ordinated program: "Improving the Sterile Insect Technique for Medflies by developing female medfly attractants for use with genetic sexing strains." The program was co-ordinated by the International Atomic Energy Agency (contract no. 7651/R1-R3/RB).

Many thanks are due to the coordinating Agency for providing materials and solving administrative and financial matters. Special thanks are due to Dr. J. Hendrichs (IAEA, Vienna, Austria) for his continuous interest and support. During the last experimental period, the experimental sites on Chios were visited by Dr. R. R. Heath, Dr. M. Heath (Gainesville, Florida, USA, Dr. J. Hendrichs and Mrs. M. Hendrichs. All contributed by providing useful materials and/or discussing constructive ideas. We sincerely thank the farmers P. Kardasilaris, S. Kokkinakis, G. Mavrogiannis, and G. Tsokos for allowing access to their farms. Also the agronomist K. Tsartsalis (Plant Protection Service of Chios) for providing administrative help.

REFERENCES

[1] BAKER, P.S., et al., Improvement of attractant dispensing systems for the Mediterranean fruit fly (Diptera: Tephritidae) sterile release program in Chiapas, Mexico, J. Econ. Entomol. **81** (1988) 1068-1072.

[2] EPSKY, N.D., et al., Visual and chemical cue interactions in a dry trap with food-based synthetic attractant for *Ceratitis capitata* and *Anastrepha ludens* (Diptera: Tephritidae), Environ. Entomol. **24** (1995) 1387-1395.

[3] EPSKY, N.D., et al., Field evaluation of female-targeted systems for *Ceratitis capitata* (Diptera: Tephritidae) in seven countries, J. Econ. Entomol. (1998) (in press).

[4] HEATH, R.R., et al., Development of a dry plastic insect trap with food-based synthetic attractant for the Mediterranean and Mexican fruit flies (Diptera: Tephritidae), J. Econ. Entomol. **88** (1995) 1307-1315.

[5] HEATH, R.R., et al., Systems to monitor and suppress *Ceratitis capitata* (Diptera: Tephritidae) populations, Florida Entomol. **79** (1996) 144-153.

[6] HENDRICHS, J., et al., Behaviour of female and male Mediterranean fruit flies, *Ceratitis capitata* in and around Jackson traps placed on fruiting host trees, Insect Sci. Appl. **10** (1989) 285-294.

[7] HENDRICHS, J., et al., Sex differences in movement between natural feeding and mating sites and tradeoffs between food consumption, mating success and predator evasion in Mediterranean fruit flies (Diptera: Tephritidae), Oecologia **86** (1991) 223-23.
[8] KATSOYANNOS, B.I., Evaluation of Mediterranean fruit-fly traps for use in the sterile insect-technique programmes, J. Appl. Entomol. **118** (1994) 442-452.
[9] KATSOYANNOS, B.I., HENDRICHS, J., Food bait enhancement of fruit mimics to attract Mediterranean fruit fly females, J. Appl. Entomol. **119** (1995) 211 - 213.
[10] KATSOYANNOS, B.I., KOULOUSSIS, N., Medfly female attractant studies in support of the Sterile Insect Technique. Experiments conducted during summer 1995 in Chios, Greece. Annual Report (1995) IAEA, 42 pp.
[11] KATSOYANNOS, B.I., PAPADOPOULOS, N., Medfly female attractant studies in support of the Sterile Insect Technique Experiments conducted during summer 1996 in Chios, Greece. Annual Report (1996) IAEA, 49 pp.
[12] KATSOYANNOS, B I., PAPADOPOULOS, N., Medfly female attractant studies in support of the Sterile Insect Technique Experiments conducted during summer 1997 in Chios, Greece. Annual Report (1997) IAEA, 30 pp.
[13] KATSOYANNOS, B.I., et al., Medfly female attractant studies in support of the Sterile Insect Technique. Experiments conducted during summer 1997 in Chios, Greece. Annual Report (1994) IAEA, 35 pp.
[14] KATSOYANNOS, B.I., et al., Response of *Ceratitis capitata* to citrus chemicals under semi-natural conditions, Entomol. Exp. Appl. **82** (1997) 181 -188.
[15] KATSOYANNOS, B.I., et al., Seasonal and annual occurrence of Mediterranean fruit flies (Diptera: Tephritidae) in Chios island, Greece: Differences between two neighboring citrus orchards, Ann. Entomol Soc. Am. **26** (1998) (in press).
[16] KATSOYANNOS, B.I., et al., Field evaluation of Mediterranean fruit fly (Diptera: Tephritidae) female selective attractants for use in monitoring, mass trapping and sterile insect technique programs, J. Econ. Entomol. (1998) (in press).
[17] KATSOYANNOS, B.I., et al., Development of a system of assessing the fertility of *Ceratitis capitata* in SIT programs, J. Econ. Entomol. (1998)(submitted).
[18] PAPAJ, D.R., et al., Use of fruit wounds in oviposition by Mediterranean fruit flies, Entomol. Exp. Appl. **53** (1989) 203 -209.
[19] VILLEDA, M.P., et al., Mediterranean fruit fly *Ceratitis capitata*: Behavior in nature in relation to different Jackson traps, Florida Entomol. **71** (1988) 154 -162.

DEVELOPMENT OF FEMALE MEDFLY, *Ceratitis capitata* (Wiedemann) ATTRACTANT SYSTEM FOR TRAPPING AND STERILITY ASSESSMENT: INVESTIGATIONS OF THE EFFICIENCY OF VARIOUS MEDFLY FEMALE TRAPPING COMBINATIONS IN THE WESTERN PART OF TURKEY IN SUPPORT OF THE STERILE INSECT TECHNIQUE

A. ZÜMREOGLU, Y. PALA, B. HEPDURGUN
Zirai Mücadele Arastirma Enstitüsü,
Plant Protection Research Institute,
Bornova, Izmir, Turkey

Abstract

Fourteen combinations, formed from eight traps including some of their versions and seven lures and attractants, were tested between the years of 1994-1997. The traps tested were: Jackson trap (JT); International Pheromone's McPhail traps (IPMT); yellow and white bottomed, Closed-bottom dry trap (CBDT); Open-bottom dry trap (OBDT); Agrisense dry trap; Tephri trap; and Frutect trap. The lures included: ammonium acetate (AA) plus putrescine (P), the FA-2 lure; AA+P+ trimethylamine (TMA), the FA-3 lure; NuLure and borax (NU+B); a special liquid lure; and Trimedlure (TML). For killing agents, either toxicant squares of DDVP or the surfactant Triton were used. Each experiment per year generally consisted of two independent tests that lasted eight weeks. The field plot design was linear or mostly randomized block design. Fruit infestation level was estimated for each test. Mating status of the captured females was also studied. The assessment was based on the number of adult captured. Since the yearly experiments were not based on the same treatments, some combinations were eliminated or modified after testing. In 1994, the CBDT baited with FA-2 was tested against JT, TML and seemed almost as attractive as JT with the percentage of 61% - 62% females. A modified trap, the OBDT was tested in 1995 along with IPMT, NU+B and Agrisense drytrap, FA-2 and they showed the weakest capture efficiencies. In 1996 when the OBDT and IPMT were tested with FA-2 and FA-3 lures, the traps with FA-3 showed better performance than the same traps with FA-2 (4.07 vs 1.96 and 10.32 vs 3.04 flies/trap/day (F/T/D) respectively). The Tephri trap, which was first tested with NU+B, had best capture efficiency results when used with DDVP plug. The Frutect trap with its own liquid lure gave the weakest result followed by OBDT, FA-2. In 1997, the Tephri, FA-3,wet, in both tests, seemed to be the most attractive treatment with 14.14 and 3.96 F/T/D followed by Tephri, FA-3,dry with 12.37 and 2.63 F/T/D, IPMT, FA-3,dry with 10.71 and 2.63 F/T/D, and IPMT-FA-3,wet with 8.97 and 2.51 F/T/D, OBDT-FA-3, which was contractors choice, seemed to be the weakest treatment with 1.51 and 0.95 F/T/D. However, it had the highest percentage of female capture percentage (94% - 97%). The wet versions of both the Tephri trap and IPMT captured higher percentages of females (92%-94%) and (91%-93%), respectively, than their dry versions (77%-83%) and (76%-79%), respectively. The mating status of the captured females seemed to be a little inconsistent in 1995 and 1996, whereas, the percentage of unmated females were higher than mated ones in all treatments in 1997.

1. INTRODUCTION

Among tephritid fruit flies, the Mediterranean fruit fly ,*Ceratitis capitata* Wied., is a good candidate species for studying new control strategies for improved plant protection technologies and improvements in Sterile Insect Technique (SIT) (e.g. development of male only strains) make it one of the most promising control methods for the medfly. However, an efficient and accurate trapping system is needed during the release and post-release phases to assess fly populations. Although several trap and lure combinations have been developed to detect and monitor medfly populations, most were based on food-based cues and attracted both sexes without showing any selectivity [1]. The development of the synthetic lure Trimedlure and the use of Trimedlure-baited traps such as used by Steiner, Jackson and Howell [2, 3, 4] greatly reduced the difficulties of observing the population trends of the adult medflies. Trimedlure, however, attracts mostly male insects. Following the FAO/IAEA Cooperative Research Program (CRP) on "Standardization of Medfly Trapping for Use in

Sterile Insect Programmes," which was completed in 1991, another CRP concerning the "Development of Female Medfly Systems for Trapping and Sterility Assessment" was organized by the Joint FAO/IAEA in 1994 to facilitate obtaining sterility data in a wild medfly population since there was no efficient female-specific attractant. Development of such an attractant is of importance since the new genetic sexing strains of medfly release only sterile males [5]. Accordingly, obtaining data for developing a female attractant for practical use in SIT will provide a simple index of wild medfly populations without the enormous task of separating wild from released sterile insects. In addition, it is anticipated that significant financial savings will result if simplified and more accurate methods for following the progress of the SIT programme through improved trapping and monitoring procedures are available.

2. MATERIALS AND METHODS

2.1. Treatments, plot selection and design

In 1994, both tests consisted of five lines of 4 traps each (2 JT, TML and 2 CBDT, FA-2) per line for a total of 10 JT and 10 CBDT per site. Traps were placed in a line with alternating trap types and rotated sequentially after each control. In 1995, and 1997 the test consisted of five blocks of 5-7 traps each in a randomized block design. In 1996, in the first test, field site consisted of 5 lines of 7 traps whereas randomized complete block design was used in the second test. Treatments used per year are as follows:

Trap	Lure	Retention	Years tested
Jackson Trap	TML	Sticky insert	1994 - 1997
CBDT	FA-2	Toxicant square	1994
CBDT	FA-2	Toxicant square	1995
OBDT	FA-2	Toxicant square	1995
Agrisense Dry Trap [a]	FA-2	Toxicant square, DDVP	1995
OBDT	FA-2	Sticky insert	1996
OBDT	FA-3	Sticky insert	1996,1997 [a]
IPMT	NU+B	Water	1995, 1997
IPMT	FA-2	Colored water	1995
IPMT	FA-2	Colored water	1996
IPMT	FA-3	Colored water	1996
IPMT, wet	FA-3	water, 0.1% triton	1997
IPMT, dry	FA-3	water, 0.1% triton	1997
Tephri	NU+B	water	1996
Tephri, wet	FA-3	DDVP [c] -water	1997
Tephri, dry	FA-3	DDVP	1997
Frutect Trap	Frutect	Yellow sticky display board	1996

[a] Contractor choice
[b] FA – *Lure 1 (ammonium acetate), Lure 2 (putrescine), Lure 3 (trimethylamine)*
[c] Used in test 2

2.2. General description of the test areas and trap placement

In 1994, tests were carried out in the experimental area of the Horticulture Department of the Faculty of Agriculture, University of Ege in Bornova (Site 1). The orchard has 500 acres and is 20 m above sea level. Annual precipitation varies between 200-700 mm. Pome and stone fruits, citrus and others (fig, pomegranate, walnut, quince olive, vine) are the main crops in the experimental area, but some tests were conducted on quince.

At Site 2, experiments were conducted on mandarins in Altinda_, which is the biggest village of Bornova. The 80 acre orchard is about 50 meters above sea level. The distance between two test sites is about 5 km. Annual precipitation is almost similar to that of the first test site. Apricot, plum, quince, citrus and olive are the main plants in the orchards.

In 1995, the tests were conducted in the same places - at Site 1, on apricots, peaches and plums and, at Site 2, on mandarins. In 1996 and 1997 all the tests were conducted in Altinda_ on apricot, peaches and mandarins respectively.

Traps were hung 1.5-2 m above the ground in the open space in the lower half of the southeastern part of host canopy. The distance between each two traps was 15-20 m. The TML plugs in the JTs were changed every two weeks. The lures of the FA-2 traps were changed at the end of 4-week period except Frutect trap which was tested only in 1996. The solutions of the wet traps were changed once a week. The inserts of the JTs, and OBDTs were replaced as needed.

2.3. Data collection and assessment; additional considerations

All traps were checked on the same day twice per week (Monday and Thursday) on a regular schedule for each 8-week test. The number of male and female medflies captured was recorded. The numbers of olive fruit fly *Bactrocera oleae* Gmel. were also recorded. The presence of fruit on the trees with traps of each blocks was recorded according to the abundance of fruits. Analysis of variance was conducted using data from female-targeted traps but trap catches in JTs were not included in the analysis. The infestation level was estimated by recording the percent of fruits with live immature stages of medfly at the beginning of each week per test in every major host in the experimental area. For this purpose, 10 fruits were picked at random and 10 trees per host plant were examined. Once per replicate, the presence of fruits, degree of fruit maturity and suitability for medfly oviposition of major host trees in the test area were also recorded. Fruit infestation level was estimated as a percentage of total fruits examined in 1995 and 1996. In 1997, it was estimated as the average number of larvae per kg of collected fruits.

As recommended during the first RCM which was held in Guatemala in May 1995, pH determination was made on freshly prepared protein solution as well as the end of each renewal.

In order to determine the female mating status, examination of spermathecae for sperm presence was made via dissection by utilizing the common methodology to standardize the determination of female mating status as described in the IAEA document D4-RC 581.

3. RESULTS

3.1. 1994 Experiment

Tables I and II give the overall results and data of the entire experiment. In the first test the JT, by capturing a total of 2403 flies (4.29 F/T/D) seemed more efficient than the CBDT

which captured a total of 1197 flies (2.13 F/T/D). This was confirmed statistically. In the second test, the CBDT captured a more flies (6 F/T/D) than did the JT (5.49 F/T/D), but this was not statistically significant. The percentage of females per trap were 0.5% and 0.7% for JTs and 62% and 61% for CBDTs respectively.

3.2. 1995 Experiment

Table III shows the results of the first test. Among the treatments, the IPMT baited with 9% NuLure + 3% borax seemed to be the most effective treatment by capturing a total of 3790 flies (14.03 F/T/D) followed by the IPMT, FA-2 (2.81 F/T/D), the CBDT, FA-2 (0.88 F/T/D) and the OBDT, FA-2 (0.55 F/T/D) respectively. However, apart from the IPMT, these three treatments formed in same statistical group. Percentage of females per trap were 69%, 58%, 59% and 54% respectively.

According to Table IV, which presents the results of the second test, the IPMT, NU+B again performed best with the capture of 29.84 F/T/D. Second best was the Agrisense dry trap baited with FA-2 which captured 13.68 F/T/D. The CBDT, FA-2 and OBDT, FA-2 produced the lowest capture efficiency with 4.89 and 4.61 F/T/D. Percentage of females found in these treatments were 61%, 68%, 74% and 78% respectively.

Mating status of captured medfly females is given in Table V.

According to the table, only the IPMT, NU+B gave the same results in both tests. Although 90% of females were found in the CBDT, FA-2 in the second test; there were only 40% during the first test. Some data was missing for mating status in 1995.

3.3. 1996 Experiment

The results are given in Tables VI and VII. In the first test, the IPMT, FA-3 captured total 2889 flies with the an average of 10.32 F/T/D followed by the Tephri, NU+B with 8.80 F/T/D. These two treatments fell into the same statistical group by discriminating from the others. Capture efficiencies from high to low were 4.07, 3.48, 3.04 and 1.96 F/T/D for the other treatments: OBDT, FA-3; Frutect; IPMT, FA-2; and OBDT, FA-2, respectively. Percentages of females per treatment were 83%, 85%, 83%, 89%, 74% and 73%, respectively.

As shown in Table VII, in the second test, the Tephri, NU+B seemed to be the most attractive treatment by capturing a total of 13,524 flies (average of 48.30 F/T/D) followed by the OBDT, FA-3 (average of 19.79 F/T/D) and the IPMT, FA-3, (average of 17.62 F/T/D). These three treatments formed in two separate statistical groups. The capture averages for the IPMT, FA-2, OBDT, FA-2 and Frutect trap were 6.98, 5.41 and 5.25 F/T/D, respectively. The percentage of females in the treatments were 88%, 89%, 80%, 86, 72% and 67%, respectively.

Mating status of captured females is given in Table VIII.

Table VIII shows that the highest unmated female capture percentage was in the OBDT, FA-2, and Frutect trap followed by the IPMT, FA-2. The IPMT, NU+B gave the same result as in 1995 experiment.

3.4. 1997 Experiment

The results of the entire experiment are given in Tables IX –XII.

During the first test, the IPMT, NU+B captured a total of 131 flies with an average of 0.62 F/T/D. The IPMT, FA-3, Tephri, FA-3, wet, IPMT, FA-3, dry, Tephri, FA-3, wet, IPMT,

TABLE I. OVERALL RESULTS AND DATA OF THE COMPARISON OF DRY TRAP FEMALE MEDFLY ATTRACTANTS (CBDT) VERSUS JACKSON TRAPS BAITED WITH TRIMEDLURE

Country:	TURKEY
Host:	Peach, quince
Altitude:	20 m
Avg.Temp, Min-Max:	26 °C (14.5 °C - 36.8 °C)
Avg.RH, Min-Max:	55 % (26.3 % - 82.3 %)
Trapping period (dates):	1/9/1994 - 27/10/1994
No. of Trap Days:	560

	Number of Medflies Captured [a]			Flies/Trap/Day			Relative Trap Efficiency			
Treatment	**Males**	**Females**	**Total[b]**	**Males**	**Females**	**Total**	**% Males**	**% Females**	**% Total**	**% Females Per Trap**
JT, TML	2391	12	2403a	4.27	0.02	4.29	84	2	67	0.5
CBDT, FA-2	469	728	1197b	0.83	1.30	2.13	16	98	33	61

[a] Total of 20 traps

[b] Totals followed by the different letters are significantly different, two-samples analysis test on square-root (X + 0.5) transformed data, P: 0.05

TABLE II. OVERALL RESULTS AND DATA OF THE COMPARISON OF DRY TRAP FEMALE MEDFLY ATTRACTANTS (CBDT) VERSUS JACKSON TRAPS WITH TRIMEDLURE

Country:	TURKEY
Host:	Mandarin
Altitude:	50 m
Avg.Temp, Min-Max:	24 °C (11.4 °C - 36 °C)
Avg.RH, Min-Max:	60 % (41 % - 80 %)
Trapping period (dates):	8/9/1994 - 3/11/1994
No. of Trap Days:	560 days

	Number of Medflies Captured [a]			Flies/Trap/Day			Relative Trap Efficiency			
Treatment	**Males**	**Females**	**Total[b]**	**Males**	**Females**	**Total**	**% Males**	**% Females**	**% Total**	**% Females Per Trap**
JT, TML	3053	21	3074a	5.45	0.04	5.49	71	0.01	48	0.75
CBDT, FA-2	1264	2094	3358b	2.26	3.74	6.00	29	99	52	62

[a] Total of 20 traps.

[b] Total followed by the same letters are not significantly different, two-samples analysis test on square-root (X + 0.5) transformed data, P: 0.05.

TABLE III. OVERALL RESULTS AND DATA OF THE CAPTURE EFFICIENCY OF VARIOUS TRAPS BAITED WITH CANDIDATE FEMALE MEDFLY ATTRACTANTS AND JACKSON TRAPS BAITED WITH TRIMEDLURE

Country:	TURKEY
Host:	Apricot, Peach, Plum
Altitude:	20 m
Avg.Temp, Min-Max:	27 °C (15.2 °C - 39.6 °C)
Avg.RH, Min-Max:	47 % (36.3 % - 52.7 %)
Trapping period (dates):	22/6/1995 - 17/8/1995
No. of Trap Days:	280
Jackson trap capture:	8.56 F/T/D
% females in Jackson trap:	0.46
Number of Jackson trap days:	280
Fruit infestation level (%):	Apricot 3-12%, Peach 2-22% , Pear 1-10%

	Number of Medflies Captured [a]			Flies/Trap/Day			Relative Trap Efficiency			
Treatment	**Males**	**Females**	**Total[b]**	**Males**	**Females**	**Total**	**% Males**	**% Females**	**% Total**	**%Females Per Trap**
CBDT, FA-2	75	170	245b	0.27	0.61	0.88	3	6	5	69
OBDT, FA-2	64	90	154b	0.23	0.32	0.55	3	3	3	58
IPMT, FA-2 (white bottom)	324	463	787b	1.15	1.66	2.81	14	16	15	59
IPMT, NU+B	1807	2123	3930a	6.45a	758	14.03	80	75	77	54

[a] Total of 20 traps in five replicates

[b] Totals followed by the same letters are not significantly different, Duncan's multiple range test on square-root (X +1) transformed data, P: 0.05

TABLE IV. OVERALL RESULTS AND DATA OF THE CAPTURE EFFICIENCY OF VARIOUS TRAPS BAITED WITH CANDIDATE FEMALE MEDFLY ATTRACTANTS AND JACKSON TRAPS BAITED WITH TRIMEDLURE

Country:	TURKEY
Host:	Mandarin
Altitude:	50 m
Avg.Temp, Min-Max:	25 °C (10.2 °C - 38.4 °C)
Avg.RH, Min-Max:	54 % (36 % - 70 %)
Trapping period (dates):	4/9/1995 - 16/10/1995
No. of Trap Days:	210
Jackson trap capture:	19 F/T/D
% females in Jackson trap:	0.06
Number of Jackson trap days:	210
Fruit infestation level (%):	Mandarin 2-7%

	Number of Medflies Captured [a]			Flies/Trap/Day			Relative Trap Efficiency			
Treatment	**Males**	**Females**	**Total[b]**	**Males**	**Females**	**Total**	**% Males**	**% Females**	**% Total**	**% Females Per Trap**
CBDT, FA-2	402	625	1027b	1.91	2.98	4.89	14	8	9	61
OBDT, FA-2	312	656	968ab	1.49	3.12	4.61	11	8	9	68
AGRISENSE,FA-2,dry	755	2118	2873ab	3.60	10.08	13.68	27	25	26	74
IPMT, NU+B	1367	4900	6267a	6.51	23.33	29.84	48	59	56	78

[a] Total of 20 traps in five replicates.

[b] Totals followed by the same letters are not significantly different, Duncan's multiple range test on square-root (X +1) transformed data, P: 0.05

TABLE V. MATING STATUS OF THE CAPTURED FEMALES DURING THE ENTIRE EXPERIMENT

Treatment	Test 1[a]		Test 2[a]	
	% Mated	% Unmated	% Mated	% Unmated
CBDT, FA-2	60	40	10	90
OBDT, FA-2	45	55	-	-
IPMT, FA-2	75	25	30	30
IPMT, NU+B	80	20	80	20

[a] Average of 8-weeks on the weekly 10 random samples from each treatment

FA-3, dry, and Tephri, FA-3, dry captured a total of 21, 20, 19, and 12 flies with averages of 0.13, 0.12, 0.11 and 0.06 F/T/D respectively. No fly was captured by the OBDT, FA-3 during this test. The percentages of females in the traps were 66%, 83%, 74%, 81% and 100%. The first fly, a single female, was captured on July 3rd, in the IPMT, FA-3, dry and the Tephri, FA-3, dry. One week after the first catch, another single female was found the IPMT, NU+B and the IPMT, FA-3, wet. Jackson traps caught the first fly ten days after the first catch in the experimental area. Capture efficiency of the Jackson traps was found to be 0.23 F/T/D after the IPMT, NU+B.

Details of the second test which was conducted when the medflies were building up their populations from middle to high are given in Table X. The F/T/D parameter was estimated to be 14.14, 12.37, 12.09, 10.71, 8.97 and 1.51 for the treatments of the Tephri, FA-3, wet, Tephri, FA-3, dry, IPMT, NU+B, IPMT, FA-3, dry, IPMT, FA-3, wet and OBDT, FA-3. All treatments except the OBDT, FA-3, represented the same statistical classification. Percentages of females in the traps were 90%, 91%, 76%, 92%, 77% and 97%. Details of the third test are given in Table XI.

During this test, the Tephri, FA-3, wet was estimated to be most powerful combination by capturing a total at 832 flies with the ratio of 3.96 F/T/D. This performance was also confirmed statistically. The Tephri, FA-3, dry, IPMT, FA-3, dry and IPMT, FA-3, wet showed very close capture efficiencies with the parameters of 2.63, 2.63, 2.51 F/T/D. The IPMT, NU+B and OBDT, FA-3 were weaker combinations with the parameters of 1.49 and 0.95 F/T/D. The percentage of females in the traps were 90%, 93%, 79%, 94%, 83% and 94% for the IPMT, NU+B, IPMT, FA-3, wet, IPMT, FA-3, dry, Tephri, FA-3, wet, Tephri, FA-3, dry and OBDT, FA-3 respectively. We are considering the second and third tests as a single experiment because the two subsequent 6-week periods were studied as the second and the third test, the results may be combined as shown in Table XII.

According to the table, similar results were found as shown in the Table X. which presents the results of the second test. All the treatments except the OBDT, FA-3 formed in the same statistical group. Captures, as F/T/D, were from the highest to low were 9.05, 7.50, 6.79, 6.67, 5.74 and 1.23 for the Tephri, FA-3, wet, Tephri, dry, IPMT, NU+B, IPMT, FA-3, dry, IPMT, FA-3, wet and OBDT, FA-3 respectively. The percentage of females in the traps varied between 76%-96% the lowest with the IPMT, FA-3, dry and the highest with the OBDT, FA-3.

TABLE VI. OVERALL RESULTS AND DATA OF THE CAPTURE EFFICIENCY OF VARIOUS TRAPS BAITED WITH CANDIDATE FEMALE MEDFLY ATTRACTANTS AND JACKSON TRAPS BAITED WITH TRIMEDLURE

Country:	TURKEY
Host:	Apricot, Peach
Altitude:	50 m
Avg.Temp, Min-Max:	28 °C (16.4 °C - 41 °C)
Avg.RH, Min-Max:	44 % (16.3 % - 69.3 %)
Trapping period (dates):	5/9/1996 - 31/10/1996
No. of Trap Days:	280
Jackson trap capture:	8 F/T/D
% females in Jackson trap:	0.04
Number of Jackson trap days:	280
Fruit infestation level (%):	Apricot 1-5%, Peach 1-8%

	Number of Medflies Captured [a]			Flies/Trap/Day			Relative Trap Efficiency			
Treatment	**Males**	**Females**	**Total[b]**	**Males**	**Females**	**Total**	**% Males**	**% Females**	**% Total**	**% Females Per Trap**
OBDT, FA-2	92	456	548d	0.33	1.63	1.96	5	6	6	83
OBDT, FA-3	174	966	1140b	0.62	3.45	4.07	11	14	13	85
IPMT, FA-2	146	706	852bc	0.52	2.52	3.04	9	10	10	83
IPMT, FA-3	322	2567	2889a	1.15	9.17	10.32	20	35	32	89
Tephri, NU+B	631	1833	2464a	2.25	6.55	8.80	39	25	28	74
Frutect	260	714	974bc	0.93	2.55	3.48	10	10	11	73

[a] Total of 30 traps in five replicates.

[b] Totals followed by the same letters are not significantly different, Duncan's multiple range test on square-root (X +1) transformed data, P: 0.05

TABLE VII. OVERALL RESULTS AND DATA OF THE CAPTURE EFFICIENCY OF VARIOUS TRAPS BAITED WITH CANDIDATE FEMALE MEDFLY ATTRACTANTS AND JACKSON TRAPS BAITED WITH TRIMEDLURE

Country:	TURKEY
Host:	Mandarin
Altitude:	50 m
Avg. Temp, Min-Max:	21 °C (8.8 °C - 34 °C)
Avg. RH, Min-Max:	50 % (47.3 % -81.3 %)
Trapping period (dates):	27/6/1996 - 22/8/1996
No. of Trap Days:	280 days
Jackson trap capture:	21 F/T/D
% females in Jackson trap:	0.04
Number of Jackson trap days:	280
Fruit infestation level (%):	Quince 2-16%, Mandarin 1-7%, Fig 5%

	Number of Medflies Captured [a]			Flies/Trap/Day			Relative Trap Efficiency			
Treatment	**Males**	**Females**	**Total[b]**	**Males**	**Females**	**Total**	**% Males**	**% Females**	**% Total**	**% Females Per Trap**
OBDT, FA-2	186	1329	1515d	0.66	4.75	5.41	3	6	5	88
OBDT, FA-3	594	4947	5541ab	2.12	17.67	19.79	10	22	19	89
IPMT, FA-2	383	1571	1954bcd	1.37	5.61	6.98	6	7	7	80
IPMT, FA-3	685	4248	4933ab	2.45	15.17	17.62	11	8	17	86
Tephri, NU+B	3767	9757	13524a	13.45	34.85	48.30	62	43	47	72
Frutect	490	979	1469cd	1.75	3.50	5.25	8	4	5	67

[a] Total of 30 traps in five replicates.

[b] Totals followed by the same letters are not significantly different, Duncan's multiple range test on square-root (X +1) transformed data, P: 0.05

TABLE VIII. MATING STATUS OF THE CAPTURED FEMALES DURING THE ENTIRE EXPERIMENT [a]

Treatment	Test 1		Test 2	
	% Mated	% Unmated	% Mated	% Unmated
OBDT, FA-2	40	60	30	70
OBDT, FA-3	60	40	65	35
IPMT, FA-2	-	-	35	65
IPMT, FA-3	-	-	80	20
Tephri, NU+B, DDVP [b]		-	40	60
Frutect	35	65	30	70

[a] Average of 8-week on the weekly 10 random samples from each treatment
[b] Test 2

Table XIII shows that the percentage of mated and unmated females were same as 40% mated, 60% unmated in the treatments of IPMT, NU+B; IPMT, FA-3, wet; and IPMT, FA-3, dry in both test. The Tephri, FA-3, dry and OBDT, FA-3 gave the highest percentage (90%) of unmated female captures in the second test and the entire experiment.

Table IV shows the olive fly captures during the entire RCA. In all cases, the IPMT and Tephri traps, both baited with NU+B, captured more olive flies than the other traps. The number of females were always higher than the males. Although fewer flies were captured by the other treatments, the number of females were still higher than the number of males.

In the above 3 years, the measurements varied between 8.05-9.16 for freshly prepared and 7.57-8.92 after renewing.

4. DISCUSSION AND CONCLUSIONS

During this Research Co-ordinated Programme, fourteen combinations formed from 8 traps including some of their versions and seven lures were tested. The candidate female targeted CBDT, FA-2 was first tested versus JT, TML in 1994 and, as a result of two subsequent tests, the capture efficiencies of two traps were almost the same. Although the percentage of females in the CBDT was lower (61%-62%) than the anticipated ratio, the relative trap efficiency was considerably high (98%-99%). However, in certain counts, some flies were found to be closely pressed together where the plastic trap body and petri dish interfaced at the bottom of the trap. This caused difficulties in counting and identifying the sex of the captured flies. Also, on rainy days, some raindrops that entered the trap caused undesirable moisture on the lures and toxicant squares. In view of these difficulties, an opaque green cylindrical open bottom trap with a yellow sticky paper insert (OBDT) was developed and tested together with the along with the CBDT with green visual cue in 1995. From the results of the two tests, the IPMT, NU+B was the most attractive treatment (14.03 and 29.84 F/T/D) followed by the IPMT, FA-2 (2.80 F/T/D). The capture efficiencies of the dry traps were 0.88 - 4.89 and 0.55 - 3.12 F/T/D, respectively. The difference between the treatments was statistically similar in both test. However, the IPMT baited with FA-2, attracted 3-5 times

TABLE IX. OVERALL RESULTS AND DATA OF THE CAPTURE EFFICIENCY OF VARIOUS TRAPS BAITED WITH CANDIDATE FEMALE MEDFLY ATTRACTANTS AND JACKSON TRAPS BAITED WITH TRIMEDLURE

Country:	TURKEY
Host:	Apricot, Peach
Altitude:	50 m
Avg.Temp, Min-Max:	28 °C (16 °C - 40.5 °C)
Avg.RH, Min-Max:	48 % (18 % -76 %)
Trapping period (dates):	27/6/1997 - 7/8/1997
No. of Trap Days:	210
Jackson trap capture:	0.23 F/T/D
% females in Jackson trap:	0
No. of Jackson trap days:	210
Average number of larvae per kg of fruit:	6 larvae/ kg of apricot, 7 larvae/ kg of peach, 18 larvae/ kg of pear

		Number of Medflies Captured [a]			Flies/Trap/Day		Relative Trap Efficiency			
%Females Per Trap	Treatment		Males	Females	Total	Males	Females	% Total	% Males	% Females	Total
	IPMT, NU+B	44	87	131	0.21	0.61	0.62	73	55	60	66
	IPMT, FA-3, wet	4	19	23	0.02	0.09	0.11	7	12	11	83
	IPMT, FA-3, DDVP, dry	7	20	27	0.33	0.1	0.13	12	13	12	74
	TEPHRI, DDVP, wet	5	21	26	0.02	0.1	0.12	8	13	12	81
	TEPHRI, DDVP, dry	0	12	12	0	0.06	0.06	0	7	5	100
	OBDT, FA-3, sticky insert	0	0	0	0	0	0	0	0	0	0

[a] Total of 30 traps in five replicates

TABLE X. OVERALL RESULTS AND DATA OF THE CAPTURE EFFICIENCY OF VARIOUS TRAPS BAITED WITH CANDIDATE FEMALE MEDFLY ATTRACTANTS AND JACKSON TRAPS BAITED WITH TRIMEDLURE

Country:	TURKEY
Host:	Peach, quince, mandarin
Altitude:	50 m
Avg.Temp, Min-Max:	22 °C (9.8 °C - 32 °C)
Avg.RH, Min-Max:	56 % (26 % - 87 %)
Trapping period (dates):	4/9/1997 - 16/10/1997
No. of Trap Days:	210
Jackson trap capture:	11 F/T/D
% females in Jackson trap:	0
No. of Jackson trap days:	210
Average number of larvae per kg of fruit:	24 larvae/ kg of peach, 30 larvae/ kg of quince, 10 larvae/ kg of mandarin

	Number of Medflies Captured [a]			**Flies/Trap/Day**			**Relative Trap Efficiency**			
Treatment	**Males**	**Females**	**Total**[b]	**Males**	**Females**	**Total**	**% Males**	**% Females**	**% Total**	**% Females Per Trap**
IPMT, NU+B	261	2278	2539a	1.24	10.85	12.09	14	21	20	90
IPMT, FA-3, wet	169	1715	1884a	0.80	8.17	8.97	9	16	15	91
IPMT, FA-3,DDVP, dry	546	1704	2250a	2.6	8.11	10.71	30	16	18	76
TEPHRI, DDVP, wet	252	2718	2970a	1.2	12.94	14.14	14	25	24	92
TEPHRI, DDVP, dry	601	1998	2599a	2.86	9.51	12.37	33	19	21	77
OBDT, FA-3, sticky insert	9	309	318b	0.043	1.47	1.51	0.0	3	2	97

[a] Total of 30 traps in five replicates

[b] Totals followed by the same letters are not significantly different, Duncan's multiple range test on log (X+1) transformed data, P:0.05

TABLE XI. OVERALL RESULTS AND DATA OF THE CAPTURE EFFICIENCY OF VARIOUS TRAPS BAITED WITH CANDIDATE FEMALE MEDFLY ATTRACTANTS AND JACKSON TRAPS BAITED WITH TRIMEDLURE

Country:	TURKEY
Host:	Mandarin
Altitude:	50 m
Avg.Temp, Min-Max:	16 °C (4 °C - 26.4 °C)
Avg.RH, Min-Max:	60 % (37 % -93 %)
Trapping period (dates):	16/10/1997 - 27/11/1997
No. of Trap Days:	210
Jackson trap capture:	2.11 F/T/D
% females in Jackson trap:	0
No. of Jackson trap days:	210
Average number of larvae per kg of fruit:	23 larvae/ kg

	Number of Medflies Captured [a]			**Flies/Trap/Day**			**Relative Trap Efficiency**			
Treatment	**Males**	**Females**	**Total[b]**	**Males**	**Females**	**Total**	**% Males**	**% Females**	**% Total**	**% Females Per Trap**
IPMT , NU+B	30	282	312bc	0.14	1.34	1.48	9	11	10	90
IPMT, FA-3, wet	38	489	527ab	0.18	2.33	2.51	11	18	18	93
IPMT, FA-3, DDVP, dry	116	437	553ab	0.55	2.08	2.63	34	17	18	79
TEPHRI, DDVP, wet	53	779	832a	0.25	3.71	3.96	15	30	28	94
TEPHRI, DDVP, dry	95	458	553ab	0.45	2.18	2.63	28	17	19	83
OBDT, FA-3, sticky insert	11	188	199c	0.05	0.90	0.95	3	7	7	94

[a] Total of 30 traps in five replicates

[b] Totals followed by the same letters are not significantly different, Duncan's multiple range test on log (X+1) transformed data, P:0.05

TABLE XII. OVERALL RESULTS AND DATA OF THE CAPTURE EFFICIENCY OF VARIOUS TRAPS BAITED WITH CANDIDATE FEMALE MEDFLY ATTRACTANTS AND JACKSON TRAPS BAITED WITH TRIMEDLURE

Country:	TURKEY
Host:	Peach, quince, mandarin
Altitude:	50 m
Avg.Temp, Min-Max:	19 °C (6.9 °C - 29.2 °C)
Avg.RH, Min-Max:	58 % (26.5 % - 98 %)
Trapping period (dates):	4/9/1997 - 27/11/1997
No. of Trap Days:	420
Jackson trap capture:	6.6 F/T/D
% females in Jackson trap:	0
No. of Jackson trap days:	420
Average number of larvae per kg of fruit:	24 larvae/ kg of peach, 30 larvae/ kg of quince, 17 larvae/ kg of mandarin

	Number of Medflies Captured [a]			**Flies/Trap/Day**			**Relative Trap Efficiency**			
Treatment	**Males**	**Females**	**Total** [b]	**Males**	**Females**	**Total**	**% Males**	**% Females**	**% Total**	**% Females Per Trap**
IPMT, Nu+B	291	2560	2851a	0.69	6.10	6.79	13	19	18	90
IPMT, FA-3, wet	207	2204	2411a	0.49	5.25	5.74	9	17	16	91
IPMT, FA-3, DDVP, dry	662	2141	2803a	1.57	5.10	6.67	30	16	18	76
TEPHRI, DDVP, wet	305	3497	3802a	0.73	8.33	9.05	14	26	24	92
TEPHRI, DDVP, dry	696	2456	3152a	1.65	5.85	7.50	32	18	20	78
OBDT, FA-3, sticky insert	20	497	517b	0.47	0.76	1.23	4	4	3	96

[a] Total of 30 traps in five replicates

[b] Totals followed by the same letters are not significantly different, Duncan's multiple range test on log (X+1) transformed data, P:0.05

TABLE XIII. MATING STATUS OF THE CAPTURED FEMALES DURING THE ENTIRE EXPERIMENT

Treatment	Test 1[a]		Test 2[a]	
	% Mated	% Unmated	% Mated	% Unmated
IPMT, NU+B	40	60	40	60
IPMT, FA-3, wet	40	60	40	60
IPMT, FA-3, dry	20	80	20	80
Tephri, FA-3, wet	60	40	50	50
Tephri, FA-3, dry	40	60	10	90
OBDT, FA-3	30	70	10	90

[a] 6-week averages on the 10 random samples from each treatments per week

TABLE XIV. OLIVE FLY CAPTURES ACCORDING TO THE YEARS AND TREATMENTS AS FLY PER TRAP DAILY (F/T/D)[a]

Year	Treatment	Test 1			Test 2			Test 3		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
1995	CBDT, FA-2			0.25			0.3			
	OBDT, FA-2			0.06			0.6			
	AGRISENSE, FA-2			0.52			1.0			
	IPMT, NU+B			1.25			2.4			
1996	OBDT, FA-2	0	0	0	0	0.01	0.01			
	OBDT, FA-3	0.007	0.04	0.05	0	0.04	0.04			
	IPMT, FA-2	0	0.5	0.5	0	0.06	0.06			
	IPMT, FA-3	0.025	0.17	0.20	0.03	0.17	0.20			
	Tephri, NU+B	0.32	0.62	0.94	0.83	1.61	2.44			
	Frutect	0	0.4	0.4	0.009	0.028	0.037			
1997	IPMT, NU+B	0.66	1.03	1.69	1.39	2.73	3.76	0.25	0.62	0.87
	IPMT, FA-3, wet	0.09	0.21	0.30	0.30	0.54	0.84	0.009	0.067	0.076
	IPMT, FA-3,dry	0.03	0.07	0.10	0.14	0.48	0.62	0.014	0.057	0.071
	Tephri, FA-3,wet	0	0	0	0.02	0.14	0.16	0	0.05	0.05
	Tephri, FA-3,dry	0	0	0	0.004	0.004	0.008	0.01	0.02	0.03
	OBDT, FA-3	0	0	0	0	0	0	0	0.02	002

[a] Number of trap days was 210 for 1997 and 1995 -2; others 280 trap days

TABLE XV. PH MEASUREMENTS ON THE PROTEIN SOLUTIONS

Year	Test 1		Test 2	
	Freshly prepared	After renewing	Freshly prepared	After renewing
1995	-	-	8.99±2.3	8.92±1.7
1996	8.96±1.1	8.90±1.5	8.05±1.08	7.57±1.37
1997	9.19±1.2	8.86±0.8	9.24±2.6	9.10±1.4

more medfly adults than the candidate traps during the test 1. The main factors which might have affected the trap catches were the shape, color and design of the traps as indicated by several researchers [6, 7]. The water inside the IPMT might have increased the number of captures since test 1 was conducted during the hot and dry conditions of the summer. The

larger area of the IPMTs might have been another advantage in increasing the number of captures. Considering these assumptions, in the second test, the IPMT with colored water, the cooperator's choice trap, was replaced with the plastic Agrisense dry traps which showed good performance for medfly males in previous CRP experiments [8]. The size and shape of this trap were similar to the candidate dry traps, except for the color, and, in test 2, this new treatment captured about 2.5-3 times more medfly adults (13.68 F/T/D) than the dry traps with female attractants (4.89 and 4.61 F/T/D) with slightly statistical differentiation. These results demonstrated that the trap type may affect the efficiency of the trap and lure combinations. Population density and fruit presence may also influence the trap catches. In 1995, during the first and second sampling periods of test 1, which was carried out on apricots, peaches and pears, a considerable number of medfly adults were captured when an adequate number of fruits existed on apricot trees. Towards the end of the test, when fewer fruits were present, the catches were reduced. Although this trend was noted, the number of medfly adults in the CBDTs were greater in the second test which was carried out on a single host plant than in the first with multiple hosts. A similar result was obtained in the first year experiment when catches in the CBDT, FA-2 were smaller than in the JT, TML when the population density was low to moderate (first test) and was higher when the medfly populations had increased in early autumn (second test). This led us to think that the CBDT was less effectiveness in low population density cases. In 1996, the CBDT was eliminated from testing and an additional lure component, trimethylamine (TMA) was introduced to the experiment to determine if it synergized the attractiveness of the FA-2. Both the OBDT and IPMT with the FA-3 lure showed better capture efficiency than the same traps with FA-2. This demonstrated that adding TMA increased the capture efficiencies of the combinations. The highest percentage of females capture (89%) was with the IPMT, FA-3. However, percentages were very close among the other female attractants except for Tephri, NU+B with yellow sticky panel which captured males as well as females.

During the second test in 1996, the Tephri, NU+B, and DDVP were the most attractive treatments with a average capture of 48.30 F/T/D. We believe that the addition of a DDVP plug ensured that the flies were killed and did not leave the trap, thus resulting in higher catches when compared to the catches during first test. However, in 1997, the percentage of females in this trap was lower (72%) when compared with the traps having FA-3 attractants, and this percentage varied between 80% - 89%. In 1997, the experiment was conducted during three different periods, starting before the first appearance of the pest through periods with moderate and high population levels. Although the second and third 6-week periods followed each other, the captures between these two periods were considerably different due to the changes in climatic conditions [9]. Thus, changes in the population within an area over time, and the ability to monitor this change with the female attractants were quite different than what we had expected with low, high and then moderate populations.

During the first test, few medflies were captured in all the treatments and the numbers were, from high to low: 0.62 F/T/D with IPMT, NU+B; 0.11 F/T/D with IPMT, FA-3, wet; 0.13 F/T/D with IPMT, FA-3, dry; 0.12 F/T/D for Tephri, FA-3, wet; and 0.06 F/T/D for Tephri, FA-3, dry. No flies were captured in OBDT, FA-3. The capture in the JT, TML was 0.23 F/T/D which indicated the low population density.

In the second test, which was carried out citrus (satsumas and mandarin) while fruit was maturing, the highest captures of the entire experiment were obtained. The Tephri, FA-3, wet captured 12.94 F/T/D - the highest among the treatments. However, all captures except for the OBDT, FA-3, varied between 8.97-12.94 F/T/D. Statistical analysis also confirmed this distribution. Capture in the JT, TML was 11 F/T/D, indicating the highest population density when compared with the other two tests.

The results of the Test 3, which was carried out under lower population density as compared with Test 2, were almost similar to the results of Test 2 with a little statistical deviation. However, when the results of subsequent tests (Table XII) were combined, almost the same results were obtained as in Table X. The percentage of females in the traps was over 90%, except for the IPMT, FA-3,dry and the Tephri, FA-3, dry which captured 76% and 78% females of the total catches. The capture with JT, TML was 2.11 F/T/D, indicating a low population density.

In 1995 mating status of female medflies seemed to be a little inconsistent, due to the poor catches in the treatments, especially in the CBDTs, time after time. However, the percentages of unmated females were almost 50/50 in the first test in CBDTs, whereas, they were not higher than 20 % in CBDTs in the second test.

In 1996, mating status of the captured female medflies was studied only in wet traps during the first test and results showed nearly a 50/50 mated/unmated ratio. However, the percentage of mated females seemed to be lower in the IPMT combinations. In the second test, during some periods, the females trapped in the dry traps were also studied and the percent of unmated females was 50% or less. This may be a confirmation of the recent findings [10].

In 1997, in both tests, the ratio of mated/unmated females was lower than in all other treatments. The Tephri, FA-3, dry and OBDT, FA-3 had the highest ratio of unmated females in the entire experiment.

Measurements of the pH of the protein solutions were noted for three years (1995-1997). The measurements varied between 8.05-9.24 for freshly prepared solution and 7.57-8.92 after renewing. Although there were a quite wide ranges between the figures, we did not observe any decay or undesirable bad smell in the renewed solutions. We do not exactly know the effects of the temperature and relative humidity on the pH. No big difference was observed between the values measured in mid-summer and autumn. However, the reference indicated that increasing the pH of the NuLure solution by adding 1-10 % Borax corresponded directly with an increase in number of medflies in the field trials. They also add that NuLure solutions containing 3% borax had pH 7.58 ± 0.27 and by increasing the amount of borax to5 %- 10%, the pH increased up to 8.5, which was the most attractive level to medfly females [11].

The reference [12] states that when sexually mature males are absent or scarce, sexually mature, virgin females may respond to male lures. Although a few females were captured in the early years of the experiment in Jackson traps, not a single female was captured in the same traps in 1997.

The IPMT and Tephri baited with Nu+B attracted some olive fruit fly adults. This was an expected case since hydrolyzed proteins have long been used in the control of fruit flies and trapping experiments [13]. On the other hand, ammonia derivatives and ammonium substances are the main olfactory lures used in the traps to monitor the olive populations [14, 15, 16, 17]. Although we do not know the attractiveness of putrescine and TMA to olive fly, at least ammonium acetate might have been an attractive source for olive fly[18].

4.1. General conclusions of the four-year experiments may be outlined as follows:

1. Testing the CBDT versus the Jackson trap gave almost the same results from the total catch standpoint. However, there was considerable variability in these two traps in relation to capture efficiency, the efficiency of CBDT was lower during the hot and dry season, and higher in warm and humid conditions.

2. The CBDT, FA-2 and OBDT, FA-2, which were the specifically developed as female-targeted traps, caught a significantly higher percentage of females did the JT, TML.

3. The capture efficiency of the CBDT, FA-2 or OBDT, FA-2 seemed inferior under very low population densities.

4. All the traps tested with the FA-3 attractants(AA+P+TMA), had considerably higher capture efficiencies than the same traps with the FA-2 attractants (AA+P). This demonstrated a good synergistic effect of TMA.

5. In low population densities, the first catches, although few in number, were found in the traps baited with the FA. There was about a ten day interval between capture by the FA baited traps and JT, TML from an early detection standpoint.

6. For female-capture selectivity, the OBDT usually captured the highest percentage of females. However, in general, all the female-targeted traps captured more females than the other treatments.

7. To some extent, the efficacy of the FA lures is dependent on the trap with which they are used. However, the lures seemed to be good female lures because they attracted olive flies as well as medflies.

8. Among the other treatments tested, the IPMT, FA-3 (dry and wet) and Tephri, FA-3 (dry and wet) seem to be the most attractive female targeted combinations. However, during heavy rains, water filled up the IPMT. Another disadvantage of this trap is that it is expensive and heavy. The Tephri trap, which is the smaller version of IPMT, is a very effective trap when used with a toxicant, but the limited carrying capacity of solution may be a problem in dry and hot conditions unless the solution is renewed often. The Tephri, FA-3, dry showed the same level effectiveness both from capture efficiency and female capture selectivity.

The objective of this CRP - the development of a female trapping system - was carried out in almost all dimensions in a given period. Future efforts should concentrate on developing new lures based on host odors, visual attractants, sexual pheromone components and standardized trap(s) on which actual problems are eliminated.

ACKNOWLEDGEMENTS

This research was supported by the joint FAO/IAEA Division under the project numbers 7654/R1/R2/R3 in the years of 1994–1997. The contractor and his co-workers are much grateful; primarily Dr. Jorge Hendrichs, Insect and Pest Control Section, and Mrs. Teresa Ann Benson, Research Contract Administration Section, and the other components of the FAO/IAEA Division for their valuable support and assistance.

REFERENCES

[1] CUNNINGHAM, R.T., Population detection, In "World Crop Pests, vol. 3B, Fruit flies, their biology, natural enemies and control," ROBINSON, A.S. and HOOPER, G. (eds.), Elsevier, Amsterdam (1989) 169-173.

[2] STEINER, L.F., Low cost plastic fruit fly trap. J. Econ. Entomol. **50** (1957) 508-509.

[3] HARRIS, E.J., et al., Sticky traps for detection and survey of three Tephritids, J. Econ. Entomol. **50** (1971) 508-509.

[4] HOWELL, J.F., et al., Comparison of the efficiency of three traps for the Mediterranean fruit fly baited with minimum amounts of Trimedlure, J. Econ. Entomol. **68** (1975) 277-279.

[5] HENDRICHS, J., et al., Use of sterile male-only releases as "Biological Pesticides" for control of Mediterranean fruit in commercial fruit production, In " Fruit Flies of Economic Importance," PIEDADE GUERRIERIO, J. (ed.), IOBC wprs Bulletin 17 (6) (1994) 212-224.

[6] KATSOYANNOS, B.I., Some factors affecting field responses of Mediterranean fruit flies to colored spheres of different sizes, In: Fruit Flies, Proc. 2nd Int. Symp. Colymbari, Crete, ECONOMOPOULOS, A.P. (Ed.), Elsevier Sci. Pbs. (1987) 469-474.

[7] ECONOMOPOULOS, A.P., Use of traps based on color and/or shape, In "World Crop Pests, vol. 3B, Fruit flies - their biology natural enemies and control," ROBINSON, A.S. and HOOPER, G. (eds.), Elsevier, Amsterdam (1989) 315-327.

[8] ANONYMOUS, Standardization of medfly trapping for use in sterile insect technique programmes. Final report of a co-ordinated research programme 1986-1992, IAEA TECDOC-883, ISSN 1011-4289, IAEA, May 1986, 206 pp.

[9] DELRIO, G., ZÜMREO_LU, A., Attractability range and capture efficiency of medfly traps. In "Fruit Flies of Economic Importance," CABALLERO, R (ed.), Proc. SEC/IOBC Intern. Symp. Athens, Nov. 1982, A.A. Balkema, Rotterdam (1983) 445-450.

[10] EPSKY, N.D., et al., Visual cue and chemical cue interactions in a dry trap with food based synthetic attractant for *Ceratitis capitata* and *Anastrepha ludens* (Diptera: Tephritidae), Entomol. Soc. Am. **24** (1995) 1387-1395.

[11] HEATH, R.R., et al., pH effect on the attractiveness of a corn hydrolysate to the Mediterranean fruit and several *Anastrepha* species (Diptera: Tephritidae), J. Econ. Entomol. **87** (1994) 1008-1013.

[12] NAKAGAWA, S., et al., Response of female Mediterranean fruit flies to male lures in the relative absence of males, J. Econ. Entomol. **63** (1970) 227-229.

[13] STEINER, L.F., Fruit fly control in Hawaii with poisoned-bait sprays containing protein hydrolysates, J. Econ. Entomol. **45** (1952) 838-843.

[14] DELRIO, G., et al., Comparative studies of food, sex and visual attractant for the olive fruit fly, Proc. Internat. Symp. of SEC/IOBC on Fruit Flies of Economic Importance, Athens, Greece, Nov. 16-18, 1982 (1983) 465-472.

[15] HANIOTAKIS, G.E., VASSILIOU-WATE, A., Effect of combining food and sex attractants on the capture of *Dacus oleae* flies, Entomologia Hellenica **5** (1987) 27-33.

[16] ZERVAS, G.A., Significant increase of *Dacus oleae* trapping using sex and food attractants separately in the same time, Proc. Internat. Symp. of CRC/IOBC, Rome, Italy (1987) 433-442.

[17] ZÜMREO_LU, A., et al., Investigations on the efficiency of various trap-lure systems against the fruit flies of economic importance in Izmir, First Turkish Entomology Congress, Izmir, Turkey (1987) 377-386.

[18] MAZOR, M.S., et al., The role of ammonia in the attraction of females of the Mediterranean fruit fly to protein hydrolysate baits, Entomol. Exp. Appl. **43** (1987) 25-29.

DEVELOPMENT OF MEDFLY FEMALE ATTRACTANT SYSTEMS FOR TRAPPING IN SPAIN

J.P. ROS
Instituto Nacional Investigaciones Agrarias,
Madrid, Spain

Abstract

This report contains information from a four-year research programme co-ordinated by the International Atomic Energy Agency. The objective of the programme was to develop a trapping system for females of the Mediterranean fruit fly (medfly), Ceratitis capitata (Diptera: Tephritidae), for practical use in Sterile Insect Technique (SIT) programs and to design and evaluate a trap to obtain eggs from wild female medflies in order to estimate sterility induction in the field population. Spain (through INIA) participated in this programme because of interest in the control of medfly in this area of the Mediterranean. Citrus, peaches, plums, apricots and other subtropical fruits are some of the cultures which are severely attacked by this pest. To facilitate comparison of results, all the trials of 1994 - 97 were carried out in the same orchards. These orchards were located near the Malaga airport in the south of Spain on the Mediterranean coast. Female medfly attractants tested were three food based "female"attractants (FA-3), namely ammonium acetate (AA), 1,4 diaminobutane (putrescine) and trimethylamine, all formulated to last at least one month. These attractants were evaluated either in combinations of two (AA + putrescine, termed FA-2) or all three (termed FA-3). The attractants were tested in various traps including the plastic International Pheromone's McPhail traps (IPMT) and Tephri traps, a Spanish trap similar to the IPMT. Traps were used either as a dry trap (provided with DDVP) or a wet trap (provided with water and 0.01% surfactant). Jackson traps with Trimedlure (JT,TML), a routinely usedmale medfly trapping system, was also used. Based on the results of successive years, we can observe progress towards the project goals. In 1994, the development of the FA-2 attractants (P+AA) with their selectivity for female medflies was a significant effort towards reaching future goals. The synergism of trimethylamine with the FA-2 attractants, yielding the FA-3 attractants (P+AA+TMA), used with the new Tephri Trap produced very good results in 1996. There were no doubt about the results of the different traps and attractants in this year. At last, the experiment of 1997 demonstrated the efficiency of both traps (Tephri and IPMT) with or without water inside the trap. The choice of which trap to use will depend, perhaps, on the temperature or humidity of the local climate, but both always gave excellent results. We now have an excellent trap and attractant to capture medfly females to assure good control of the pest. Killing the first overwintering generation of medfly females by a mass trapping method will provide a powerful tool to avoid big populations in the summer and fall in countries with moderate climates.

1. INTRODUCTION

From 1986 to 1992, the JOINT FAO/IAEA Division, which has long been involved in medfly eradication and control activities in different regions, organized a co-ordinated research programme with the objective of standardizing the new and the most common medfly traps in several countries of Africa, Europe and Central America.

Spain (through INIA) participated in this programme because of interest in the control of medfly in this area of the Mediterranean. Citrus, peaches, plums, apricots and other subtropical fruits are some of the cultures which are severely attacked by this pest [1, 2, 3].

From these studies, the Trimedlure plug and NuLure were found to be the best attractants for males and females respectively and the International Pheromone's McPhail trap (IPMT) was the best of all traps tested [4].

In September 1993, the Joint FAO/IAEA Division offered a research contract to INIA to participate in the Co-ordinated Research Programme (CRP) "Development of Female Medfly Attractant Systems for Trapping and Sterility Assessment". The objective of this programme was to obtain data on the efficacy of new medfly female attractants (synthetic substances) and new traps supporting it. The development of a female trapping system for medflies would be a major step towards improving eradication and control technologies because it could be used to

monitor wild populations when used with the male-only strains currently employed in Sterile Insect Technique (SIT) programs. Also, a good female medfly attractant would give a great impulse to the mass trapping systems to control this noxious insect in the countries not involved in SIT programmes.

During the months of September - November of 1994 -1997, we carried out the experiments with the female attractants and traps that the Agency was proposing in yearly base protocols for all countries participating in this CRP.

Two Co-ordination Meetings were established by the Agency to evaluate the results obtained to date. The first was held in Antigua, Guatemala in May 1995. The action of a combination of putrescine and ammonium acetate (FA-2 attractants) against NuLure as control was discussed by the participants. The efficacy of a new dry trap, the Closed bottom dry trap or CBDT, was evaluated. For the next two years, the FA-2 attractants plus a third component, trimethylamine, (FA-3 attractants) were tested in a new trap, the Open bottom dry trap or OBDT, and in two other traps - Tephri Trap and Frutect Trap. The second Coordination Meeting was held in Funchal, Madeira Island, Portugal in January 1997. The FA-3 attractants formulated in slow release polyethylene bag dispensers, showed the most powerful attraction to medfly females known to date. The performance of the IPMT and Tephri Trap were evaluated as very efficient by the participants. The proposed protocol for the last year of the Programme was to compare the efficiency of these two traps baited with the three component (FA-3) lure.

We describe here the year by year detail of the trials carried out in Spain under the framework of the Programme cited above.

2. MATERIAL AND METHODS

2.1. Placement

To facilitate comparison of results, all the trials of 1994 - 97 were carried out in the same orchards. These orchards were located near the Malaga airport in the south of Spain on the Mediterranean coast.

2.2. Traps and attractants

The protocols for the first year were established by the Agency. After the discussion at the end of the first CRP meetings, new protocols were established and the next basic protocols gave the investigators the opportunity to test some local traps or attractants.

2.3. Trap placement

Traps were hung 1 - 2 m above the ground in the lower half of the south eastern part of host tree canopy.

2.4. Plot selection and design

Six or seven blocks (A-F) or (A-G) of four, five or six traps each (variable with the protocol) were placed in the different fruit trees in orchards previously selected for the trials. These types of fruit trees in the orchards were the follows: Mango, Chirimoya, Orange (Navelina, Navalate, Valencia late) and Mandarin.

2.5. Data collection

All traps were checked twice per week on a regular schedule and the number of male and female medflies captured was recorded. Traps within a block were rotated sequentially after each sample. The trials were run on 2 replicates of 4 weeks each (minimum) during fall of 1994, 95, 96 and 97.

2.6. Statistical analysis

All data were transformed by the change of variable X'= SQRT(X + 0.5),
X = flies/trap/day or female/trap/day (F/T/D). An analysis of variance procedure was performed with the transformed data and followed by a Duncan's multiple range test to estimate the signification of the means. Generally, data from the Jackson trap was not included in the analysis.

2.7. Traps and attractants

Since the traps and attractants were variable each year, we are providing a complete description of the what was used during a given year.

2.7.1. 1994 Traps

There were five blocks (A-E) of four traps each (2 JT, TML, 2 CBDT, FA-2)

1. Jackson Trap (JT, TML) - a triangular trap with white sticky insert and baited with a trimedlure (TML) plug placed in a plastic basket hung inside the trap in the middle of the horizontal wire hanger

2. Closed bottom, dry trap with green visual cue **(CBDT, FA-2)** [5,6] - a closed, cylindrical trap with a green visual cue, baited with putrescine and ammonium acetate (FA-2) patches placed inside the trap on a lateral wall, two toxicant squares on top and bottom, and lateral holes for fly entrance and chemical release

2.7.2. 1995 Traps

There were six blocks of five traps each. The complete traps are described below.

1. Jackson Trap (JT, TML) - as above

2. CBDT, FA-2 - as above.

3. Open bottom plastic dry trap (OBDT, FA-2) an opaque green trap baited with putrescine and ammonium acetate patches (FA-2) placed inside the trap on a lateral wall and a yellow sticky insert to catch the attracted insects

4. Tephri Trap (Tephri, FA-2) - a yellow and clear plastic McPhail type trap with four symmetric lateral holes, baited with FA-2 attractants and containing two toxicant squares to kill the attracted insects

5. International Pheromone's McPhail Trap (IPMT, NU+B) - the standard plastic McPhail type trap baited with an aqueous solution of 9% of NuLure and 3% borax

2.7.3. 1996 Traps

There were seven blocks (A-G) of seven traps each. The complete traps are described below.

1. Jackson Trap (JT, TML) - as above

2. Open Bottom Dry Trap (OBDT, FA-2) a cylindrical plastic trap with an open bottom, a yellow sticky insert to capture the flies and

baited with FA-2 attractants on the inside wall

3. Open Bottom Dry Trap (OBDT, FA-3) a cylindrical trap with a open bottom, a yellow sticky insert to capture the flies, baited FA-3 patches on the inside lateral wall of the trap

4. Tephri, FA-2 - a Tephri trap baited with FA-2 attractants placed on in inside lateral wall of the trap and a piece of toxicant glued at the top

5. Tephri, FA-3 - a Tephri trap baited with FA-3 attractants placed on an inside lateral wall of the trap and a piece of toxicant glued at the top

6. International Pheromone's McPhail Trap (IPMT, NU+B) as previously described.

7. Frutect Trap - a trap consisting of a sticky yellow plastic square with a sphere in the middle and containing its own attractant inside the sphere

2.7.4. 1997 Traps

There were seven blocks (A-G) of six traps each. The traps and attractants of the basic and optional protocol are described below.

1. Jackson Trap (JT, TML) - as previously described

2. International Pheromone's McPhail Trap (IPMT, NU+B) - as previously described . **3. International Pheromone's McPhail Trap (IPMT, FA-3, wet)** - an IPMT trap used as a wet trap, baited with the FA-3 attractants, 300 ml water, and 1-2 drops of surfactant in the base to facilitate capture of flies

4. International Pheromone McPhail Trap (IPMT, FA-3, dry) - an IPMT used as a dry trap, baited with FA-3 attractants, and a piece of DDVP as killing agent

5. Tephri Trap (Tephri, FA-3, dry) - a Tephri trap used as a dry trap, baited with the FA-3 attractants, and a piece of DDVP in the basket of the trap

6. Tephri Trap (Tephri, FA-3, wet) - a Tephri trap used as a wet trap, baited with the FA-3 attractants, 200 ml water, 1-2 drops of surfactant in the base, and an optional piece of DDVP in the basket of the trap.

3. RESULTS

3.1. 1994 Experiments

TABLE I. CAPTURES OF FLIES (MALES/FEMALES) IN BLOCKS A AND B (ORANGE NAVELATE) - 81 Days

Trap	Attractant	Captures	Males	Females	Flies/T/D	Females/T/D
JT	TML	1499	1499	0	9.2	0
JT	TML	1140	1140	0	7.0	0
CBDT	FA-2	456	25	431	2.8	2.6
CBDT	FA-2	524	34	490	3.2	3.0

TABLE II. CAPTURES OF FLIES (MALES/FEMALES) IN BLOCKS C, D AND E(HIRIMOYA) - 81 Days

Trap	Attractant	Captures	Males	Females	Flies/T/D	Females/T/D
JT	TML	1265	1262	3	5.2	0
JT	TML	1274	1274	0	5.2	0
CBDT	FA-2	230	19	211	0.9	0.8
CBDT	FA-2	151	13	138	0.6	0.5

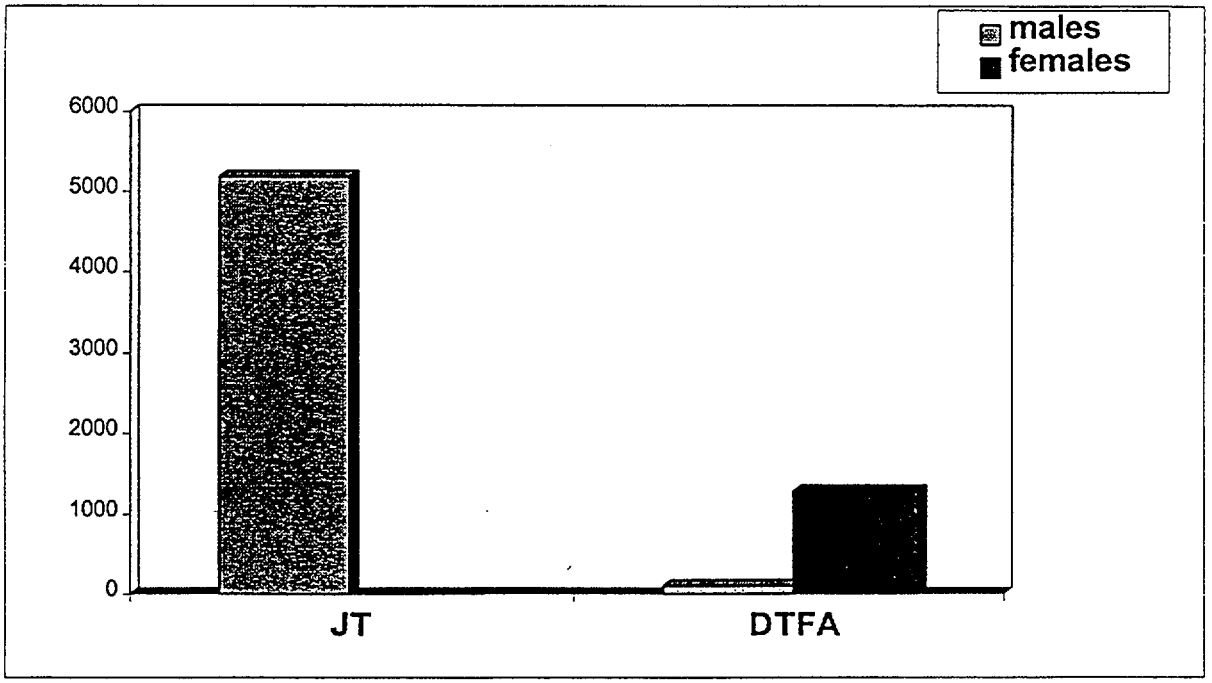


Fig. 1. Medfly captures obtained by each type of trap in the experiment of 1994; DTFA=CBDT

3.2. 1995 Experiments

TABLE III. CAPTURES OF FLIES (MALES/FEMALES) IN BLOCK A (MANGO) - 56 DAYS

Trap	Attractant	Captures	Males	Females	Flies/T/D	Females/T/D
JT	TML	670	669	1	11.9	0
CBDT	FA-2	172	35	137	3	2.4
OBDT	FA-2	136	22	114	2.4	2
Tephri	FA-2	378	112	267	6.7	4.7
IPMT	NU+B	393	103	290	7	5.1

TABLE IV. CAPTURES OF FLIES (MALES/FEMALES) IN BLOCK B (CHIRIMOYA) - 56 DAYS

Trap	Attractant	Captures	Males	Females	Flies/T/D	Females/T/D
JT	TML	767	761	6	13.6	0
CBDT	FA-2	29	3	26	0.5	0.4
OBDT	FA-2	101	10	91	1.8	1.6
Tephri	FA-2	80	7	73	1.4	1.3
IPMT	NU+B	484	94	390	8.6	6.9

TABLE V. CAPTURES OF FLIES (MALES/FEMALES) IN BLOCK C (ORANGE) - 56 DAYS

Trap	Attractant	Captures	Males	Females	Flies/T/D	Females/T/D
JT	TML	1300	1282	18	22.8	0.3
CBDT	FA-2	226	18	208	4.3	3.7
OBDT	FA-2	462	17	445	8.2	7.9
Tephri	FA-2	821	80	741	14.6	13.2
IPMT	NU+B	1631	391	1240	29.1	22.1

TABLE VI. CAPTURES OF FLIES (MALES/FEMALES) IN BLOCKS D, E AND F (MANDARIN) - 56 DAYS

Trap	Attractant	Captures	Males	Females	Flies/T/D	Females/T/D
JT	TML	1433	1426	7	25.5	0
CBDT	FA-2	78	22	56	13.9	1
OBDT	FA-2	97	21	76	1.7	1.3
Tephri	FA-2	474	136	339	8.4	6
IPMT	NU+B	845	196	649	15	11.5

TABLE VII. NUMBER OF FLIES CAPTURED BY EACH TYPE OF TRAP IN ALL EXPERIMENTS - MALAGA 1995

Trap	Attractant	Total Captures	Flies/T/D	Statistical Mean
JT	TML	4170	12.4	2.7 a
IPMT	NU+B	3354	9.9	2.3b
Tephri	FA-2	1755	5.2	1.7b
OBDT	FA-2	796	2.3	1.2d
CBDT	FA-2	505	1.5	1.1d

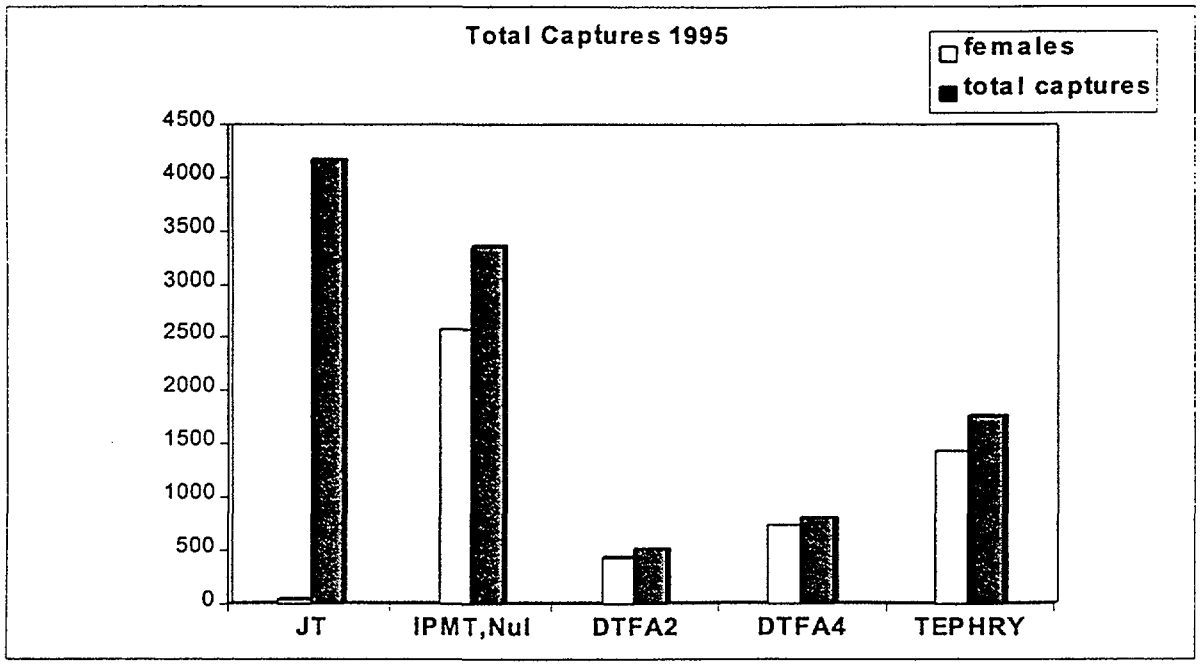


Fig. 2. Medfly captures (total and females) obtained by each type of trap in the experiment of 1995; IPMT,Nul=IPMT,NU+B, DTFA2=CBDT, DTFA4=OBDT

TABLE VIII. NUMBER OF FEMALES CAPTURED BY EACH TYPE OF TRAP IN ALL EXPERIMENTS - MALAGA 1995

Trap	Attractant	Total Females	Females/T/D	Statistical Mean
IPMT	NU+B	2570	7.6	1.7 a
Tephri	FA-2	1420	4.2	1.4 a
OBDT	FA-2	726	2.3	1.2b
CBDT	FA-2	427	1.5	1.1b
JT	TML	32	0	0c

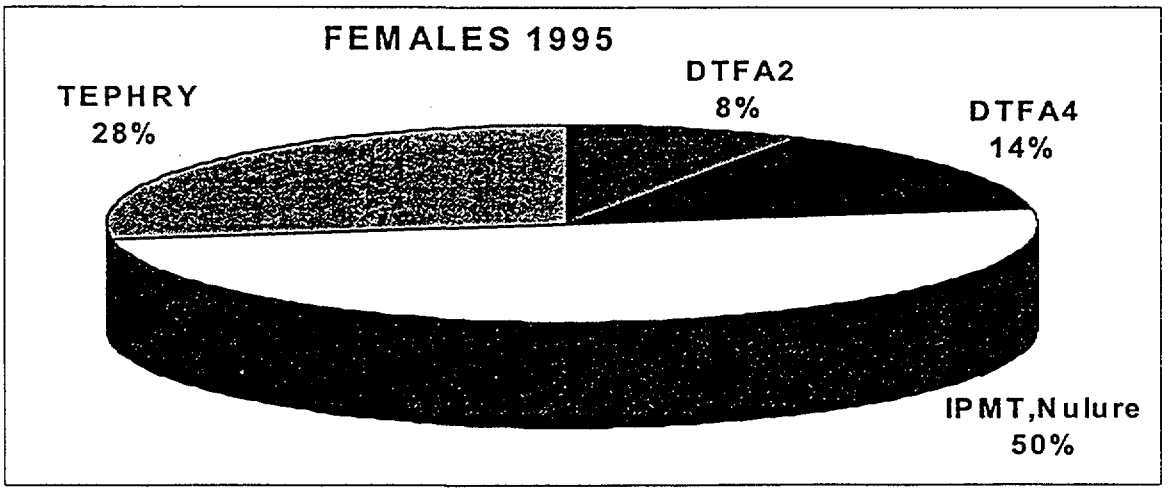


Fig. 3. Percentage of medfly females trapped by each type of trap in the experiment of 1995; DTFA2=CBDT, DTFA4=OBDT

3.3. 1996 Experiments

TABLE IX . CAPTURES OF FLIES (MALES/FEMALES) N BLOCK A (MANGO) - 56 DAYS

Trap	Attractant	Captures	Males	Females	Flies/T/D	Females/T/D
JT	TML	3751	3739	12	66.9	0
OBDT	FA-2	223	77	146	4.1	2.6
OBDT	FA-3	701	157	544	12.5	9.7
Tephri	FA-2	1008	226	782	18	13.9
Tephri	FA-3	1623	324	1299	29	23.1
IPMT	NU+B	801	88	721	14.4	12.8
FRUTECT	Frutect	2195	108	464	10.2	8.2

TABLE X. CAPTURES OF FLIES (MALES/FEMALES) IN BLOCK B (CHIRIMOYA) - 56 DAYS

Trap	Attractant	Captures	Males	Females	Flies/T/D	Females/T/D
JT	TML	2356	2354	2	42	0
OBDT	FA-2	102	19	93	2	1.6
OBDT	FA-3	398	51	347	7.1	6.2
Tephri	FA-2	359	35	324	6.4	5.7
Tephri	FA-3	325	25	300	5.8	5.3
IPMT	NU+B	159	11	148	2.8	2.6
FRUTECT	Frutect	152	73	179	4.5	3.2

TABLE XI. CAPTURES OF FLIES (MALES/FEMALES) IN BLOCK C (ORANGE) - 56 DAYS

Trap	Attractant	Captures	Males	Females	Flies/T/D	Females/T/D
JT	TML	1489	1487	2	26.5	0
OBDT	FA-2	256	28	228	4.5	4
OBDT	FA-3	573	63	510	10.2	9.1
Tephri	FA-2	524	36	488	9.3	8.7
Tephri	FA-3	577	59	518	10.3	9.2
IPMT	NU+B	429	11	418	7.6	7.6
FRUTECT	Frutect	250	81	169	4.4	3

TABLE XII. CAPTURES OF FLIES (MALES/FEMALES) IN BLOCKS D, E, AND F (MANDARIN/ORANGE) - 56 DAYS

Trap	Attractant	Captures	Males	Females	Flies/T/D	Females/T/D
JT	TML	4732	4723	9	28.1	0
OBDT	FA-2	943	377	566	5.6	3.3
OBDT	FA-3	1794	577	1217	10.6	7.2
Tephri	FA-2	2191	454	1737	13	10.3
Tephri	FA-3	4049	664	3385	24.1	20.1
IPMT	NU+B	926	139	787	5.5	4.6
FRUTECT	Frutect	697	277	420	4.1	2.5

TABLE XIII. CAPTURES OF FLIES (MALES/FEMALES) IN BLOCK G (ORANGE) - 56 DAYS

Trap	Attractant	Captures	Males	Females	Flies/T/D	Females/T/D
JT	TML	1861	1861	0	33.2	0
OBDT	FA-2	204	27	177	3.6	3.1
OBDT	FA-3	278	55	223	4.9	4
Tephri	FA-2	461	32	429	8.2	7.6
Tephri	FA-3	748	56	692	13.3	12.3
IPMT	NU+B	305	18	287	5.4	5.1
FRUTECT	Frutect	281	79	203	5	3.6

TABLE XIV. NUMBER OF FLIES CAPTURED BY EACH TYPE OF TRAP IN ALL EXPERIMENT - MALAGA 1996

Trap	Attractant	Total Captures	Flies/T/D	Statistical Mean
JT	TML	14191	36.2	5.9 a
OBDT	FA-2	1748	4.4	1.7 d
OBDT	FA-3	3744	9.5	2.6 c
Tephri	FA-2	4543	11.5	2.8 c
Tephri	FA-3	7222	18.4	3.5 b
IPMT	NU+B	2628	6.7	2.3 cd
FRUTECT	Frutect	2282	5.8	2.1 d

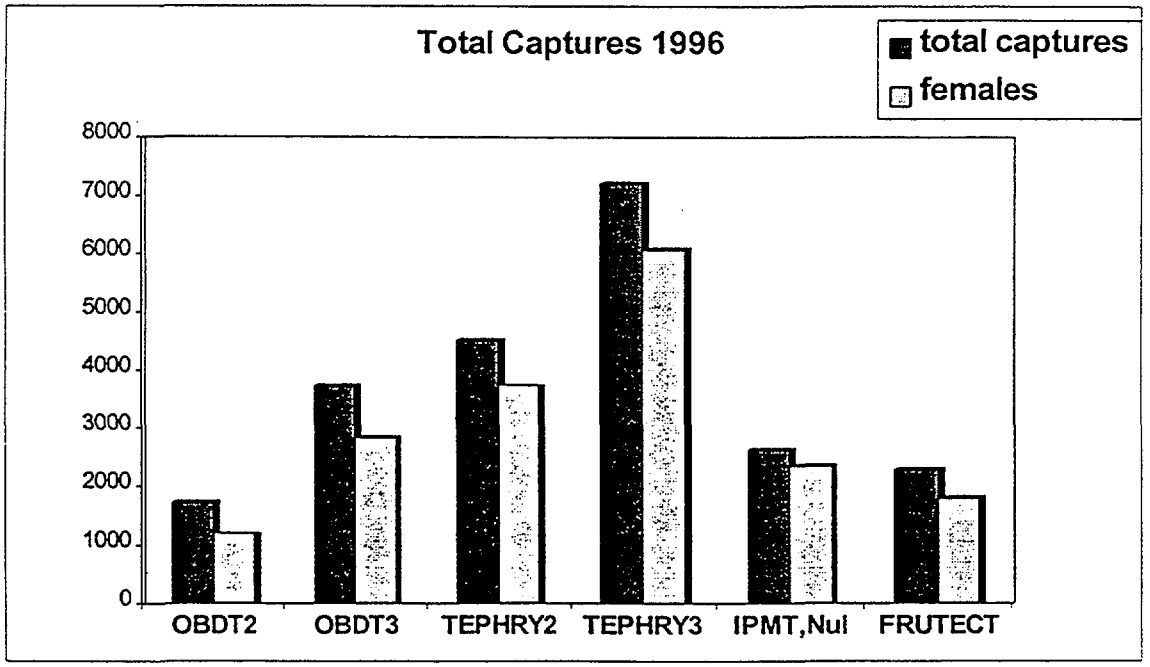
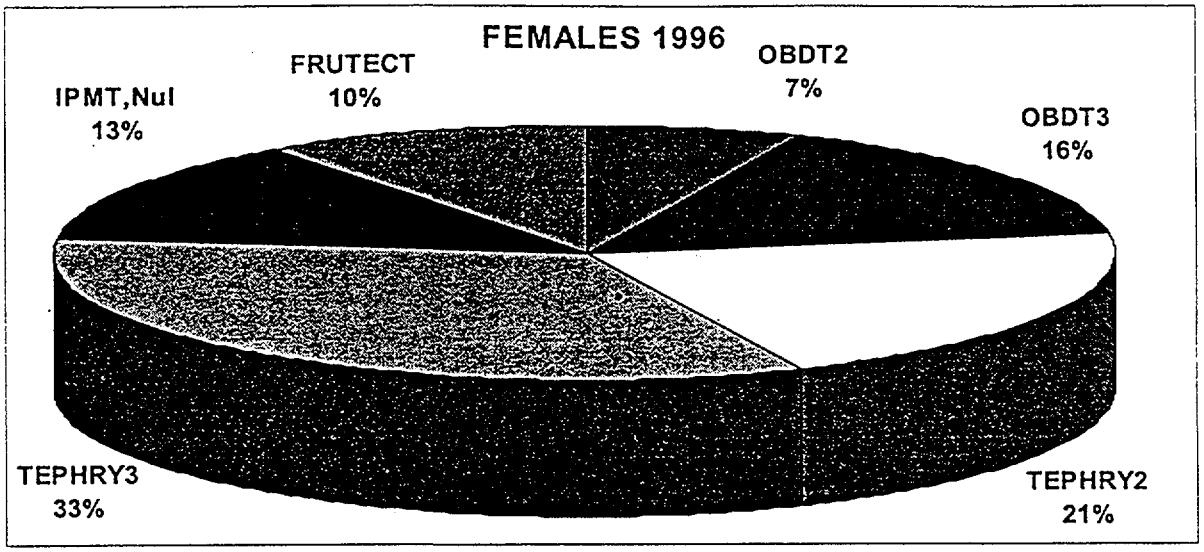


Fig.4. Medfly captures (total and females) obtained by each type of trap in the experiment of 1996;OBDT2=OBDT, FA-2, OBDT3=OBDT, FA-3, Tephry2=Tephri, FA-2, Tephry3=Tephri, FA-3, IPMT,Nul=IPMT, NU+B

TABLE XV. NUMBER OF FEMALES CAPTURED BY EACH TYPE OF TRAP IN ALL EXPERIMENT - MALAGA 1996

Trap	Attractant	Total Females	Females/T/D	Statistical Mean
JT	TML	35	0	0.7 d
OBDT	FA-2	1210	3	1.5 c
OBDT	FA-3	2841	7.2	2.3 b
Tephri	FA-2	3760	9.5	2.6 b
Tephri	FA-3	6094	15.5	3.2 a
IPMT	NU+B	2361	6	2.2 bc



Frutect	Frutect	1802	4.5	1.9 c

Fig 5. Percentage of Medfly females trapped by each type of trap in the experiment of 1996, OBDT2=OBDT, FA-2, OBDT3=OBDT, FA-3, Tephry2=Tephri, FA-2, Tephry3=Tephri, FA-3, IPMT,Nul=IPMT,NU+B

3.4. 1997 Experiments

TABLE XVI. CAPTURES OF FLIES (MALES/FEMALES) IN BLOCKS A AND B (MANGO) - 59 DAYS

Trap	Attractant	Captures	Males	Females	Flies/T/D	Females/T/D
JT	TML	4725	4723	2	40	0
IPMT	NU+B	1458	70	1388	12.3	11.7
IPMT, wet	FA-3	2639	192	2447	22.3	20.7
IPMT, dry	FA-3	2978	567	2411	25.2	20.4
Tephri, dry	FA-3	2968	637	2331	25.1	19.7
Tephri, wet	FA-3	3137	391	2746	26.5	23.2

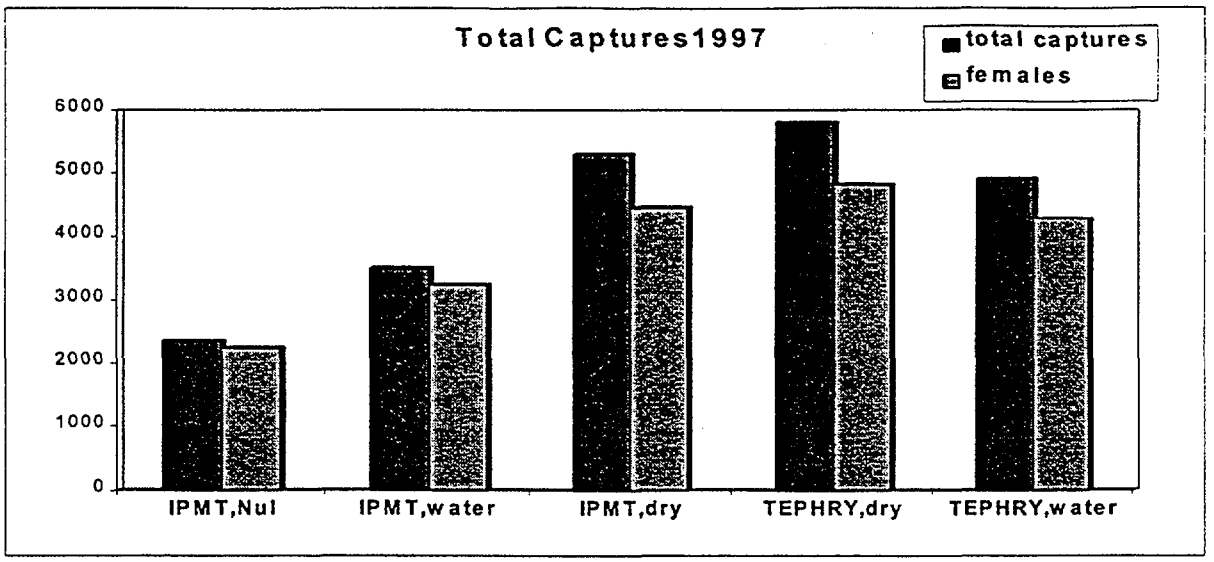


Fig 6. Medfly captures (total and females) obtained by each type of trap in the experiment of 1997; IPMT,Nul=IPMT,NU+B, all other traps contained the FA-3 lures

TABLE XVII. CAPTURES OF FLIES (MALES/FEMALES) IN BLOCK C (ORANGENAVELATE) - 59 DAYS

Trap	Attractant	Captures	Males	Females	Flies/T/D	Females/T/D
JT	TML	615	592	23	10.4	0.4
IPMT	NU+B	527	12	515	8.9	8.7
IPMT, wet	FA-3	468	32	436	7.8	7.3
IPMT, dry	FA-3	802	124	678	13.5	11.5
Tephri, dry	FA-3	940	111	829	15.9	14
Tephri, wet	FA-3	1009	145	964	17.1	16.3

TABLE XVIII. CAPTURES OF FLIES (MALES/FEMALES) IN BLOCKS D AND E (CHIRIMOYA) -59 DAYS

Trap	Attractant	Captures	Males	Females	Flies/T/D	Females/T/D
JT	TML	2724	2720	4	23	0
IPMT	NU+B	395	39	356	3.3	3
IPMT, wet	FA-3	277	32	245	2.3	2
IPMT, dry	FA-3	1259	104	1155	10.6	9.8
Tephri, dry	FA-3	1599	177	1422	13.5	12
Tephri, wet	FA-3	358	36	292	2.8	2.4

TABLE XIX. CAPTURES OF FLIES (MALES/FEMALES) IN BLOCK F (ORANGE VALENCIA LATE) -59 DAYS

Trap	Attractant	Captures	Males	Females	Flies/T/D	Females/T/D
JT	TML	876	870	6	14.8	0
IPMT	NU+B	68	4	64	0.5	0.5
IPMT, wet	FA-3	140	29	111	1.1	0.9
IPMT, dry	FA-3	258	48	210	2.2	1.7
Tephri, dry	FA-3	253	32	221	2.1	1.9
Tephri, wet	FA-3	118	22	118	1	0.8

TABLE XX. NUMBER OF FLIES CAPTURED BY EACH TYPE OF TRAP IN ALL EXPERIMENTS - MALAGA 1997

Trap	Attractant	Captures	Flies/T/D	Statistical mean
JT	TML	11144	30.9	
IPMT	Nu + B	2362	6.5	2.18 b
IPMT, wet	FA-3	3524	9.7	2.64 b
IPMT, dry	FA-3	5307	14.7	3.45 a
Tephri, dry	FA-3	5815	16.1	3.53 a
Tephri, wet	FA-3	4900	13.6	3.07 a

TABLE XXI. NUMBER OF FEMALES CAPTURED BY EACH TYPE OF TRAP IN ALL EXPERIMENTS - MALAGA 1997

Trap	Attractant	Females	Females/T/D	Statistical mean
JT	TML	6	0	
IPMT	NU+B	2258	6.2	2.12 c
IPMT, wet	FA-3	3239	9	2.50 bc
IPMT, dry	FA-3	4465	12.4	3.16 a
Tephri, dry	FA-3	4823	13.4	3.22 a
Tephri, wet	FA-3	4289	11.9	2.86 ab

TABLE XXII. MEAN NUMBER OF TOTAL FLIES AND FEMALES CAPTURED BY EACH TRAP TYPE MALAGA - 1997

Trap	Mean flies/trap/day	Mean Statistical *	Mean females/trap/day	Mean Statistical*
Tephri, FA-3, dry	16.1	3.53a	13.4	3.22a
IPMT, FA-3, dry	14.7	3.45a	12.4	3.16a
Tephri, FA-3, wet	13.6	3.07a	11.9	2.86ab
IPMT, FA-3, wet	9.7	2.64b	9.0	2.50bc
IPMT, NU+B	6.6	2.18b	6.2	2.12c

* In a column, means with the same letter are not significantly different (alpha= 0.05)
(F=12.28, P=0.0001 for flies/T/D analysis and F= 6.93 P= 0.001 for females/T/D analysis)

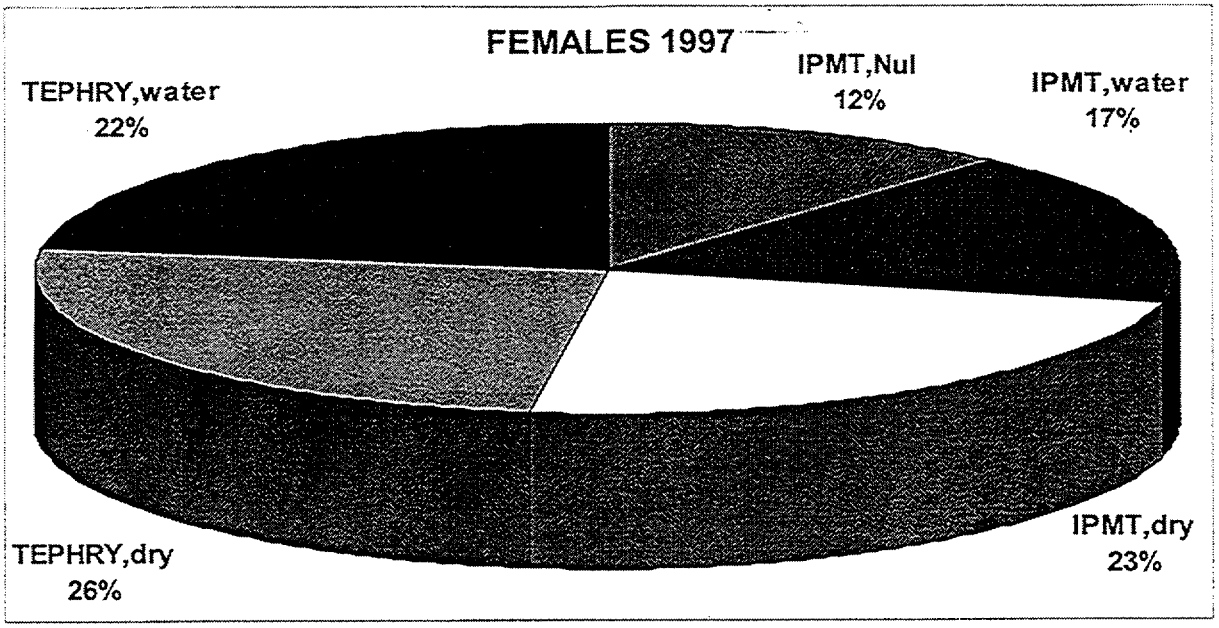
4. DISCUSSION

By following the results of successive years, we can observe progress towards the project goals. In 1994, the development of the FA-2 attractants (P+AA) with their selectivity for medfly females was a big step towards reaching future goals.

The synergism of trimethylamine with the FA-2 attractants, yielding the FA-3 attractants (P+AA+TMA), used with the new Tephri Trap produced very good results in 1996. There were no doubt about the results of the different traps and attractants in this year. The use of trimethylamine was an authentic discovery.

At last, the experiment of 1997 demonstrated the efficiency of both traps (Tephri and IPMT)
with or without water inside the trap. The choice of which trap to use will depend, perhaps, on the temperature or humidity of the local climate, but both always gave excellent results.

Now we have an excellent trap and attractant to capture medfly females to assure good control of the pest. Killing the first overwintering generation of medfly females by a mass



trapping method would be a good practice to avoid big populations in the summer and fall in countries with moderate climates.

Fig 7. Percentage of Medfly females trapped by each type of trap in the experiment of 1997

ACKNOWLEDGEMENTS

This work was supported by the International Atomic Energy Agency (Research Contract SPA 7724/RB), Vienna, Austria. We are grateful to Dr Hendrichs his encouragement during the course of this investigation and the real strike up of science and friendship with all participants of the different countries that have taken part in this programme.

REFERENCES

[1] ROS, J.P., et al., Estudio de la eficacia en campo de dos formulaciones de atrayentes para la mosca de la fruta *C. capitata* Wied., Bol. San. Veg. Plagas No 2, Ministerio de Agricultura. España (1979).

[2] ROS, J.P., La mosca mediterranea dela Fruta *Ceratitis capitata Wied.* Biología y métodos de control, Hojas divulgadora Ministerio de Agricultura, No 8/88 España (1988).

[3] ROS, J.P., Estudio de diferentes combinaciones de productos atrayentes en las pulverizaciones cebo contra *C. capitata* Wied., Bol. San. Veg. Plagas No 16, Ministerio de Agricultura. España (1990).

[4] IAEA, Standardization of medfly trapping for use in sterile insect technique programmes, Final report of a Co-ordinated Programme 1986-1992, IAEA-TECDOC-883, Vienna (1996).

[5] EPSKY, N.D., et al., Visual cue and chemical cue interactions in a dry trap with food-based synthetic attractant for *C. capitata* and *Anastrepha ludens* (Diptera:Tephritidae), Environ. Entomol. **24** (1995) 1387-1395.

[6] HEATH, R.R., et al., Development of a dry plastic insect trap with food-based synthetic attractant for the Mediterranean and Mexican fruit flies (Diptera:Tephritidae), J. Econ. Entomol. **88** (1995) 1307-1315.

ROS, J.P., et al., Ensayos de campo con un nuevo atrayente de hembras de la mosca de la fruta Wied. (Diptera: Tephritidae), Bol. San. Veg. Plagas No 32, Ministerio de Agricultura España. (1996).

DEVELOPMENT OF FEMALE MEDFLY ATTRACTANTS TO SUPPORT THE STERILE INSECT TECHNIQUE: EXPERIMENTS CONDUCTED IN MADEIRA, PORTUGAL

R. PEREIRA
Programa Madeira-Med,
Direcção Regional de Agricultura,
Madeira, Portugal

Abstract

With the availability of genetic sexing strains of Mediterranean fruit fly, *Ceratitis capitata* (Wied.), it is possible to release only sterile males in SIT programs. The availability of a new female medfly attractant can reduce labor costs because program progress can be monitored by trapping females instead of the usual male trapping with its labor intensive identification of sterile and wild males. Three Madeira studies evaluated new female attractants; ammonium acetate, putrescine and trimethylamine. One study was carried out in the same area during two different periods of 1996 (8 June to 27 July and 12 October to 30 November). A second study was conducted between 24 May to 05 July, 1997, in two different areas at the same altitude. One area had a wild fly population (sex ratio 1:1) and the other was in an area where sterile males were released (sex ratio > 9:1). The third study, conducted from 18 October to 29 November, 1997, compared wild fly captures at low elevations (80m) with those at high elevations (700m). The first study showed that the inclusion of the attractant trimethylamine significantly increased the wild female medfly. The percentage of medfly females in the traps with the two and the three attractants (FA-2 and FA-3) was more than 70%. In the second and third studies, the dry traps were more effective than wet traps in capturing wild medfly females. In areas with only wild females, the percentage of females captured was more than 62%. In areas where sterile males were released, the percentage of females captured was between 12% and 19%. In conclusion, the new attractants captured high percentages of females and, when combined with medfly genetic sexing strains, can reduce program costs significantly.

1. INTRODUCTION

The work reported here is part of the FAO/IAEA Co-ordinated Research Programme (CRP) entitled "Development of Female Medfly Attractant Systems for Trapping and Sterility Assessment."

The objective of this CRP was to develop a trapping system for female medflies which could be used in practical Sterile Insect Technique (SIT) programmes where medfly genetic sexing strains are used [1], in detection programmes based on capturing female medflies, and in suppression programmes using female traps for mass trapping [2].

In Madeira, a SIT programme for medfly control has been started using a temperature sensitive lethal (*tsl*) strain, for release of sterile males only [3]. If a suitable female medfly trapping system were available, it could be used in association with SIT to suppress female medfly populations by mass trapping prior to the release of sterile males and to monitor feral populations. One of these methods is mass trapping combined with post-harvest removal of fruit fly hosts [4]. Mass trapping of females, using the new female attractants, would enhance population suppression before the release of sterile males.

2. MATERIALS AND METHODS

Madeira (32°N, 17°W) is located 980 km WSW of mainland Portugal. Its two principal islands, Porto Santo (50 km^2) and Madeira (740 km^2), are populated by 255,000 people and fruit and vegetable production is widespread. The climate of Madeira is variable, depending upon altitude and northern/southern aspect. On the whole, climate is moderated by the effects of the surrounding sea.

The studies were done on the southern coast of Madeira (Fig. 1). The first study in Ribeira Brava Valley (0-160 m altitude) during two seasons assessed wild medfly phenology, the second study in Ribeira Brava Valley assessed the effect of sterile releases on the wild medfly population (Quebradas, 80 m altitude) and the third study compared wild medfly populations at low elevations (Quebradas) with populations at higher elevations (Camacha, 700 m altitude).

Hourly climatic data were obtained from automatic climate stations near the test areas. The data included daily maximum, minimum and average temperatures and relative humidity and daily rainfall.

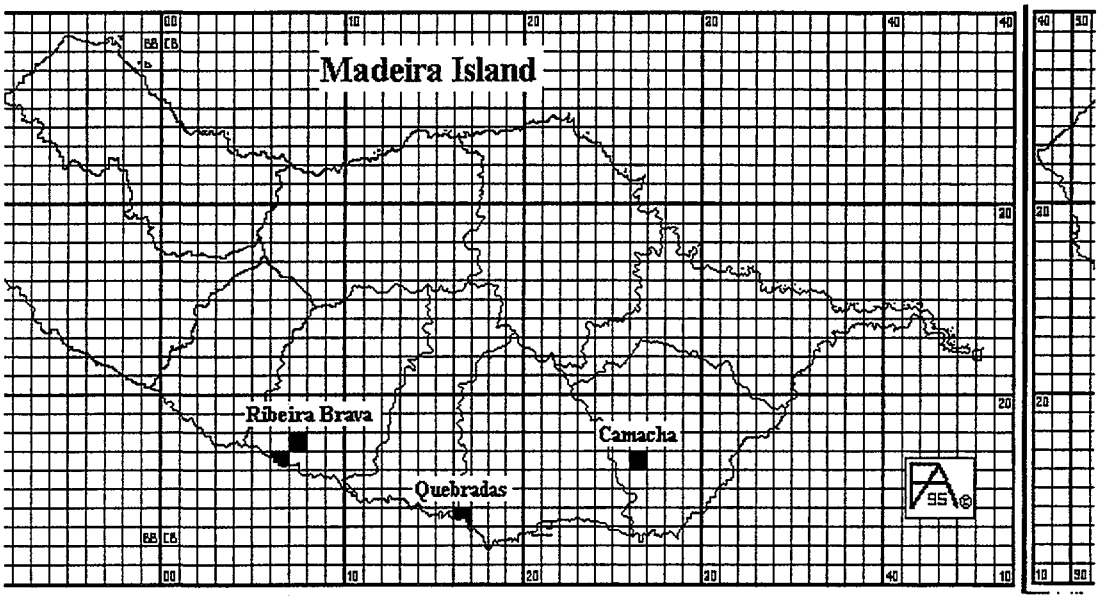


*Fig. 1-Location where the studies were done on Madeira Island (**first**: Ribeira Brava; **second**: Ribeira Brava and Quebradas; **third**: Quebradas and Camacha).*

2.1. Study One - 1996

This study was conducted in the same area of Ribeira Brava during two different periods (period 1: 8 June-27 July, 1996, and period 2: 11 October-30 November, 1996).

Each experiment consisted of five blocks, with 7 different types of traps in each. The traps were rotated weekly within blocks and trap captures were assessed twice a week for 7 weeks.

The traps and attractants used are described below:

- Jackson trap (JT). This trap has a standard sticky insert, baited with a Trimedlure (TML) plug placed in a plastic basket hung inside the trap in the middle of the horizontal wire hanger. The sticky insert was replaced weekly and the TML plug replaced every two weeks.
- Open bottom dry trap (OBDT, FA-2) [5]. This trap has an open bottom and a yellow sticky insert to capture flies, and was baited with ammonium acetate and putrescine (FA-2 attractants). The yellow sticky insert was replaced weekly, and the FA-2 lure replaced monthly.

- Open bottom dry trap (OBDT, FA-3) [5]. This trap was the same as above except it was baited with ammonium acetate, putrescine and trimethylamine (FA-3 attractants).
- Cooperators Choice (CC-2) - Period 1: The JT, with the standard sticky insert, was baited with FA-2 attractants. The sticky insert was replaced weekly, and baits replaced monthly.

  Period 2: The trap was a yellow container with holes in the bottom [3]. The toxicant, sugar mixed with fention, was placed inside the trap which was baited with FA-2 attractants. The sugar/toxicant was replaced biweekly, and baits replaced monthly.
- (CC-3) - This was the same trap as above, except baited with the FA-3 attractants.
- Tephri trap (Tephri, NU+B). This Spanish version of the plastic McPhail trap was baited with 300 ml of an aqueous solution containing 9% NuLure and 3% borax (NU+B). The bait was replaced weekly.
- Frutect trap and lure. This red spherical container has a special bait and one yellow display board suspended from the sphere. There was a yellow panel coated with sticky material to trap the medflies. This panel was replaced weekly.

2.2. Studies Two and Three - 1997

The second study was conducted in different areas at the same altitude (80 m) with two different wild fly densities. It compared natural wild fly population growth with the release of sterile males using ground release techniques (sex ratio > 9:1), between 24 May to 05 July, 1997.

Ground releases from paper bags were carried out twice a week (1000 fliers by hectare). The released flies were two day old sterile males only. The person who released the flies had no knowledge of the trap locations.

The third study was conducted in different areas to compare wild medfly captures at low elevations (80 m) and high elevations (700 m) (18 October-30 November, 1997).

Each study consisted of five blocks, with 6 different types of traps in each block. The traps were rotated weekly within blocks. Each study ran for 6 weeks. All traps were serviced twice per week. The bait in the IPMT, NU+B traps was replaced weekly. The FA-3 attractants were not replaced during the course of the study. The traps and attractants used in both studies are described below:

- The International Pheromone's McPhail trap (IPMT) was baited with 300 ml of NU+B. The bait was replaced weekly.
- Open bottom dry trap with FA-3 attractants (OBDT, FA-3) had a yellow sticky insert to capture flies. The insert was replaced weekly.
- The Tephri trap with FA-3 attractants (Tephri, FA-3, wet), when used as a wet trap, contained 200 ml of water and surfactant. This solution was replaced weekly.
- The Tephri trap with FA-3 attractants (Tephri, FA-3, dry), when used as a dry trap, contained DDVP in its base.
- The IPMT with FA-3 attractants (IPMT, FA-3, wet), when used as a wet trap, contained 300 ml of water and surfactant in its base. This solution was replaced weekly.
- The IPMT with FA-3 attractants (IPMT, FA-3, dry), when used as a dry trap, contained DDVP in its base.

3. RESULTS AND DISCUSSION

Data from each study was analyzed using analysis of variance and Duncan's multiple range test for comparison of averages [6].

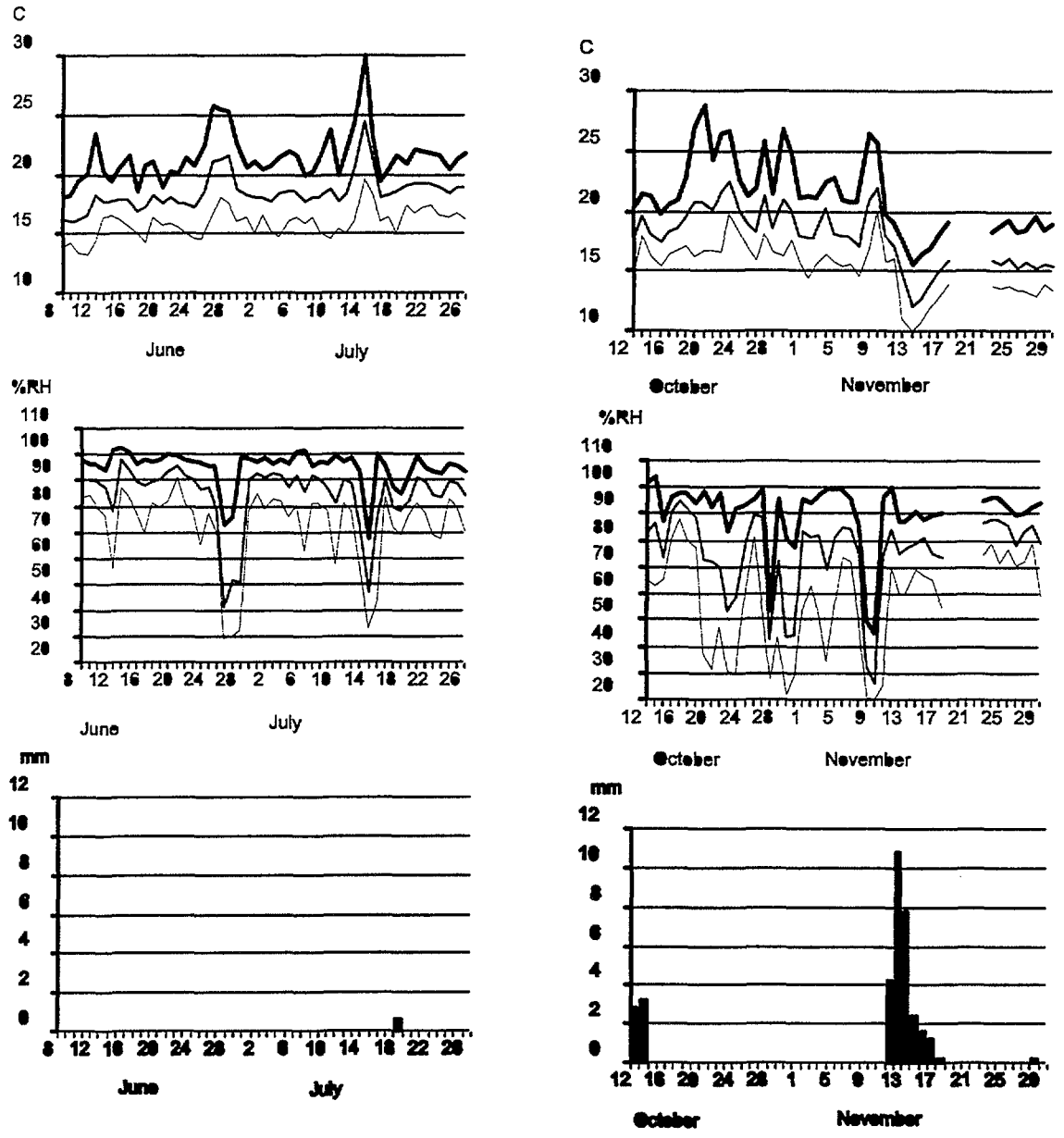


Fig. 2-Climate data during the first study: ***left column*** *- period 1 (8 June-27 July, 1996);* ***right column-*** *period 2 (12 October- 30 November);* ***top*** *- daily temperature (maximum, mean and minimum);* ***middle*** *- relative humidity (maximum, mean and minimum);* ***bottom*** *- rainfall.*

3.1. Study One - 1996

Fig. 2 shows temperature (maximum, mean and minimum), relative humidity (maximum, mean and minimum) and rainfall data for the two different periods.

During period 1 (8 June-27 July, 1996) the minimum temperature fluctuated between 13 - 20 °C with most days about 15 °C. The maximum daily temperatures ranged from 18 - 30 °C with an average of 21.45 ± 2.11° C. The relative humidity (RH) was greater than 60% during nearly all of the test period (Fig. 2). Rain occurred for only 1 day, with a total of 0.6mm.

During period 2 (11 October-30 November, 1996) temperatures during the first 4 weeks were similar to period 1, but decreased during the last three weeks of the study. The RH was lower than in the first period and rain occurred on 10 days, with a total of 34.4mm (Fig. 2). Data from four days are missing because of battery failure in the automatic climate measuring device.

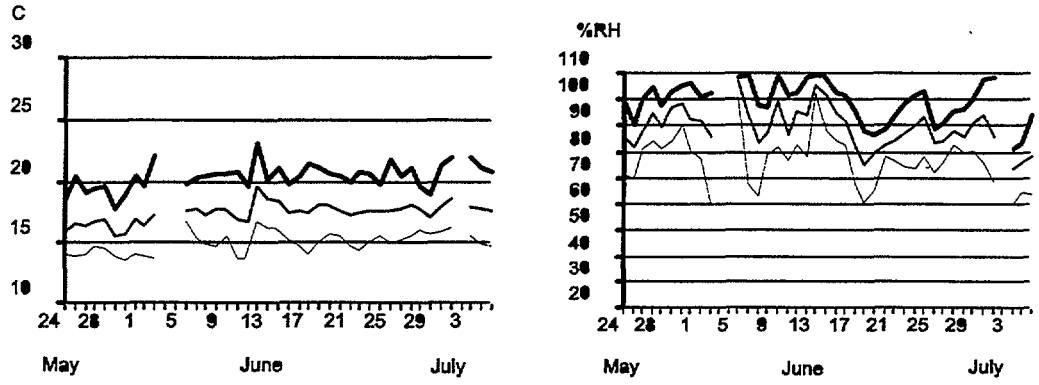
The wild medfly capture data for both periods were very different. Tables I and II show the number of flies/trap/day (F/T/D) and the percentage of the females by week. The last three columns show average F/T/D, % females captured and the total number of adult medfly captured.

In period 1, the JT, TML was the most effective, capturing 2128 flies, of which only 2 were female, compared to the OBDT, FA-3 which captured 295 flies, of which 183 were female (Table I). Although the JT, TML removed 7 times more flies from the overall population, the OBDT, FA-3 removed 90 times more females (potentially lowering the progeny going to the next generation) from the population than did the JT, TML [7].

Wild medfly capture during period 2 demonstrated a higher medfly population than period 1 (Table II). While the JT, TML was again the most effective (7367 flies captured), the OBDT, FA-3 caught 2271 flies. The JT caught about 20 females, while the OBDT, FA-3 trapped about 1770 females. As in period 1, the OBDT, FA-3 removed about 90 times more females from the medfly population than did the JT, TML.

During period 2, wild medfly captures were higher during the first four weeks than during the last three, probably because of higher temperatures. Traps baited with the new female attractants, showed significant decreases in captures as temperature decreased, and is similar to data reported by [8].

During both periods, the addition of TMA to AA+P (FA-3 attractants) enhanced the capture of wild female medflies and is clearly shown in the data (Tables I and II). This data is also similar to that of [9].



3.2. Study Two - 1997

Fig. 3 shows temperature (maximum, mean and minimum), relative humidity (maximum, mean and minimum) and rainfall data during the time of the study and close to the study areas.

During the second study (24 May-5 July, 1997), the minimum temperature fluctuated between 14 -17° C with most days about 15° C. The maximum daily temperatures ranged from 18 - 23 °C with an average of 20.38 ± 1.06 °C. The relative humidity was high during nearly all of the test period. Rain occurred on 16 days, with a total of 51.2mm. Three days of data are missing because of battery failure in the automatic climate measuring device.

TABLE I. CAPTTURE OF ADULT MEDFLIES IN F/T/D, PERCENT FEMALES AND TOTAL FLIES (EXPERIMENT 1: 8 JUNE - 27 JULY, 1996)

Trap	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Total		
	F/T/D	%_	F/T/D	%_	F/T/D	%_	F/T/D	%_	F/T/D	%_	F/T/D	%_	F/T/D	%_	F/T/D	%_	Flies
JT, TML	1.11b	0.00	0.14a	0.28	7.17a	0.40	4.09a	0.00	5.97a	0.00	14.91a	0.00	17.40a	3.45	**7.26±6.60a**	**1.08**	**2128**
OBDT,FA-2	0.20c	85.71	0.00d	-	0.00c	-	0.03e	0.00	0.06d	50.00	0.66cd	60.87	1.34b	65.96	**0.33±0.50c**	**65.0**	**80**
OBDT,FA-3	0.00d	-	0.00d	-	0.00c	-	0.00e	-	0.09d	100.0	7.57b	43.40	0.77bc	77.78	**1.20±2.82b**	**62.0**	**295**
CC, FA-2	0.03d	100.0	0.00d	-	0.00c	-	1.31b	78.28	0.71c	0.00	1.03c	47.22	1.46b	19.61	**0.65±0.64c**	**46.3**	**138**
CC, FA-3	0.00d	-	0.00d	-	0.00c	-	0.46c	68.75	1.31b	39.13	2.46c	56.98	2.69b	48.94	**0.99±1.18b**	**51.2**	**242**
Tephri, NU+B	0.40d	92.86	1.09c	94.74	0.03c	100.0	0.09de	66.67	0.69c	50.00	0.17d	33.33	0.03c	100.0	**0.36±0.40c**	**77.0**	**87**
Frutect	3.77a	90.15	0.23b	62.50	0.35b	52.82	0.18d	88.89	0.14d	42.86	0.14d	42.86	0.76bc	64.86	**0.80±1.33b**	**78.3**	**217**

*the data with the same letter in each column have no significant differences (Duncan's multiple range test, P=0.05)

TABLE II. CAPTURE OF ADULT MEDFLIES IN F/T/D, PERCENT FEMALES AND TOTAL FLIES (EXPERIMENT 2: 12 OCTOBER-30 NOVEMBER, 1996)

Trap	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Totals		
	F/T/D	%	F/T/D	%	F/T/D	%	F/T/D	%	F/T/D	%	F/T/D	%	F/T/D	%	F/T/D	%	Flies
JT, TML	40.11a	0.07	42.40a	0.27	38.63a	0.52	22.11a	0.39	17.80a	0.00	29.57a	0.39	20.11a	0.28	**30.10±10.32a**	**0.28**	**7376**
OBDT, FA-	20.63b	71.47	11.00b	83.12	9.11c	82.45	9.89bc	82.37	2.97bc	86.54	1.69c	66.10	0.49c	70.59	**7.97±7.01b**	**78.12**	**1952**
OBDT, FA-	18.77b	74.73	8.20bc	79.09	14.26b	79.56	14.17b	83.06	4.89d	77.78	1.74c	57.38	2.86b	81.00	**9.27±6.55b**	**78.20**	**2271**
CC, FA-2	2.06c	76.39	3.63c	80.31	8.54c	76.59	4.37d	83.01	0.26d	66.67	0.49d	82.35	0.49c	82.35	**2.83±2.99d**	**78.82**	**694**
CC, FA-3	16.51b	73.88	4.29c	66.67	6.03cd	75.36	3.17d	79.28	0.66d	65.22	1.26c	63.64	0.49c	76.47	**4.63±5.62c**	**73.19**	**1134**
Tephri,	2.09c	82.19	2.06c	80.56	3.49d	77.87	3.66d	82.81	2.00c	87.14	0.26d	77.78	2.89b	84.16	**2.35±1.51d**	**82.09**	**575**
Frutect	4.71c	60.61	3.91c	80.29	4.46d	81.41	7.34c	79.77	1.43c	72.00	4.09b	76.92	0.83c	96.55	**3.82±2.01cd**	**76.41**	**937**

*the data with the same letter in each column have no significant differences (Duncan's multiple range test, P=0.05)

Tables III and IV show the total number of wild medfly captured, the F/T/D and the percentage of the female medflies captured for each week of the study. The last 5 columns show the total numbers of males and females captured, the average F/T/D and % females captured.

The best wild medfly captures were found in the IPMT, FA-3, dry with 23.18 F/T/D, the Tephri, FA-3, dry with 20.49 F/T/D and the IPMT, FA-3, wet with 19.24 F/T/D (Table III). The best recapture of sterile males was found in the Tephri, FA-3, dry with 32.15 F/T/D (Table IV).

In the natural wild medfly population the lowest percentage of females captured was 61.26% in the OBDT, FA-3, and in four trap types the percentage was greater than 70%.

On the other hand, in the area with sterile released males, the percentage of females captured was between 11.82% to 18.41%.

In all cases, the dry traps were more effective than the wet traps (Tables III and IV).

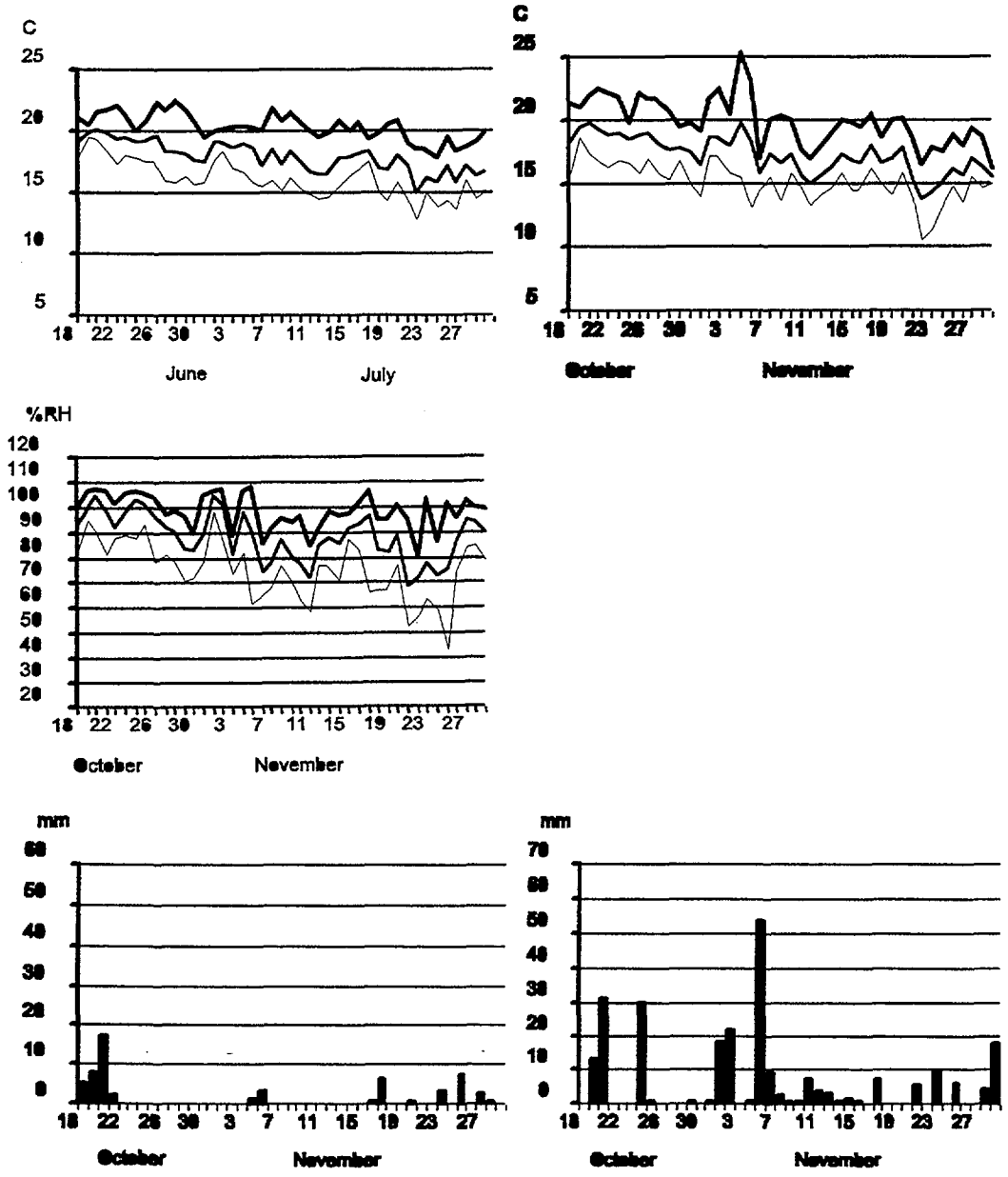


*Fig. 4. Climate data during the third study (18 October-30 November, 1997): **left column** - Experiment 1, Quebradas 80m; right column - Experiment 2, Camacha, 700m; **top** - daily temperature (maximum, mean and minimum); **middle** - relative humidity (maximum, mean and minimum); **bottom** - rainfall.*

TABLE III-CAPTURE OF ADULT MEDFLIES IN F/T/D, PERCENT FEMALES AND TOTAL FLIES, AT QUEBRADAS, WITH A WILD MEDFLY POPULATION FROM 24 MAY - 05 JULY, 1997

Trap	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6				Totals		
	F/T/D	%	F/T/D	%	F/T/D	%	F/T/D	%	F/T/D	%	F/T/D	%			Flies	F/T/D	%
IPMT, NU+B	2.74c	96.87	2.11b	98.65	2.97d	76.92	1.86d	64.08	2.34d	68.29	2.80d	73.47	104	415	**519**	**2.47±0.44c**	**79.96**
OBDT, FA-3	2.37c	84.34	5.43b	71.58	2.43d	74.12	4.17dc	45.21	5.46c	56.54	1.20d	59.52	296	468	**764**	**3.51±1.77c**	**61.26**
Tephri, FA-3, wet	9.91b	89.05	5.17b	86.19	14.66c	58.28	15.63bc	59.41	5.43c	55.26	4.23c	63.51	638	1288	**1926**	**9.17±5.04b**	**66.87**
Tephri, FA-3, dry	19.60a	88.63	23.66a	92.15	37.71a	70.98	20.74c	54.75	10.60b	61.46	10.66a	63.00	1136	3169	**4305**	**20.50±10.02a**	**73.61**
IPMT, FA-3, wet	20.74a	82.64	20.03a	87.30	18.71bc	64.58	25.20b	66.10	21.83a	62.04	8.91b	68.27	1135	2911	**4046**	**19.24±5.52a**	**71.95**
IPMT,FA-3, dry	27.17a	88.96	22.46a	85.50	21.34b	69.72	37.14a	59.46	16.46a	62.85	14.49a	66.17	1443	3686	**5129**	**23.18±8.19a**	**71.87**

*the data with the same letter in each column have no significant differences (Duncan's multiple range test, P=0,05)

TABLE IV. CAPTURE OF ADULT MEDFLIES IN F/T/D, PERCENT FEMALES AND TOTAL FLIES AT RIBEIRA BRAVA WITH GROUND STERILE MALES RELEASES FROM 24 MAY-05 JULY, 1997

Trap	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6				Totals		
	F/T/D	%	F/T/D	%	F/T/D	%	F/T/D	%	F/T/D	%	F/T/D	%			Flies	F/T/D	%
IPMT, NU+B	2.14d	8.00	9.29d	13.23	3.05d	54.21	1.11d	28.20	0.94c	54.55	8.91d	8.97	727	164	**891**	**4.24±3.84d**	**18.41**
OBDT, FA-3	18.29c	23.75	38.54b	5.63	13.71c	14.32	5.46c	19.61	3.57b	34.40	16.86c	4.58	2858	383	**3241**	**16.07±12.53c**	**11.82**
Tephri, FA-3, wet	19.26c	21.21	31.69c	4.24	8.09c	17.31	7.89c	19.93	4.89b	44.44	17.57c	15.61	2662	466	**3128**	**14.94±10.13c**	**14.90**
Tephri, FA-3, dry	55.49a	12.36	42.40a	7.14	22.37a	15.84	23.54a	21.18	11.75a	39.21	37.34a	9.72	5660	844	**6504**	**32.15±15.89a**	**12.98**
IPMT, FA-3, wet	11.43b	14.75	25.49a	11.55	22.50c	22.38	7.50c	20.95	5.36b	36.67	15.39c	13.23	2254	459	**2713**	**14.61±8.09c**	**16.92**
IPMT, FA-3, dry	41.43b	11.51	44.79a	8.05	21.31b	28.82	12.71b	40.45	3.25b	43.96	24.46b	10.51	3878	775	**4653**	**24.66±16.12b**	**16.98**

*the data with the same letter in each column have no significant differences (Duncan's multiple range test. P=0.05)

TABLE V. CATCH OF ADULT MEDFLIES IN F/T/D, PERCENT FEMALES AND TOTAL FLIES AT CAMACHA (700 M) FROM 18 OCTOBER - 29 NOVEMBER, 1997

Trap	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6				Totals		
	F/T/D	%_	F/T/D	%_	F/T/D	%_	F/T/D	%_	F/T/D	%_	F/T/D	%_	_	_	Flies	F/T/D	%_
IPMT, NU+B	0.29c	50.00	0.06c	50.00	0.14b	60.00	0.14c	60.00	0.00e	-	0.08d	100.00	10	14	**24**	**0.12±0.10e**	**58.33**
OBDT, FA-3	0.77b	85.19	1.34a	40.43	1.20a	54.76	1.06a	56.76	1.06a	51.35	0.37c	61.54	90	113	**203**	**0.97±0.35b**	**55.67**
Tephri, FA-3, wet	0.80b	82.14	0.40b	64.29	0.11b	50.00	0.29b	50.00	0.06d	50.00	0.09d	0.00	21	40	**61**	**0.29±0.28d**	**65.57**
Tephri, FA-3, dry	3.91a	72.26	1.43a	64.00	0.29b	62.50	0.50a	50.00	0.21bc	16.67	1.04b	65.52	81	163	**244**	**1.23±1.39a**	**66.80**
IPMT, FA-3, wet	0.14c	100.00	0.39b	63.63	0.00c	-	0.10c	100.00	0.14c	0.00	1.19b	60.00	17	28	**45**	**0.33±0.44d**	**62.22**
IPMT, FA-3, dry	0.64b	72.22	0.32b	77.78	0.00c	-	0.29b	50.00	0.68b	31.58	1.46a	53.66	43	52	**95**	**0.57±0.50c**	**54.74**

*the data with the same letter in each column have no significant differences (Duncan's multiple range test. P=0.05)

TABLE VI. CATCH OF ADULT MEDFLIES IN F/T/D, PERCENT FEMALES AND TOTAL FLIES AT QUEBRADAS (80 M) FROM 18 OCTOBER - 29 NOVEMBER, 1997

Trap	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6				Totals		
	F/T/D	%_	F/T/D	%_	F/T/D	%_	F/T/D	%_	F/T/D	%_	F/T/D	%_	_	_	Flies	F/T/D	%_
IPMT, NU+B	0.26d	44.44	0.51e	66.67	0.37d	38.46	0.71e	64.00	0.74f	73.08	0.03d	100.00	35	57	**92**	**0.44±0.27d**	**61.96**
OBDT, FA-3	2.46c	56.47	3.17d	50.45	1.74c	45.90	1.74d	72.13	2.26e	68.35	1.09c	52.63	185	250	**435**	**2.08±2.72c**	**57.47**
Tephri, FA-3, wet	2.17c	64.47	5.54c	67.53	2.06c	47.22	2.46d	70.93	5.74d	43.28	1.66c	41.38	301	386	**687**	**3.27±1.85c**	**56.19**
Tephri, FA-3, dry	4.17b	59.59	8.86b	68.71	7.17ab	53.78	7.34a	66.15	8.37c	68.94	1.66c	50.00	479	836	**1315**	**6.26±2.78b**	**63.57**
IPMT, FA-3, wet	8.74a	64.38	11.34a	72.29	5.74b	55.72	4.89c	64.33	5.40d	60.32	2.80b	46.94	496	866	**1362**	**6.49±3.05b**	**63.58**
IPMT, FA-3, dry	7.63a	65.17	12.03a	62.00	9.03a	60.76	6.14ab	62.79	21.89a	51.83	5.77a	60.89	905	1282	**2187**	**10.42±6.06a**	**58.62**

*the data with the same letter in each column have no significant differences (Duncan's multiple range test. P=0.05)

3.3. Study Three - 1997

Fig. 4 shows temperature (maximum, mean and minimum), relative humidity (maximum, mean and minimum) and rainfall data for the two areas (Quebradas and Camacha).

During the study at 80 meters above sea level (Study l), the minimum temperature fluctuated between 13 - 19 °C, decreasing as the study progressed. The maximum daily temperatures ranged from 18 - 22 °C with an average of 20.26± 1.14 °C. The relative humidity was high during nearly all of the test period. Rain occurred only on 17 days, with a total of 56.8mm.

During the study at 700m (Study 2), temperatures during the first three weeks were similar to the first study, but were lower during the last three weeks. Rain occurred on 30 days, with a total of 248.2mm. There was no RH data available.

Tables V and VI show the F/T/D and the percentage of the female medflies captured. The last five columns show the total numbers of males and females and the average F/T/D and % females captured.

At high elevations (700 m) the Tephri, FA-3, dry captured the most flies with 1.23 F/T/D (Table V). At the low elevations (80 m) the IPMT, FA-3, dry captured 10.41 F/T/D (Table VI).

In both studies the percentage of females captured ranged between 55.67% to 65.57%. Again, dry traps were more effective than the wet traps at capturing wild flies.

4. CONCLUSIONS

4.1. First study

The most effective female medfly attractant during both 7 week periods were the FA-3 attractants - a combination of ammonium acetate, putrescine and trimethylamine (FA-3).

Trimedlure (TML) baited traps captured essentially no females, although they captured more flies than the other 6 traps combined.

FA-3 baited traps removed about 90 times more female medflies from the population than TML baited traps.

The addition of trimethylamine to ammonium acetate plus putrescine increased total fly capture but had no impact on % females captured.

FA-3 baited traps have potential as a survey tool for female medflies. Additional data are needed to determine the effect of cool temperatures on trapping effectiveness of FA-3.

4.2. Second study

The best traps in natural wild medfly populations were: IPMT, FA-3, dry; Tephri, FA-3, dry; and IPMT, FA-3, wet with an average F/D/T of 20.97±2.01.

The best trap in areas with sterile males was the Tephri, FA-3, dry with 32.15 F/T/D.

In areas with only wild medfly populations, the lowest percentage of females captured was 61.26% in the OBDT, FA-3. In 4 trap types, this percentage was above 70%.

In areas with sterile males, the percentage of females captured was between 11.82% to 18.41%.

Dry traps were more effective than the wet traps.

4.3. Third study

At high elevations (700m) the best trap was the Tephri, FA-3, dry with 1.23 F/T/D.

At low elevations (80m) the best trap was the IPMT, FA-3, dry with 10.41 F/T/D.

At both elevations, the percentage of female medflies captures was between 55.67% to 65.57%, similar to results from Study 2.

Dry traps were more effective than the wet traps as in Study 2.

ACKNOWLEDGEMENTS

This research was supported by the joint FAO/IAEA Division under the research contract POR 5841.

REFERENCES

[1] HENDRICHS, J., et al., Increased effectiveness and applicability of the sterile insect technique through male-only releases for control of Mediterranean fruit flies during fruit seasons, J. Appl. Entomol. **119** (1995) 371-377.

[2] EPSKY, N.D., et al., Visual cue and chemical cue interactions in a dry trap with food-based synthetic attractant for *Ceratitis capitata* and *Anastrepha ludens* (Diptera: Tephritidae), Environ. Entomol. **24** (1995) 1387-1395.

[3] PEREIRA, R., CARVALHO, J.P.,"Trap utilization on study of Mediterranean fruit fly populations at citrus groves in Portugal", In: Fruit fly pests, a world assessment of their biology and management (McPheron & Steck Ed.) (1996) 135-140.

[4] HEATH, R.R., et al., Systems to monitor and suppress *Ceratitis capitata* (Diptera: Tephritidae) populations, Florida Entomol. **79** (1996) 144-153.

[5] HEATH, R.R., et al., Development of a dry plastic insect trap with food-based synthetic attractant for Mediterranean and Mexican fruit flies (Diptera: Tephritidae), J. Econ. Entomol., **88** (1995) 1307-1315.

[6] MONTGOMERY, D.C., Design and analysis of experiments, Wiley & Sons Ed., New York (1991)

[7] EPSKY, N.D., et al., Field evaluation of female-targeted trapping systems for *Ceratitis capitata* (Diptera: Tephritidae) in seven countries (in press).

[8] ROS, J.P., et al., Ensayos de campo con un nuevo atrayente de hembras de la mosca mediterránea de la fruta *Ceratitis capitata* Wied. (Diptera: Tephritidae), Bol. San. Veg. Plagas **22** (1996) 151-157.

[9] ROS, J.P., et al., La trimetilamina: un efectivo potenciadr de los atrayentes putescina y acetato de amónio para capturar las hembras de la mosca mediterránea de la fruta *Ceratitis capitata* Wied. (Díptera: Tephritidae), Bol. San. Veg. Plagas **23** (1997): 515-521.

PEREIRA, R., et al., Area-wide control of the Mediterranean fruit fly on Madeira with Sterile Insect Technique, Proc. Int. Soc. Citriculture (1997) 568-572.

FINAL REPORT OF THE CO-ORDINATED RESEARCH PROGRAMME ON MEDFLY FEMALE ATTRACTANTS

Y. GAZIT, Y. RÖSSLER
The Institute for Biological Control,
Citrus Marketing Board of Israel,
Bet-Dagan, Israel

Abstract

Experiments were conducted to find the most effective combination of traps and lures for use in two different climates - the coastal and the desert regions of Israel. Three trials were conducted following the IAEA CRP- phase 4 protocol. Two simultaneous trials were carried out around June 1997. One was in a citrus grove in Tsrifin, the coastal region, and the other in a mango grove in Hatseva, the Arava Valley, a desert region where there has been on ongoing SIT program since January 1998. A third trial was also conducted in Tsrifin, at the same location as the first trial, but during February 1998. In all trials, the International Pheromone's McPhail Trap (IPMT) with NuLure + borax (NU+B) was the standard trap. The FA-3 attractants (ammonium acetate, putrescine, and trimethylamine) were used with water and surfactant Triton-X (wet version) or without water but with DDVP (dry version) in IPMT and Tephri traps. Treatments and traps included in the trials were: IPMT, FA-3, wet; IPMT, FA-3, dry; Tephri, FA-3, dry; Tephri, FA-3, wet. The results of these trials indicated that, at both locations, medfly populations differed greatly - 153 versus 82,500 flies at Hatseva and Tsrifin, respectively. All traps caught more females than males. At Tsrifin, the Tephri, FA-3 traps outperformed the IPMT, NU+B, capturing 4 to 5 times more than standard (IPMT,NU+B). The addition of water to the traps at this location resulted in a slight decrease in captures. At Hatseva, the addition of water improved capturing in both IPMT and Tephri traps. Replacing the water with ethylene glycol resulted in the highest capture level indicating the importance of humidity to the trap performance.

1. INTRODUCTION

We joined the efforts of the "Development of Female Medfly Attractant System for Trapping and Sterility Assessment" in 1996 – when the third phase of the project was just about to terminate. The results of the Co-ordinated Research Programme (CRP) and of our earlier studies carried out during 1996 have clearly indicated that the three component female attractants, FA-3 (ammonium acetate, putrescine and trimethylamine) lured more medflies than other food-based attractants such as the NuLure and Naziman (Tamugan, Israel). More females were attracted to the FA-3 than males. The superiority of the FA-3 was shown in every trap type studied.

Therefore, we used the FA-3 in all of our studies. Our objectives were to compare the synthetic female attractants with our local food-based baits in several traps including two local traps - an improvisation of a locally used bait station 'Ga'aton' and the commercial trap, 'Frutect' (Ronpal, Israel). The latter was one of the traps studied by the Co-ordinated Research Programme in the third phase.

In these studies, we found the efficacy of the traps baited with FA-3 (total number of medflies and % females) was as follows: International Pheromone's McPhail trap (IPMT) > Frutect > cylindrical green trap >> Ga'aton trap. This indicated that the design of the trap (color, size, shape, and openings) are important in terms of the overall captivity and female preference.

The CRP studies pointed out two traps which caught the highest number of medflies: the plastic IPMT and the Tephri trap. Both consist of a yellow container with clear top and an opening in the bottom. Some results have indicated a decrease in efficacy of the FA-3 lures in dry climates. Since a large area of Israel is desert, we concentrated on optimizing a trapping system for these environmental conditions.

2. MATERIALS AND METHODS

The main objective of the experiments was to find the most effective combination of trap and lure in two different climates - the coastal and the desert regions of Israel. We conducted three trials following the CRP- phase 4 protocol. Two simultaneous trials were carried out around June 1997. One was in a citrus grove in Tsrifin, the coastal region, and the other in a mango grove in Hatseva, the Arava Valley, a desert region. There has been a SIT program in the Arava Valley since January 1998. A third trial was conducted also in Tsrifin, at the same location as the first trial, but during a different season - February 1998. In all trials the IPMT with NuLure + borax (NU+B) was the standard trap. The FA-3 were used with water/ triton-X (wet version) or without water (dry version) in IPMT and Tephri traps.

Geographical and climatological data for the experiments at Tsrifin are summarized in Tables I and II. At this site was a 2 ha of citrus collection, mostly oranges, grapefruit, and pumello. During the May - June1997 study, daily temperatures varied from19 - 29 °C with 53 - 72% RH. A few trees were left unpicked, many fruits were decaying on the ground and the medfly population was very high (52 F/T/D in the Jackson traps). However, during the February - March 1998 studies, daily temperatures varied from 8 - 20 °C, with 54 - 80% RH. Most of trees were bearing ripe fruits (judged by their color). Under some trees, there were fruits on the ground. Due to a very mild January, the fly population was low (although higher than usual with 0.81 F/T/D in the Jackson traps).

Geographical and climatological data for the experiments at Hatseva are summarized in Table III. There are 10 ha of mango. From May - July 1997, there were few immature fruits on most of the trees. Daily temperatures varied from 22 -38 °C with 15 - 38% RH. The fly population was low (0.77F/T/D in the Jackson traps).

In the first two trials our cooperative choice trap was the wet IPMT in which ethylene glycol (antifreeze additive for car radiators) replaced the water/ triton to achieve high humidity with a reduced evaporation rate.

3. RESULTS

3.1. CRP experiments

The results of these trials indicated that:

- At both locations, medfly populations differed greatly - 153 versus 82,500 flies in Hatseva and Tsrifin, respectively. All traps caught more females than males.
- At Tsrifin, the Tephri, FA-3 traps outperformed the IPMT, NU+B (4 to 5 times more than standard). The additional of water in that location resulted in a slight decrease in captures.
- At Hatseva, the addition of water improved capturing in IPMT and Tephri traps and replacing the water with ethylene glycol resulted in the highest capture level indicating the importance of humidity to the trap performance.

3.2. Side experiment

The rapid water evaporation rate (1 cm/ day) in the Arava Valley, which caused FA-3 traps to lose water within 2-3 days, required a solution for retaining water in the traps. In two separate trials we have found that ethylene glycol, which is toxic, can be replaced with non-

toxic propylene glycol/ water (1:1 solution) without decreasing performance. The Tephri trap with propylene glycol outperformed the IPMT with ethylene glycol (twice the number of females). From these results, we decided to use this version of Tephri, FA-3, propylene glycol in the Arava Valley for both female monitoring and population suppression in urban areas

NOTE!!! Recent trapping results in the Arava Valley have indicated that some sterile flies were losing the DayGlow marker in the propylene glycol solution within few days. The addition of of propylene glycol is not recommended when sterile flies released.

TABLE I. TRAPPING DATA FROM THE JUNE 5 - JULY 6, 1997 TRIAL - TSRIFIN, ISRAEL

Country:	ISRAEL
Site of study:	Tsrifin
Host:	Citrus
Altitude:	+ 60 m
Avg. Temp, Min. - Max.:	19.05 ± 0.36 to 29.23 ± 0.39 ^{0}C
Avg. RH, Min. - Max.	53.51 ± 1.34 to 72.70 ± 1.11%
Trapping period (dates):	25.5.97 - 6.7.97
No of trap days (#trap per treatment x #days):	210
Jackson trap capture (#F/T/D):	51.99
%Females in Jackson trap (#females/ #total):	We didn't record any
Number of Jackson trap days (#traps x #days)	84
Average number of larvae per kg of fruit (total 43.2 kg):	5.81

Trap/ Lure Treatment			**Flies per Trap (F/T/D)**						**Relative Trap Efficiency**			%Females/ trap
Trap	Lure/ retention	Trap days	Males	Females	M+F	#Total medfly	Males[1]	Females[1]	%Male	%Female	%Total	(#Fem x 100 /#Total)
IPMT	NU+B	210	8.19	9.65	17.84	22.89	10.50	12.38	6.22	5.39	5.75	54.11
IPMT	FA-3, water	210	13.42	16.05	29.47	46.94	21.38	25.56	12.67	11.13	11.79	54.45
IPMT, dry	FA-3, DDVP	210	17.49	23.90	41.40	63.60	26.87	36.73	15.93	16.00	15.97	57.75
Tephri, dry	FA-3, DDVP	204	15.49	21.96	37.44	91.01	37.64	53.37	22.31	23.25	22.85	58.64
Tephri,wet	FA-3, water	203	15.75	22.91	38.66	85.33	34.76	50.57	20.60	22.03	21.42	59.26
IPMT, ethylene	FA-3, antifreeze	210	21.16	28.71	49.87	88.55	37.56	50.98	22.26	22.21	22.23	57.58
					TOTAL	**398.32**	**168.72**	**229.59**	100.00	100.00	100.00	

[1] Since we took samples to determine the sex ratio, calculations were made by multiplying the ratio by the total number
Data do not include traps with ants

TABLE II. TRAPPING DATA FROM THE FEBRUARY 1 - MARCH 15, 1998 TRIAL - TSRIFIN, ISRAEL

Country:	ISRAEL
Site of study:	Tsrifin
Host:	Citrus
Altitude:	+ 60 m
Avg. Temp, Min. - Max.:	8.63 ± 0.37 to 20.26 ± 0.51 ^{0}C
Avg. RH Min. - Max.	53.79 ± 2.26 to 80.44 ± 1.53%
Trapping period (dates):	1.2.98 - 15.3.98
No of trap days (#trap per treatment x #days):	210
Jackson trap capture (#F/T/D):	0.81
%Females in Jackson trap (#females/ #total):	We didn't record any
Number of Jackson trap days (#traps x #days)	84
Average number of larvae per kg of fruit (total 43.2 kg):	0.74

Trap/ Lure/ Treatment			**Flies per 5 Traps**				**Relative Trap Efficiency**		
Trap	Lure	Retention	# Males	# Females	M+F	Others	% Male	% Female	% medfly
IPMT	NU+B	lure	119	251	370	764	32.16	67.84	32.63
IPMT	FA-3	water	296	485	781	910	37.90	62.10	46.19
IPMT	FA-3	DDVP	218	419	637	1416	34.22	65.78	31.03
Tephri	Fa-3	water	164	364	528	488	31.06	68.94	51.97
Tephri	FA-3	DDVP	216	510	726	557	29.75	70.25	56.59
IPMT	FA-3	propylene glycol	225	473	698	771	32.23	67.77	47.52
		TOTAL	1238	2502	3740	4906			

TABLE III. TRAPPING DATA FROM THE MAY 26 - JULY 7, 1997 TRIAL - HATSEVA, ISRAEL

Country:	ISRAEL
Site of study:	Hatseva
Host:	Mango
Altitude:	-160 m
Avg. Temp, Min. - Max.:	22.2 - 37.9^{0}C
Avg. RH, Min. - Max.	14.8 - 37.7%
Trapping period (dates):	26/5 - 7/7/97
No of trap days (#trap per treatment x #days):	210
Jackson trap capture (#F/T/D):	0.77
%Females in Jackson trap (#females/ #total):	not recorded
Number of Jackson trap days (#traps x #days)	84
Average number of larvae per 300 fruits:	2

Trap/ Lure/ Treatment			**Flies per Trap per Day (F/T/D)**			**Relative Trap Efficiency**			**%Females/ trap**
Trap	Lure/retention	Trap days	Males	Females	# Total medfly	% Male	% Female	% Total	(#Fem x 100 /#Total)
IPMT	NU+B	210	0.02	0.08	0.10	13.81	14.43	14.29	77.27
IPMT, wet	FA-3, water	210	0.04	0.12	0.16	24.86	21.23	22.08	73.53
IPMT, dry	FA-3, DDVP	210	0.00	0.05	0.05	0.00	9.34	7.14	100.00
Tephri, dry	FA-3, DDVP	204	0.00	0.04	0.05	2.84	7.87	6.69	90.00
Tephri, wet	FA-3, water	203	0.02	0.07	0.10	14.29	13.17	13.44	75.00
IPMT, ethylene	FA-3, antifreeze	210	0.08	0.19	0.27	44.20	33.96	36.37	71.43
		TOTAL	**0.17**	**0.56**	**0.73**	100.00	100.00	100.00	

DEVELOPMENT OF A FEMALE MEDFLY ATTRACTANT SYSTEM IN MOROCCO

A. BAKRI
Unit of Biological Control of Insects,
Faculty of Science Semlalia,
University Cadi Ayyad,
Marrakech, Morocco

Abstract

Field trials were conducted in Morocco to evaluate food-based attractants according to the FAO/IAEA international network program. Ammonium acetate plus putrescine (FA-2 attractants) were very effective and selective for female medfly attraction. The addition of trimethylamine (FA-3 attractants) increased trap catches. The association of the female attractants with various traps were tested in two medfly host plants, argan (*Argania spinosa*) and mandarin (*Citrus reticulata* Blanco) during two seasons (fall and summer). Open bottom dry traps (OBDTs), closed bottom dry traps (CBDTs), dry International Pheromone's McPhail traps (IPMTs), wet IPMTs, locally made traps and Tephri traps, all baited with the synthetic lures (FA-2 and FA-3), were compared to liquid protein baited IPMTs and Trimedlure baited Jackson traps. Results showed that the new trapping systems were as effective in capturing females as the standard IPMT baited with NuLure + borax. Furthermore, dry Tephri traps were the most effective under certain conditions. Only in one experiment were CBDTs baited with the synthetic two component lure (FA-2) as effective as Trimedlure baited Jackson traps. In most cases the attracted females were immature. Attempts to increase the attractiveness of the synthetic lure by the addition of male medfly synthetic pheromone failed. Based on the results obtained, it is apparent that the three component synthetic female attractant (FA-3) provides an effective system for capturing female medflies and could be used as an alternative to NuLure baited IPMT traps for assessing the efficacy of SIT when sterile males are released.

1. INTRODUCTION

The Mediterranean fruit fly, *Ceratitis capitata*, poses a major problem for fruit production in Morocco. With an annual production of more than 2 million tons, the yearly losses are valued at more than 32 million US dollars, of which $4-5 million per year are spent for insecticide treatments.

The production of the fruits, notably citrus, has been oriented toward finding export markets. The future of horticulture in Morocco depends on remaining competitive with other Mediterranean countries which are producing the same varieties and exporting to the same markets as Morocco. This competitiveness requires the production of citrus of consistently high quality. However, in spite of efforts and encouragement offered to farmers and producers by public services for converting or renewing their trees, the yields have remained weak (<17 ton/ha for the citrus fruits). In general, orchards are old (50% of some varieties are more than 35 years) and the product quality is often poor.

The control of medflies by chemical treatments alone is difficult and causes pollution of the environment. Problems due to overuse of insecticides have been poorly studied but some consequences include proliferation of other pests such as acarina, scales, aphids and aleurothrixus, all of which cause important damage. Also, current strategies for control of medflies prevents the utilization biological control methods. Furthermore, presence of residues in the treated fruit could close some potential export markets, such as Japan and the United States. Recent data shows that even though chemical treatments are applied 8 - 10 times a year in some commercial operations, large proportions of fruits are still infested by medflies. This is because treatments are not made in a coordinated way by regional producers. This poor coordination is due to a lack of precise data on the development cycle of the population in relation to the climatic data and the phenology of the host-plant.

Therefore, the implementation of a sterile insect technique (SIT) program using only sterile males for the control of medflies is a good option which would obviate some of the problems cited above and provide an opportunity for development and diversification of the national production by introduction of other fruit cultures. Biological control strategies could then be developed against other citrus pests such as the citrus leafminer, *Phyllocnistis citrella.*

The development of an attractant for female medflies would improve the SIT technique efficacy by removing feral females, provide data on the population levels and indicate the percentage of sterility introduced in the population of medflies. Significant progress has been made in this regard with the development of a food-based synthetic attractant which uses ammonium acetate and putrescine in association with a dry trap [2]. Addition of trimethylamine (TMA) further increased the potential of the lure for attraction. Further experiments were conducted to find the best association lure - trap which could give maximum female catches. These experiments were launched in a number of countries in Mediterranean area, Central and Latin America to test the trapping system efficacy under various climatic conditions (dry and humid). The International Network Research Project, operated as part of a FAO/IAEA Research Contract Program, was the framework that coordinated this research. Twelve countries were involved in this program for "Development of female medfly attractant systems for trapping and sterility assessment." Reported herein are results from 5 years of field studies in Morocco. We also report on findings from side experiments which were conducted to develop an oviposition device for collecting eggs in order to assess the level of sterility introduced in the wild population.

2. MATERIALS AND METHODS

Experiments were conducted either during summer (high population levels) or autumn-winter (low population levels). The sites of experiment were in argan forest and/or citrus orchard.

The experiment consisted in comparing 4 to 7 trap treatments distributed randomly in 5 experimental block designs and rotated after each check. Traps were checked every 3 - 4 days for a period of 8 weeks and serviced according to each trap requirement. Trap types, the experimental design and the material used were those described in the experimental protocol provided by the IAEA.

2.1. Description of the experimental sites

Argan forest: Argan forests (*Argania spinosa*, Sapotacea) cover 700,000 ha in southwest of the country. It has been reported that this is the largest habitat of medfly in the world [2]. The site of experimentation was localized inside the Institute of Agronomy and Veterinary Sciences of Agadir. This was a convenient place for conducting experiment because there are no children or foraging animals. The plot was not treated with pesticides, and was close to a meteorological station. The site area was around 1 ha.

Citrus orchard: This site was 9 km from Marrakech and localized inside a farm with various fruit crops (mandarin, navel and peach). Traps were deployed within the navel parcel. In other experiments, a citrus site was selected inside the Agadir Institute. During the experiments, fruits were not treated with insecticide. In some cases, fruit had been harvested already.

Climatic conditions: Morocco has a typical Mediterranean climate with hot, dry summers and mild, rainy winters. The experiments were conducted in the central

southwestern part of the country. The altitude is about 20 m at Agadir and 200 m around Marrakech. The average precipitation is 230 mm per year. The average temperature was 29°C maximum and 16°C minimum. The average relative humidity varied between 55 and 98%. In some period of the summer, a hot wind, called Sirocco, blows from the southeast and instantly increases the temperature towards the maximum.

2.2. Traps

1st year: The objective of the first year experiments was to evaluate a new female trapping system for *C. capitata* consisting of a new cylindrical dry trap (closed bottom trap, CBDT) and a combination of two new female attractants (ammonium acetate and putrescine - the FA-2 attractant) which were formulated in long-lasting dispensers by USDA-ARS (Gainesville, FL, USA). A description of lures and traps has been reported [1]. Jackson traps baited with Trimedlure (TML) were included in the experiment as an indicator of medfly population levels. Traps were deployed in argan and citrus in Agadir during fall 1994 and summer 1995.

2nd year: The experiments consisted of comparing the performances of several trap and lure combinations which included: CBDTs with FA-2 lures; FA-2 lures in open bottom dry traps (OBDTs) containing a yellow sticky insert; locally-made open bottom traps with yellow color and yellow sticky insert (CC)[3]; a liquid protein-baited IPMT (aqueous solution of 9% NuLure + 3% borax, NU+B); and Jackson traps baited with TML. The Jackson traps were included as an indicator of the medfly population. Traps were deployed in argan forest and mandarin orchard in Agadir during fall 1995.

3rd year: This year, a third component, TMA, was added to the synthetic lure. The two component, FA-2 lures consisting of patches of ammonium acetate (AA) + putrescine (P) and the three component, FA-3 lures (consisting of AA + P + TMA) were tested in OBDTs and CC traps. A new "Frutect" medfly trap (a trap with a red spherical container containing a special formulation of liquid protein bait mounted on a yellow sticky board) was also tested. As in year 2, these were compared to IPMTs baited with NU+B and Jackson traps baited with TML. All traps were deployed in an orange orchard. The field trial was conducted during fall 1996.

4th year: The lure was improved by the addition of a third component, TMA. Additionally, preliminary experiments carried out in Guatemala [4] using IPMTs with water in the reservoir and, in Spain with the Tephri trap, using DDVP showed that these traps out-captured the OBDTs. The purpose of experiments this year was to test the FA-3 lures in wet and dry traps to differentiate between trap design and presence of water in the trap. These tests included: IPMTs using water or DDVP for fly retention; Tephri traps with DDVP; and OBDTs + yellow sticky insert + medfly synthetic pheromone on a rubber bung sleeve (provided by Dr. Howse). As in the previous experiments, Jackson traps with TML and IPMT traps with liquid protein were used as standards.

Lures provided this year were commercially produced and slightly different than those provided in previous years. The FA-3 components were individually packaged in a white envelope labeled "Biolure"

2.3. Side experiments

The maturity status of captured female medflies was determined via dissection and examination of ovaries. A sub-sample of 25 - 30 females was collected from each trap.

The development of an egging system using female attractant or argan extract failed.

2.4. Data analysis

The results obtained were submitted to the variance analysis and means were separated with least significant test or Tukey's test. The original data were log (x+1) transformed. Tables show non-transformed data.

3. RESULTS AND DISCUSSION

From the results of field trials conducted during the fall of the first year field (Table I), it was apparent that the food-based synthetic attractants provided an effective system for capturing female medflies. More than 90% of females were captured by FA-2 baited traps but only 5% of males. Catches in Jackson traps indicated that the population levels were moderate, which is normal for this time of year.

When the same experiment was repeated during summer, when the medfly populations were high in argan forest, dry traps caught almost 100% of total females and this represented 73% of dry trap catches. Analysis of variance of log (x + 1) transformed data followed by least significant difference test indicated that the mean number of females in dry traps was significantly lower than the mean number of males in Jackson traps (Table II). However, the total number of flies caught in both male and female targeted traps was not significantly different (F=0,63; dl 1,63; $P > 0,05$). This promising data should be analyzed with care since trap capacity was a limiting factor for fly catches in Jackson traps. Indeed, during the summer experiments, Jackson traps were 100% saturated when dry traps could still be filled. In addition, FA-2 baited dry traps were slightly specific for medflies. Further experiments were conducted to compare this new female trapping system with the standard IPMT, NU+B system. Also, other traps were tested with the new female attractant to acquire more knowledge about the relation between trap designs and climatic conditions. In this regard, the OBDT and the local CC trap, both baited with FA-2 were also tested. Tables III and IV show that trap captures in both argan and citrus were similar and lower than in the summer experiment. The food-based synthetic attractant was designed to be used mainly for monitoring and controlling medfly population. Therefore, tests at low population level would give more information concerning the performance of the attractant. Trap captures in Jackson traps ranged from 0.93-0.58 males/trap/day in argan and citrus, respectively, representing 51 - 60% of total captures. During the summer, trap captures reached 47 males/trap/day in argan, and represented 47.8% of total catches. Traps with FA-2 attractants and IPMT, NU+B captured the most females in the test and there were no significant differences in capture among any of the female targeted-traps. Female capture ranged from 0.06 - 0.20 females/trap/day and representing 58-88 % of the trap capture. If only females are considered, ANOVA followed by Tukey's test indicated that IMPTs attracted significantly more females than the other traps. TML baited Jackson traps captured almost no females at both sites. At low populations, trap efficiency comparisons demonstrated that TML baited Jackson traps were still the best for attracting a large number of medflies, but 80-82% of these were males. A trap which can remove females is considered more significant in pest control because females cause the most fruit damage.

In decreasing order, Jackson traps were the most medfly specific, followed by OBDT, CBDT, CC, and IPMT traps. It seems that argan has lower insect diversity than citrus. The highest percentage of non-target insects was caught in citrus and reached 25% of total capture of CC traps.

TABLE I. *Ceratitis capitata* CAPTURE IN JACKSON TRAPS BAITED WITH TML AND CBDT BAITED WITH FA-2 DURING FALL 1994 IN ARGAN FOREST

Trap/lure/treatment			Flies/trap/day			Relative trap efficiency (in %)		
Trap	Bait	Retention	Male	Female	Total	Male	Female	Total
JT	TML	Sticky Insert	3.26	0.02	3.28	94.7	6.5	87.5
CBDT	FA-2	methomyl	0.18	0.29	0.47	5.3	93.5	12.5
		TOTAL	3.44	0.31	3.75	100	100	100

TABLE II. *C. capitata* CAPTURE IN JACKSON TRAPS BAITED WITH TML AND CBDT BAITED WITH FA-2. FIELD TRIAL CONDUCTED IN ARGAN FOREST DURING SUMMER 1995

Trap/lure/treatment			Flies/trap/day			Relative trap efficiency (in %)		
Trap	Bait	Retention	Male	Female	Total	Male	Female	Total
JT	TML	Sticky Insert	47.4	0.002	47.4	77.2	0	47.8
CBDT	FA-2	methomyl	14.0	37.8	51.8	22.8	100	52.2
		TOTAL	61.4	37.802	99.2	100	100	100

TABLE III. MEAN FLIES/TRAP/DAY CAPTURED WITH MALE-TARGETED JACKSON TRAPS BAITED WITH TML AND WITH FEMALE-TARGETED TRAPS (OBDT, CBDT, LOCAL TRAP, IPMT) BAITED WITH EITHER FA-2 OR NU+B. FIELD TRIALS CONDUCTED IN ARGAN FOREST IN FALL 1995

Trap/lure/treatment			Flies/trap/day			Relative trap efficiency (in %)		
Trap	Bait	Retention	Male	Female	Total	Male	Female	Total
JT	TML	Sticky Insert	0.93	0.00	0.93	80	0	60
CBDT	FA-2	methomyl	0.04	0.07	0.12	4	19	7
OBDT	FA-2	Sticky Insert	0.05	0.08	0.12	4	20	8
Local trap	FA-2	Sticky Insert	0.06	0.08	0.14	5	21	9
IPMT	NU+B	Water	0.09	0.15	0.24	8	39	16
		TOTAL	1.17	0.38	1.55	100	100	100

TABLE IV. MEAN FLIES/TRAP/DAY CAPTURED WITH MALE-TARGETED JACKSON TRAPS BAITED WITH TML AND WITH FEMALE-TARGETED TRAPS (OBDT, CBDT, LOCAL TRAP, IPMT) BAITED WITH EITHER FA-2 OR NU+B. FIELD TRIALS CONDUCTED IN CITRUS (MANDARIN) IN FALL 1995

Trap/lure/treatment			Flies/trap/day			Relative trap efficiency (in %)		
Trap	Bait	Retention	Male	Female	Total	Male	Female	Total
JT	TML	Sticky Insert	0.58	0.00	0.59	82	1	51
CBDT	FA-2	methomyl	0.03	0.10	0.14	4	24	12
OBDT	FA-2	Sticky Insert	0.01	0.06	0.08	2	14	7
Local trap	FA-2	Sticky Insert	0.01	0.07	0.08	2	15	7
IPMT	NU+B	Water	0.07	0.20	0.27	10	46	23
		TOTAL	0.70	0.43	1.16	100	100	100

Further improvements were made to increase the efficacy of the new trapping system. In this regard, a third component, TMA, was added to the FA-2 lure. Since trap design may have an effect on the capacity of capture, experiments were carried out using the same trap for comparing the FA-3 to the FA-2 attractants. IPMTs with NU+B and TML baited Jackson traps were used as standards. The field trial results (Table V) show that traps baited with either the FA-2 or FA-3 synthetic lure captured as many females as the liquid protein baited IPMT and Frutect traps. However, female targeted traps baited with the synthetic lure were more specific. IPMT and Frutect traps attracted, in addition to medflies, *Bactrocera oleae* males and females, *Musca domestica*, spiders and other unidentified diptera. Jackson traps caught at least 30% more flies than the rest of the traps. It seems that trap design had no effect in this case and the third component did improve the new trapping system. In this experiment,70 to 90 % of the dissected females caught in female-targeted traps were mature (90% in liquid protein-baited traps, 80% in FA-2 baited traps and 70% in FA-3 baited traps).

Frutect traps were not easy to use in the field because of the sticky surface collected dust and was difficult to handle. In other countries (Greece and Spain), wet IPMT traps baited with the FA-3 lures captured the highest number of females. For this reason, further experiments were conducted in two medfly host plants, argan and mandarin (*Citrus reticulata* Blanco). The aim of these tests was to evaluate the efficacy of the FA-3 lure in association with wet IPMTs (with water) or dry IPMTs (with DDVP), dry Tephri traps (with DDVP), and OBDTs baited with FA-3 to which a rubber bung loaded with synthetic male pheromone was added. TML baited Jackson traps and NU+B baited IPMTs were used as standards. Tables VII and VIII show that the synthetic FA-3 lures tested in wet and dry IPMTs seem to be as attractive for females as the standard IPMT, NU+B. However, in citrus, the daily average of female captures was significantly higher in Tephri traps baited with the FA-3 lure than in other traps. Contrary to previous results [5], addition of pheromone components to the FA-3 lure in cylindrical open dry traps (with sticky insert) did not increase trap catches. It is not yet known if the inconsistent results with the pheromone were due to the component instability or to other factors. The capture in TML baited Jackson traps ranged from 44 - 17 males/T/D in

TABLE V. COMPARISON OF MEAN NUMBER OF FLIES/TRAP/DAY CAPTURED WITH MALE-TARGETED JACKSON TRAPS BAITED WITH TML AND WITH FEMALE-TARGETED TRAPS (OBDT, LOCAL TRAP) BAITED WITH EITHER FA-3 OR FA-2 SYNTHETIC LURES. IPMT AND FRUTECT BAITED WITH LIQUID PROTEIN WERE INCLUDED IN THE TEST. FIELD TRIALS CONDUCTED IN CITRUS (MANDARIN) IN FALL 1996

Trap/lure/treatment			Flies/trap/day			Relative trap efficiency (in %)		
Trap	Bait	Retention	Male	Female	Total	Male	Female	Total
JT	TML	Sticky Insert	8.27	0.02	8.29	86	0	41
OBDT	FA-2	Sticky Insert	0.15	1.25	1.40	2	12	7
OBDT	FA-3	Sticky Insert	0.41	2.75	3.16	4	26	16
Local Trap	FA-2	Sticky Insert	0.25	2.75	3.00	3	26	15
Local trap	FA-3	Sticky Insert	0.20	1.58	1.78	2	15	9
IPMT	NU+B	Water	0.14	1.23	1.37	1	12	7
Frutect	Frutect Bait	Sticky	0.20	1.11	1.31	2	10	6
		TOTAL	0.70	0.43	1.16	100	100	100

argan and citrus, respectively, which represented only 35 - 50% of total capture, while in the first, second and third year captures in Jackson traps represented 50 to 87 %. NU+B baited IPMT traps were more effective for female capture than all types of dry traps baited with FA-2 lures and their capture ranged from 39 - 46% versus 14 - 24 in dry traps. However, when the third component was added, the dry traps, mainly the OBDT, were twice as effective as NU+B and the Frutect. Only the locally-made traps showed a decrease in female capture when the third component was added, but still captured more females than IPMT, NU+B traps. Furthermore, the relative efficiency of NU+B baited IPMTs was lower or equal to IPMTs with the FA-3 synthetic components and ranged from 13 - 22% in citrus and argan, respectively. This means that trap design has no effect, but the type of lure affects the trap efficiency.

The percentage of females caught in each female-targeted trap ranged from 58 - 92% and this seemed not to be not related to host-plant or the season of experiment. The proportion of females in NU+B baited IPMTs followed the same trend as well.

In citrus, female captures in all female targeted traps were significantly and negatively correlated with minimum relative humidity and minimum temperature. Captures in Jackson traps were not affected by weather conditions. Data from all traps indicated that the population levels in both hosts was gradually declining throughout the experiment.

The IPMTs baited with NU+B were far less specific and caught 50% of total non-target flies in all female-targeted traps, followed by wet IPMTs (30%), dry IPMTs (11%), Tephri traps (4%) and cylindrical dry traps (3.6%). The non-target species captured were mostly ants, spiders and small unidentified black diptera. The fruit infestation level was similar in both hosts and ranged from 10 - 11%.

During the first phase of experiments, the ratio of immature/ mature females changed during the course of both fall and summer experiments conducted in argan. Dissection of a sub-sample of 30 females caught every 3 days indicated that in summer only 39% of captured females were immature while in fall 57% were immature (Table VI). In the second phase of the experiment, conducted in fall, dissection and observation of female ovaries indicated that percent of immature females was 62 and 70% in citrus and argan, respectively. Only in the case of argan was there a significant difference between immature and mature females. In the third year tests, conducted in citrus, during fall, only 10 - 30% of females were immature. From the results of the last year, most of females captured in female-targeted traps were immature. The percent of sexually immature females was 80% and 82% in citrus and argan, respectively. In NU+B baited traps the percentage of immature females ranged from 84 - 87%.

It seems that the ratio of immature/mature females in medfly population changed during the different field tests, and this variation occurred regardless of the season of the test.

Percentages of fruit infestation (Table VI) varied according to the stage of maturity of the fruits. In general, it was high in summer, in argan, when fruits were mature and in fall, in citrus, when fruits became mature and had not been chemically treated for a long period.

TABLE VI. PERCENTAGE OF IMMATURE FEMALES CAUGHT IN FEMALE TARGETED TRAPS BAITED WITH SYNTHETIC FEMALE ATTRACTANT OVER 4-YEAR TRAPPING RESULTS

	% IMMATURE FEMALES	HOST- PLANT	SEASON	% infestation
1st year	39%	ARGAN	Summer	65-85%
	57%	ARGAN	Fall	0-20%
2nd year	60%	CITRUS	Fall	10-30%
	70%	ARGAN	Fall	0-10%
3rd year	10 - 30%	CITRUS	Fall	70- 85%
4th year	80%	CITRUS	Summer	10%
	82%	ARGAN	Summer	11%

TABLE VII. REPRESENTATIVE DATA SUMMARY

Country:	MOROCCO
Host:	ARGAN
Altitude:	60m
Avg. Temp. Min-Max:	16.5 - 29.8 °C
Avg. RH. Min-Max:	54.9 - 97.7
Trapping period (dates):	28 July - 4 September 97
No. of Trap Days (#traps per treatment x #days):	5 Traps x (6wk x 7) = 210
Jackson trap capture (# Total F/T/D):	44.2
% females in Jackson trap ([# Females/ # Total] x 100):	0.00%
Number of Jackson trap days (# traps x # days):	5 x (6 wk x 7) = 210
Average number of larvae/kg fruit:	103 pupae/kg fruit

TRAP/LURE			FLIES/TRAP/DAY			Relative Trap Efficiency			%fem/trap
Trap	Bait	Retention	#Males	# Females	#Total	%Males	%Females	%total	(#fem/#tota
IPMT	NU+B	Water	3.74	5.16	8.9	26	22	23	58
IPMT	FA-3	Water	2.96	6.03	8.99	21	25	24	67
IPMT	FA-3	DDVP	3.19	5.14	8.33	22	22	22	62
TEPHRI	FA-3	DDVP	2.43	4.1	6.53	17	17	17	63
OBDT	FA-3	Sticky	2.05	3.3	5.35	14	14	14	62
JT	TML	Sticky	44.2	0.005	44.205	##########	#########	##########	#########
						100%	100%	100%	

TABLE VIII. REPRESENTATIVE DATA SUMMARY

Country:	MOROCCO
Host:	CITRUS
Altitude:	60m
Avg. Temp. Min-Max:	16.5 - 29.8 °C
Avg. RH. Min-Max:	54.95 - 97.7
Trapping period (dates):	28 July - 4 September 97
No of Trap Days (# traps per treatment x # days):	5 traps x (6 wk x 7days) = 210
Jackson trap capture (#Total F/T/D):	17.31
% females in Jackson trap ([# Females/ #Total]x100):	0.00%
Number of Jackson trap days (# traps x # days):	5 x (6 wk x 7days) = 210
Average number of larvae per kg of fruit:	LARVAE NOT DETECTED, ONLY PUNCTURES WERE OBSERVED, AVERAGE INFESTATION LEVEL 10%.

TRAP/LURE			FLIES/TRAP/DAY			Relative Trap Efficiency			%fem/trap
Trap	Bait	Retention	#Males	# Females	#Total	%Males	%Females	%total	(#fem/#total)
IPMT	NU+B	Water	0.67	1.56	2.23	14	13	13	70
IPMT	FA-3	Water	1.16	2.78	3.94	23	23	23	71
IPMT	FA-3	DDVP	0.73	2.35	3.08	15	20	18	76
TEPHRI	FA-3	DDVP	1.63	3.59	5.22	33	30	31	69
OBDT	FA-3	Sticky insert	0.75	1.67	2.42	15	14	15	69
JT	TML	Sticky insert	17.31	0	17.31	##########	##########	##########	##########
					Total=	100%	100%	100%	

4. CONCLUSIONS

The finding from these field trials showed that significant progress was made in developing a female medfly attractant. The dry Tephri trap baited with the FA-3 lure is satisfactory and fulfills the requirements for use in dry and dusty areas as an alternative to NU+B baited IPMTs. We should also mention that, in only one case (CBDT baited with FA-2 lure), did the female-targeted traps reached the level of Trimedlure baited Jackson traps captures (37 versus 47 female/trap/day). Based on these results, it is apparent that the synthetic attractants provide an effective system for capturing female medflies and could be used as a tool for assessing the efficacy of SIT when sterile males are released. Further programs should be implemented to evaluate the potential for use of the synthetic attractants in mass-trapping strategies for feral females, in addition to use with sterile male release programs.

It is not clear if the synthetic lure is more mature or immature female oriented. Attraction of mature females could be explained by their need to feed on protein as an exogenous source for egg development, but the attraction of immature females shows that there must be another reason.

Captures in traps baited with the FA-3 attractants were mainly affected by changes in minimum relative humidity and minimum temperature. When humidity and temperature decreased, female catches decreased as well.

Development of an oviposition device using argan extract as attractant was promising in the laboratory, but, as yet, field tests have not been as successful. Preliminary identification of argan airborne volatile components revealed that the earlier peaks correspond to the so-called " general green leaf volatiles," viz. hexanol, hexanal, hexenol and hexenal. Tests of medfly response to these components in the laboratory and in the field were also disappointing.

REFERENCES

[1] HEATH, R.R., et al., Development of a dry plastic insect trap with food-based synthetic attractant for the Mediterranean and the Mexican fruit fly (Diptera: Tephritidae), J.Econ.Entomol. **88** (1995)1307-1315.

[2] SACANTANIS, K.B., La forêt d'arganier. Le plus grand foyer de *Ceratitis capitata* dans le monde, Boll. Lab. Ent. Agr. Portici **15** (1957)1-53.

[3] EPSKY, N.D., et al., Visual cue and chemical cue interactions in a dry trap with food-based synthetic attractant for *Ceratitis capitata* and *Anastrepha ludens* (Diptera: Tephritidae), Environ. Entomol. **24** (1995) 1387-1395.

[4] HEATH, R.R., et al., Effect of adding methyl-substituted ammonia derivatives to a food-based synthetic attractant on capture of Mediterranean and Mexican fruit fly (Diptera: Tephritidae), J.Econ. Entomol. (in press)

[5] BAKRI, A., HADIS, H., Development of female medfly attractant systems for trapping and sterility assessment. Second research co-ordinated meeting with the FAO/ IAEA co-ordinated research program, Funchal, Madeira, Portugal, 20-24 January 1997.

FIELD EVALUATION OF FEMALE MEDFLY ATTRACTANTS IN MALLORCA (BALEARIC ISLANDS)

A. ALEMANY, R. ALONSO, M.A. MIRANDA
Laboratory of Zoology,
Department of Environmental Biology,
University of the Balearic Islands. Spain,

Abstract

The report contains data from experiments conducted in Mallorca in collaboration with the Year 4 Experiments of the Co-ordinated Research Programme (CRP) on Development of Medfly Female Attractants. In the last year of the program, research focused on testing three female attractants (FA-3: putrescine, ammonium acetate, and trimethylamine) in plastic International Pheromone's McPhail traps (IPMT) or Tephri traps (a Spanish version of the IPMT). Traps were either used as dry traps (provided with DDVP) or wet traps (provided with water and 0.01%surfactant). Field trials were carried out in an unmanaged citrus orchard of about 14 ha situated at sea level in the south of the island of Mallorca, about 7 km from Palma. The experimental orchard was a mixed citrus orchard of 3 ha and included tangerines, navel and navelate varieties. Two experiments were carried out. The first was with cold temperatures and a high population level (about 12 flies/trap/day) in October, November and December 1997. The second was with warm temperatures and a low population level (< 1.4 flies/trap/day) in April and May 1998. Treatments and traps included in both trials were: IPMT, FA-3, wet; IPMT, FA-3, dry; Tephri, FA-3, dry; IPMT, NU+B (IPMT trap baited with NuLure 9% and borax 3%); Tephri, FA-3, wet; and De, TML (a yellow delta trap baited with Trimedlure). The methodology followed was that described in the IAEA protocol. Fly captures were expressed as numbers of flies or flies/trap/day (F/T/D). Based on results from both studies, the Tephri, FA-3, wet was the most efficient for capturing female medflies in cool temperatures and high population conditions as well as in moderate temperatures and low population conditions. Although Tephri, FA-3, wet was the most efficient, we recommend the use of the Tephri, FA-3, dry as being the best choice for female trapping in Balearic conditions because of several drawbacks for the use of the Tephri trap as a wet trap. These included: capture of high numbers of non targeted insects (some of them beneficials); small capacity for water, which evaporated quickly under the weather conditions of Mallorca; and the size of the FA-3 lures. Trials under different conditions showed that trap design, climatic conditions, population density and fruit availability have a great influence on female capture by FA-3 baited traps. The low male capture capacity showed by FA-3 makes it adequate for using in SIT programs, although massive male releases could modify this results. The FA-3 treatments captured both mated and unmated females. Thus, these attractants may be useful to assess the sterility status of female wild population in SIT programs. FA-3 baited traps seemed to be able to detect female medfly at low population levels as well as to monitor growing population better than TML.

1. INTRODUCTION

The use of the Sterile Insect Technique (SIT) in practical applications for control or eradication of Mediterranean fruit fly populations requires a system to evaluate the progress in implemented SIT programs. This system is based on developing specific females attractants which would allow capture of only wild females and few sterile and wild males. Analysis of captured females provides important information about egg sterility induced in the wild population by the sterile males, thus being a measure of the efficacy of the program. Improving a selective medfly female trap system is also interesting for detection of early populations and in suppression programs using female mass trapping.

The present work is included as a collaboration in the Co-ordinated Research Programme (CRP) Year Four on Development of Medfly Female Attractants. In the last year of the program, the research was focused on the test of the 3 females attractants (FA-3: putrescine, ammonium acetate, and trimethylamine) in dry and wet conditions.

2. MATERIAL AND METHODS

2.1. Description of sites

Field trials were carried out in an unmanaged citrus orchard of about 14 ha situated at sea level in the south of the island of Mallorca at 7 km from Palma (main town in Mallorca). The experimental orchard was a 3 ha mixed citrus orchard including Tangerines, Navel and Navelate varieties.

Two experiments were carried out. The first was with cold temperatures and a high population level (about 12 flies/trap/day) in October, November and December 1997, and the second was with warm temperatures and a low population level (< 1.4 flies/trap/day) in April and May 1998.

During the two trials all the trees were unirrigated, but still produced fruit suitable for medfly infestation.

The maximum and minimum temperatures in this zone ranged between 25 ^{o}C and 0 ^{o}C. Daily humidity variation was from 50 % to 80 %.

Climatic data were recorded in the experimental orchard and also were provided by the nearest weather station situated 2 km from the experimental site (data not shown).

The prevailing wind direction was from west to east.

2.2. Traps and attractants

Treatments and traps included in both trials were:

- IPMT, FA-3, wet - IPMT trap baited with FA-3 (Female Attractants: putrescine, trimethylamine and ammonium acetate) and water with surfactant Triton (4-5 drops)
- IPMT, FA-3, dry - IPMT trap baited with FA-3, DDVP (insecticide), dry
- Tephri, FA-3, dry - Tephri trap baited with FA-3, DDVP, dry
- IPMT, NU+B - IPMT trap baited with NuLure 9% and borax 3%
- Tephri, FA-3, wet - Tephri trap baited with FA-3 and water with surfactant (4-5 drops)
- De, TML - Yellow delta trap baited with Trimedlure

The methodology followed was that described in the IAEA protocol. Fly captures were expressed as numbers of flies or flies/trap/day (F/T/D).

The first experiment was carried out from 24/10/97 to 13/1/98 (80 days) and the second from 7/4/98 to 26/5/98 (50 days).

Data were analyzed using LSD Multirange Test at 95% confidence on log(x+1) transformed data.

Data from second experiment was analyzed in the whole sampling period (50 days) and also considering only a sampling period of 30 days to assure the adequate performance of the lures.

3. RESULTS

3.1. 1st Experiment 24/10/97 TO 13/1/98

TABLE I. FEMALE CAPTURES

	Treatments				
	IPMT,FA-3,wet	IPMT,FA-3,dry	Tephri,FA-3,dry	IPMT,NU+B	Tephri,FA-3,wet
Mean F/T/D	4.8	6.4	9.9	7.1	11
Mean[1]	0.049a	0.052ab	0.057bc	0.052ab	0.06c

[1]Values followed by the same letters are not significantly different. (ANOVA LSD Multiple Range Test on log (x+1) transformed data,P= 0,05)

TABLE II. MATING STATUS

TREATMENT	TOTAL MALES	TOTAL FEMALES	% FEMALES	% MATED FEMALES[2]
IPMT, FA-3, wet	414	1951	82.5	72.5
IPMT, FA-3, dry	761	2573	77.2	64.0
Tephri, FA-3, dry	813	3970	83.0	64.4
IPMT, NU+B	622	2847	82.1	74.0
Tephri, FA-3, wet	820	4400	84.3	74.4
De, TML	6315	-	-	-

[2] Only the first period of the experiment (30 days) was considered

TABLE III. MALE CAPTURES

	Treatments					
	IPMT, FA-3, wet	IPMT, FA-3, dry	Tephri,FA-3, dry	IPMT, NU+B	Tephri,FA-3, wet	De, TML
Mean F/T/D	1	1.9	2	1.5	2	15.7
Mean[1]	0.023a	0.028b	0.030b	0.030b	0.032b	0.067c

[1] Values followed by the same letters are not significantly different. (ANOVA LSD Multiple Range Test on log (x+1) transformed data,P= 0,05)

TABLE IV. MEAN NON TARGETED INSECTS/TRAP/DAY IN EACH TREATMENT

TREATMENT	Mean
IPMT, FA-3, wet	1.6
IPMT, FA-3, dry	1.5
Tephri, FA-3, dry	1.4
IPMT, NU+B	3.6
Tephri, FA-3, wet	1.9
De, TML	0.2

TABLE V. FRUIT INFESTATION NO. PUPAE/KG OF GROUND AND TREE FRUITS DURING SAMPLING PERIOD

	No. pupae/kg Ground Fruit	No. pupae/kg Tree Fruit
October-97	10	1.42
November-97	4	14.6
December-97	3	0
January-98	0	0

3.2. 2nd Experiment 7/4/98 - 26/5/98

TABLE VI. FEMALE CAPTURES

	Treatments				
	IPMT,FA-3, wet	IPMT,FA-3, dry	Tephri,FA-3,dry	IPMT,NU+B	Tephri,FA-3,wet
Mean F/T/D	0.047	0.041	0.045	0.041	0.133
Mean [1]	0.009a	0.008a	0.010a	0.007a	0.016b

[1] Values followed by the same letters are not significantly different. (ANOVA LSD Multiple Range Test on log (x+1) transformed data $P = 0,05$)

TABLE VII. FEMALE CAPTURES 1ST MONTH

	Treatments				
	IPMT,FA-3,wet	IPMT,FA-3,dry	Tephri,FA-3,dry	IPMT,NU+B	Tephri,FA-3,wet
Mean F/T/D	0.022	0.016	0.017	0.013	0.037
Mean [1]	0.005ab	0.004ab	0.004ab	0.003a	0.009b

[1] Values followed by the same letters are not significantly different. (ANOVA LSD Multiple Range Test on log (x+1) transformed data,P= 0,05)

TABLE VIII. MATING STATUS OF FEMALES CAPTURED IN VARIOUS TREATMENTS

TREATMENT	TOTAL MALES	TOTAL FEMALES	% FEMALES	% MATED FEMALES
IPMT, FA-3, wet	15	58	79.5	81.0
IPMT, FA-3, dry	23	35	60.3	44.4
Tephri, FA-3, dry	13	66	83.5	23.8
IPMT,NU+B	11	48	81.4	71.4
Tephri, FA-3, wet	37	169	82.0	62.5
De, TML	84	-	-	-

TABLE IX. MALE CAPTURES

	Treatments					
	IPMT,FA-3, wet	IPMT,FA-3, dry	Tephri,FA-3, dry	IPMT,NU+B	Tephri,FA-3, wet	De,TML
Mean F/T/D	0.012	0.020	0.009	0.009	0.028	0.068
Mean [1]	0.002a	0.004ab	0.002a	0.002a	0.005b	0.015c

[1] Values followed by the same letters are not significantly different. (ANOVA LSD Multiple Range Test on log (x+1) transformed data,P= 0,05)

TABLE X. MALE CAPTURES WITHOUT TREATMENDe,TML

	Treatments				
	IPMT,FA-3,wet	IPMT,FA-3,dry	Tephri,FA-3,dry	IPMT,NU+B	Tephri,FA-3,wet
Mean F/T/D	0.012	0.020	0.009	0.009	0.028
Mean [1]	0.002a	0.004ab	0.002ab	0.002bc	0.005c

[1] Values followed by the same letters are not significantly different. (ANOVA LSD Multiple Range Test on log (x+1) transformed data,P= 0,05)

TABLE XI. MALE CAPTURES 1ST MONTH

	Treatments					
	IPMT,FA-3, wet	IPMT,FA-3, dry	Tephri,FA-3, dry	IPMT,NU+B	Tephri,FA-3, wet	De,TML
Mean F/T/D	0	0.01	0.003	0.007	0.006	0.036
Mean [1]	0a	0.002a	0.001a	0.002a	0.001a	0.009b

[1] Values followed by the same letters are not significantly different. (ANOVA LSD Multiple Range Test on log (x+1) transformed data $P = 0,05$)

TABLE XII. MEAN NON TARGETED INSECTS/TRAP/DAY IN EACH TREATMENT

TREATMENT	Mean
IPMT, FA-3, wet	4.3
IPMT, FA-3, dry	4.2
Tephri, FA-3, dry	2
IPMT, NU+B	18.3
Tephri, FA-3, wet	6.5

TABLE XIII. FRUIT INFESTATION NO. PUPAE/KG OF GROUND AND TREE FRUITS DURING SAMPLING PERIOD

	No. pupae/kg Ground Fruit	No. pupae/kg Tree Fruit
April 98	0	0
May 98	0	0

4. DISCUSSION

4.1. First experiment

Results showed significant differences in females captures among the tested treatments (Table I). The most efficient treatment was Tephri, FA-3, wet followed by Tephri, FA-3, dry, IPMT, NU+B, IPMT, FA-3, dry and IPMT, FA-3, wet. It seems that adding water to the Tephri trap increased the number of females captures but not with a significant difference with respect to the Tephri, FA-3, dry treatment. Water could be an attractant for flies in combination with FA-3. The high number of female captures could also be due to water working as killing mechanism.

Both Tephri trap treatments presented relative low captures of males indicating a good performance for their use as a female-targeted monitoring system.

All the treatments showed a relationship between captures and minimum temperature. Increases and decreases in weekly captures were related to maximum and minimum temperatures which switch daily insect activity and emission rate of the attractant substances.

The De, TML showed the highest number of male captures, a significantly different result from that obtained with the others treatments (Table III). TML is still the best lure for monitoring male populations.

The weekly pattern of male capture with De, TML was similar to that of female attractant- based treatments. Thus, we can assume that odour emission was equivalent in all treatments except for some irregularities shown with the IPMT, FA-3, wet.

IPMT traps baited with FA-3 (wet and dry) seem to have had poor results compared with those obtained using Tephri traps. Even IPMTs baited with NuLure recorded higher captures than the IPMT, FA-3 (wet and dry), probably due to the lesser capacity for FA-3 odour emission in the IPMT, but a good capacity to maintain NuLure in good conditions throughout time. NuLure inside Tephri traps (direct observations) becomes dry in a short period of time during warm seasons. Lower females captures in treatment IPMT, FA3, wet could be consequence of having no insecticide inside. Thus, flies remained alive for a long time inside the trap and have more possibilities to find a way out.

All treatments were quite selective for females (Table I), with values around 80 % of females captures. The Tephri, FA-3, wet treatment showed the best performance in % females captured, followed by Tephri, FA-3, dry, IPMT, FA-3, wet, IPMT, NU+B, IPMT, FA-3, dry. These results indicate the possibility of using FA-3 as an adequate system for monitoring female wild population in control or eradication SIT programs, and for checking egg sterility in mated females (Table II).

Results showed that the Tephri, FA-3, wet was the most effective treatment in catching females, being also the second treatment in capturing non targeted species (Table IV). For this reason, the Tephri, FA-3, wet and others based on water and liquid bait could be inadequate for SIT trapping systems in such climatic conditions, because water makes it laborious to take off the captures while an important number of non targeted species (mainly Diptera and some beneficial insects) are also caught, which causes further, time-consuming difficulties in separating captures.

Higher captures during sampling periods were related to the fruit infestation rate both in tree and ground fruits, the result being that all treatments were able to detect significant changes in population. The relationship between fruit infestation and captures could therefore be an assessment of efficiency in SIT programs (Table V).

In conclusion, these results suggest that treatment Tephri, FA-3, dry is the best choice as a trapping system for monitoring medfly females, as it is the most efficient and less time consuming. Water based trapping, on the other hand, increases the number of females, but also that of non targeted species, among which some are beneficial fauna.

Further studies are necessary to improve the capacity of FA-3 to detect early low level population compared with others lures such as NuLure and TML.

4.2. Second experiment

Captured female data from first month of sampling period (Table VII) were analyzed separately to assure a correct life span of the FA-3 during this period. The analysis showed significant differences only between IPMT, NU+B and Tephri, FA-3, wet. In this period, with a very low population level, the Tephri, FA-3, wet was the most effective, although there was

no significant difference comparing IPMT, FA-3, wet, IPMT, FA-3, dry, and Tephri, FA-3,dry. It seems that at this population level both wet and dry IPMT and Tephri combinations were able to detect medfly, and probably the better performance of Tephri, FA-3, wet was due to the presence of water in the Tephri trap, which is more open than IPMT.

The significant difference in effective catches among Tephri, FA-3, wet and the others increased when the population began to increase (Table VI). Then, the analysis of the whole experiment (50 days.) showed that Tephri, FA-3, wet was the most effective followed by Tephri, FA-3, dry, IPMT, FA-3, wet, IPMT, FA-3 dry and IPMT, NU+B. Combination of Tephri trap with FA-3 and water seems to be a good tool for increasing the number of medfly captures low population condition in early spring, although there was also an increasing of non targeted insects (Table XII), mainly Diptera from Calliphoridae and Muscidae families that can saturate the trap which involves spending time to separate the captures. Low water containing capacity and high evaporation rate (more than IPMT) are also problems in using Tephri trap in such conditions.

All FA-3 treatments showed a good selectivity for females (Table VIII), following the same results as in the first experiment. The Tephri, FA-3, dry and wet were the most selective in capturing females.

The sexual maturity status of females differed from the first experiment, showing that in the second experiment there was a young, early growing population situation, with a high percentage of virgin females that were captured mainly by Tephri, FA-3, dry and IPMT, FA-3, dry. Treatments with water may attract mature females. Although FA-3 is a food based attractant, mature females were clearly attracted to IPMT, NU+B, based on hydrolyzed protein (Table VIII).

Temperature was the main factor in population development under the conditions in the second experiment conditions. Fruit availability was non limiting. Minimum and maximum temperatures switched weekly captures pattern. As maximum temperatures ranged between 17 -26 ^{o}C, which is an optimum range for medfly development, minimum temperatures seemed to enhance medfly populations, mainly when it was above 10 ^{o}C.

Comparing females captures of Tephri, FA-3, wet and males captures of De, TML, both showed a direct response in captures as minimum temperatures increases, although the response to Tephri, FA-3, wet seemed better for population detection and estimation than De, TML.

As in the first experiment, De, TML showed a significant difference from the others (Table IX). TML was again the most efficient lure for males, being 5 times better than the best of the others treatments (Table X), even in the first month of sampling with very low population level (Table XI). Under such conditions, TML was shown to be an adequate tool to detect medfly (males) and for monitoring the growing population

Fruit infestation showed very poor results (Table XIII). Low population levels and the fruit sampling method did not allow for detection of larvae in fruit under such conditions. Screening more fruit is probably necessary in order to detect early populations by fruit sampling.

5. CONCLUSIONS

1. Adding water to FA-3 based treatments allowed to increase the number of medfly females captures. The Tephri, FA-3, wet was the most efficient in capture female medfly in cool temperatures and high population conditions as well as in temperate and low population conditions.
2. Although Tephri, FA-3, wet was the most efficient, high numbers of non targeted insects, some of them beneficials, low carrying water trap capacity, high water evaporation rate from

the trap, and size of the FA-3 lures, confirm Tephri, FA-3, dry as being the most adequate to use for female trapping in Balearic conditions.

3. Trials in different conditions have showed that trap design, climatic conditions, population density and fruit availability have a great influence in female catching by FA-3 baited traps.

4. The low male capture capacity showed by FA-3 makes it adequate for using in SIT programs, although massive male release could modify this results.

5. The FA-3 treatments captured both mated and unmated females. Thus, these attractants may be useful to assess the sterility status of female wild population in SIT programs.

6. FA-3 baited traps seemed to be able to detect female medfly in low population levels as well as monitoring the growing population even better than TML.

7. More efforts are necessary in order to improve the interpretation of the relationship between TML and FA-3 captures.

8. A different fruit sampling methodology is needed to detect medfly in low population conditions.

DEVELOPMENT OF FEMALE FRUIT FLY, *Ceratitis* species, ATTRACTANT SYSTEMS FOR TRAPPING AND STERILITY ASSESSMENT IN SOUTH AFRICA

D.K. EYLES, N. DU PLESSIS, B.N. BARNES
ARC-Fruit, Vine and Wine Research Institute,
Stellenbosch, South Africa

Abstract

Fruit in the Western Cape Province of South Africa is attacked by the Mediterranean fruit fly, *Ceratitis capitata*, and the Natal fruit fly, *C. rosa*. Control costs and crop losses amount to an estimated US$5 million per year. The ARC-Fruit, Vine and Wine Research Institute in Stellenbosch has been taking part in the FAO/IAEA Co-ordinated Research Programme (CRP) to develop a female attractant systems for *C. capitata* during the 1996/97 and 1997/98 growing seasons. These seasons represented Year 3 and Year 4, respectively, of the female attractant CRP. The performance of these attractant systems in monitoring *C. rosa* was also evaluated. The Year 3 trial was carried out in a plum orchard with a low fruit fly population, and the Year 4 trial was carried out in the same plum orchard, as well as in a pear orchard with a high fruit fly population. Four female trapping systems were evaluated in Year 3 and five in Year 4. In Year 3, two systems consisted of a locally-manufactured bucket-type "Sensus" trap containing one of two different female attractants (β-caryophyllene, or β-caryophyllene + protein hydrolysate), one was a McPhail trap (IPMT) baited with borax + protein hydrolysate, and the fourth was an open bottom dry trap (OBDT) baited with the three component ammonium acetate, putrescine and trimethylamine system (FA-3). Sensus traps and Jackson traps baited with the male fruit fly attractant Trimedlure (TML) were also included. In Year 4, there was one wet and one dry IPMT system (both baited with FA-3), one IPMT system (borax + protein hydrolysate), and one wet and one dry Tephri trap system (both with FA-3). Jackson traps baited with TML were also included. Results from Year 3 showed that of the systems tested, the best female *C. capitata* attractant systems under low population conditions were the IPMT system baited with borax + protein hydrolysate, and the OBDT system baited with FA-3. β-caryophyllene in a Sensus trap did not adequately attract female *C. capitata*. No conclusions could be drawn on *C. rosa* in this trial. In Year 4, the most effective traps for both *C. capitata* and *C. rosa* females were the wet TEPHRI (FA-3) and the wet IPMT (FA-3) systems. The least effective systems for females of both species were the dry TEPHRI (FA-3) system and the IPMT (borax + protein hydrolysate) system. Fruit fly population levels affected the performance of some systems.

1. INTRODUCTION

Two fruit fly species, the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), and the Natal fruit fly, *C. rosa* (Karsch), attack fruit in the Western Cape Province of South Africa. *C. rosa* is unique to southern Africa and Madagascar. These fruit flies are declared phytosanitary pests, and are estimated to cost the South African deciduous fruit industry US$3.5 million per annum in control costs and another US$1.5 million per annum in residual losses.

This is the second deciduous fruit season (1997/98) that South Africa has been involved in testing female fruit fly attractant systems for use during a Sterile Insect Technique (SIT) control programme according to the FAO/IAEA Co-ordinated Research Programme (CRP) protocol. Due to the late entry by South Africa into Year 3 (1996/97) of the CRP programme, the preliminary trials carried out did not form part of Year 3 CRP research. Nevertheless, at the CRP co-ordination meeting in Madeira, results of trials with various dry, wet and sticky traps under low fruit fly population conditions in South Africa were presented, together with some earlier results on the performance of protein fruit fly attractants for monitoring *C. capitata, C. rosa,* and the mango fruit fly, *C. cosyra*, in a subtropical fruit area.

It was decided at the Madeira meeting that South Africa would continue with Year 4 of the CRP protocol. This report presents the results of Year 4 with a summary of the preliminary work done during Year 3. In addition, trials are being carried out in the subtropical fruit area of South Africa to determine whether the three-patch lure system (ammonium acetate, putrescine and trimethylamine) would attract *C. cosyra*. This work is still in progress and is not reported here.

Our involvement with the female attractant CRP is in addition to an FAO/IAEA-supported study to determine the feasibility of eradicating fruit fly from the Western Cape by means of SIT, currently being undertaken by the ARC-Fruit, Vine & Wine Research Institute.

2. MATERIALS AND METHODS

All the trials in both Year 3 and Year 4 were conducted during December and January, a period of low to moderate fruit fly infestation levels. The peak of fruit fly infestation in the deciduous fruit growing areas is usually from February to April.

2.1. Year 3 - 1996/97

2.1.1. Description of trapping systems and trial layout

During the 1996/97 season the effectiveness of the following fruit fly trapping systems was determined:

- Jackson trap withTrimedlure (JT, TML)
- Sensus trap (locally-manufactured dry, plastic trap) baited with 3 ml of a mixture of 96% TML (Capilure) and 4%dichlorvos (Sensus, TML)
- Sensus trap with 3 ml of a mixture of 96% β-caryophyllene (Outspan *Ceratitis* Attractant) and 4% dichlorvos (Sensus, B)
- Sensus trap with 3 ml solution of β-caryophyllene, Hym-lure (protein hydrolysate) and mercaptothion (30 ml Hym-lure, 5 g Malathion 250 g/kg WP and 5 ml β-caryophyllene) (Sensus, BH)
- International Pheromone's McPhail Trap baited with 300 ml of a solution containing 9% NuLure, 3% borax, and 88% water (PMT, NU+B)
- Open bottom dry trap baited with separate patches of ammonium acetate, putrescine and trimethylamine (OBDT, FA-3)

A randomized block design with seven replicates was used. Data were collected over a period of 5 weeks during which the fruit increased in size from 20 mm to 60 mm. During the final week of the trial the fruit had started colouring. Data on fruit fly catches were collected once a week and not twice a week as stipulated in the protocol, as the fruit fly population during the trial period was low. All traps were maintained as described in the protocol for Year 3 [2].

2.1.2.Description of site

An 8-year-old plum orchard of the cultivar Harry Pickstone on the farm Wildekraans was used. Both *C. capitata* and *C. rosa* were present. This orchard was 46 m above sea-level and was adjacent to a nectarine orchard and a wine grape vineyard. The average monthly rainfall and the average maximum and minimum monthly temperatures are given in Fig. 1. A plan of the site is given in Fig. 2. Weekly fruit fly protein-bait applications were applied routinely during the trial by the grower at his insistence.

No fruit fly cover sprays were applied during this period.

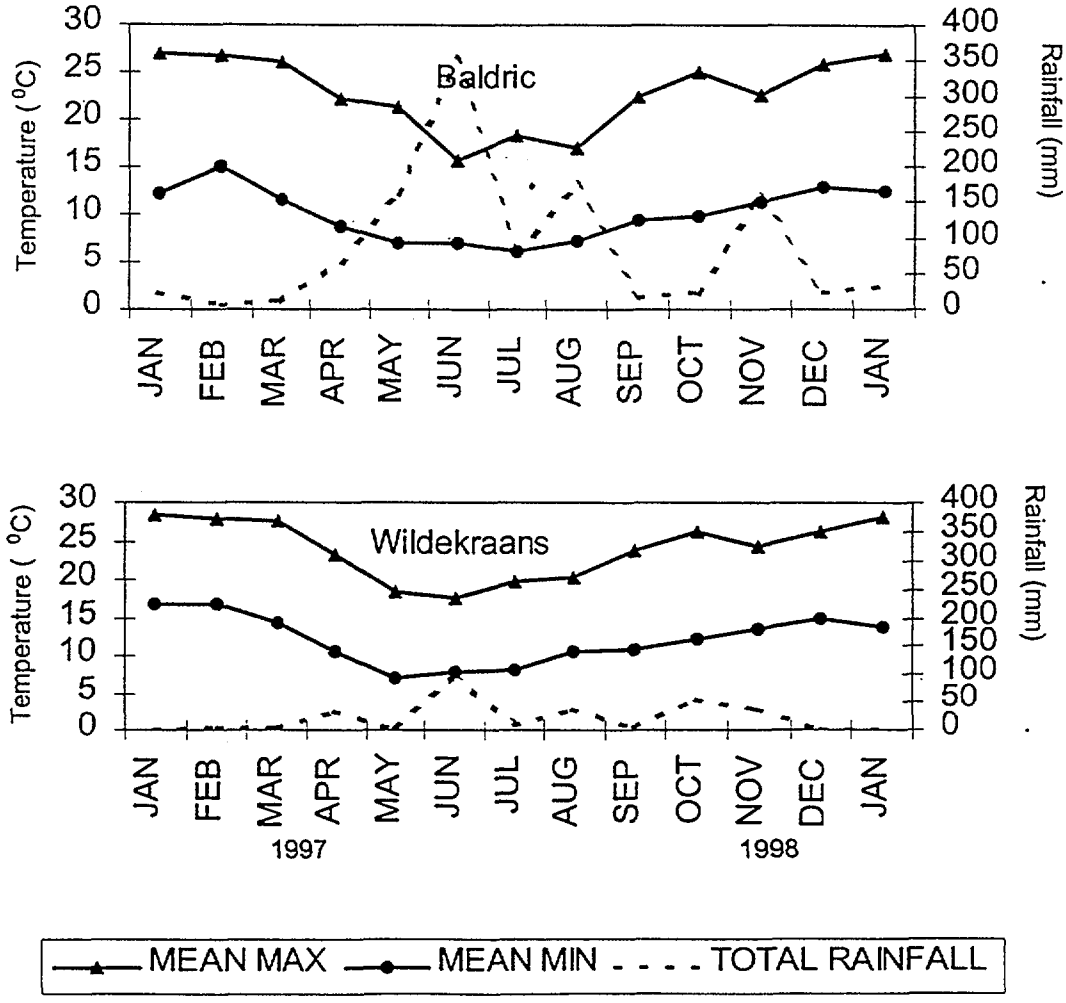


Figure 1. Mean monthly minimum and maximum temperatures and total monthly rainfall for both sites from January 1997 to January 1998.

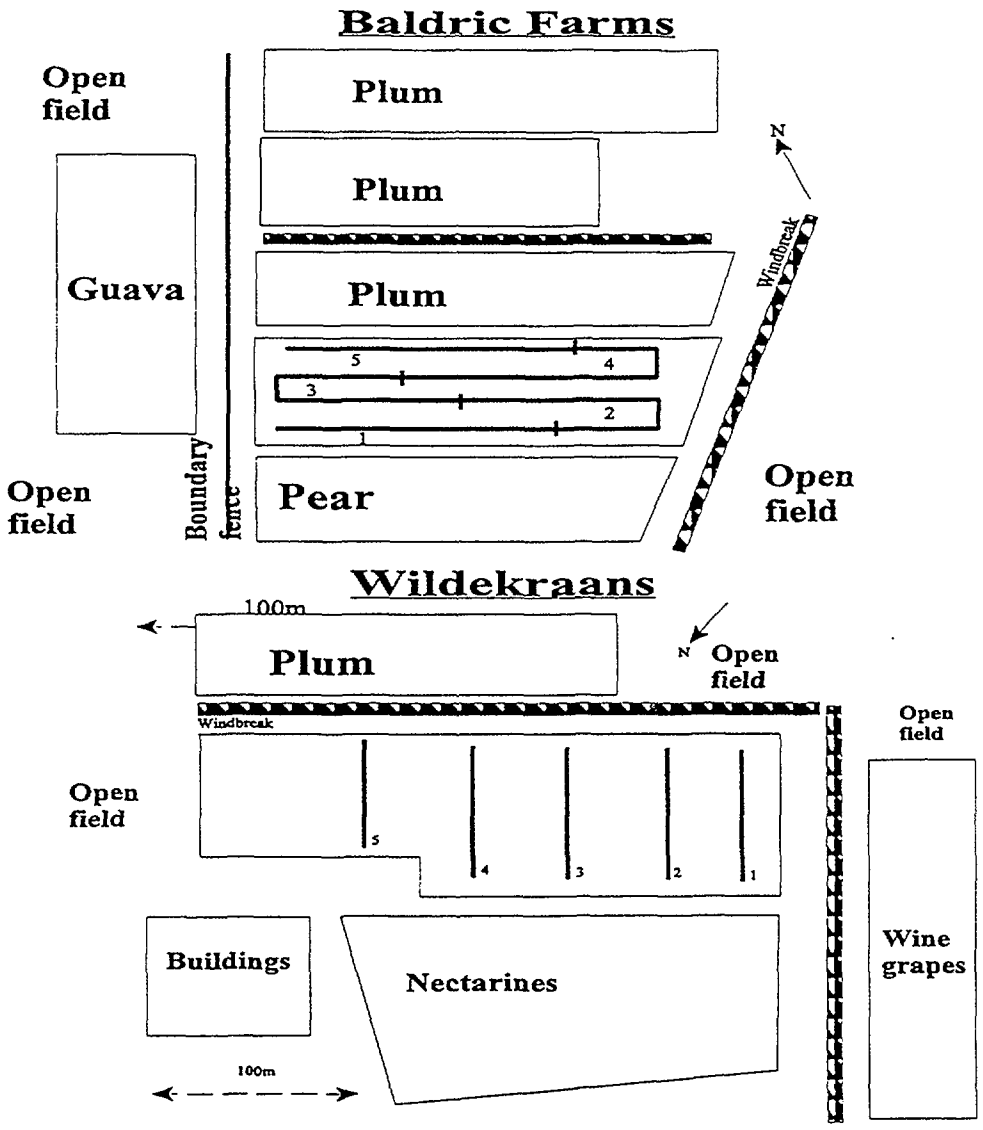


Figure 2. Plan of Baldric and Wildekraans sites used during the FAO/IAEA Co-ordinate Research Programme for Year 3 (1996/7) and Year 4 (1997/98) in South Africa. The experimental blocks are numbered one to five. The trial at Baldric was conducted in a pear orchard, while the trial at Wildekraans was conducted in a plum orchard.

During the 1997/98 season the effectiveness of the following fruit fly trapping systems was determined:

- IPMT, FA-3 used as a wet trap - two drops of the Triton surfactant per 300 ml of water were placed in the trap bottom
- IPMT, FA-3 used as a dry trap - a 5 mm^2 block of a DDVP strip was placed in the trap base
- IPMT, NU+B, same trapping system as used during Year 3
- Tephri, FA-3 used as a dry trap - a 5 mm^2 block of a DDVP strip was placed in the basket
- JT, TML, same trapping system as used during Year 3

Two field sites were used with different fruit fly population pressures (see *2.2.2.* below). Each site consisted of five trap lines of six traps each as a randomized complete block. Traps

were placed 2 m above the ground within the tree canopy. All traps were approximately 25 m apart.
All traps and lures were supplied by the IAEA. Traps were checked weekly for 6 weeks from 22 December 1997. Data was collected once a week, and not twice a week as in the protocol, as fruit fly populations were relatively low during the period when this trial was carried out. All *C. capitata* and *C. rosa* caught were counted and sexed. Each week, each trap was rotated sequentially and the liquid bait in each trap changed where relevant. The TML septa in the JT s were changed fortnightly. The FA-3 lures were not changed. A weekly protein-based fruit fly bait was applied routinely during the trial at the insistence of the growers. No fruit fly cover sprays were applied during this period.

2.2.2. Description of sites

The two sites used were in a plum orchard in an area with low fruit fly pressure, and a pear orchard in an area with a high fruit fly pressure. Both *C. capitata* and *C. rosa* were present. The sites were about 60 km apart in different climatic areas (see Fig. 1). Site 1 was the same site as that used during the previous season - a 9-year-old plum orchard of the cultivar Harry Pickstone on the farm Wildekraans (see *2.1.2.* and Fig. 2). This site had a relatively low fruit fly pressure. Site 2 was a pear orchard of the cultivar Forelle on the farm Baldric (Fig. 2). This site had a high fruit fly pressure, and was surrounded on two sides by plum orchards. On a third side was a guava orchard which was not clean-picked at harvest nor was fruit on the ground removed, resulting in a large source of fruit flies.

Rainfall and temperature data for both sites are given in Fig. 1. Total monthly rainfall was lower on site 1 than on site 2. Mean monthly temperatures were higher on site 1 than on site 2. According to data from the Jackson traps, *C. capitata* populations were substantially higher than *C. rosa* populations on both sites.

3. RESULTS AND DISCUSSION

3.1. Year 3 - 1996/97

Results of the performance of the different traps is given in Table I. Although the results were not analysed statistically due to the low numbers of fruit flies caught, trends were evident.
The locally-manufactured Sensus trap, baited with either TML or β-caryophyllene, appeared to be the most effective in trapping male *C. capitata*, while very few female *C. capitata* were trapped. Sensus traps appeared to be more effective in attracting male *C. capitata* than Jackson traps.

Traps which detected the first increase in populations were the Sensus traps baited with TML (males only) and the OBDT, FA-3 and IPMT, NU+B systems, which trapped more or less equal numbers of male and female *C. capitata*.
The IPMT, NU+B and OBDT, FA-3 systems were the most effective in trapping female *C. capitata*. Sensus traps baited with β-caryophyllene attracted female fruit flies but only in very low numbers. The OBDT trap was more "user friendly" than the IPMT trap. No conclusions could be made regarding which trap was the most effective in trapping either males or females of *C. rosa* as only one specimen was caught in a Sensus trap baited with β-caryophyllene. The above results have been summarised from the report delivered at the Madeira female fruit fly trapping meeting [2].

TABLE I. MEAN NUMBER OF *C. capitata* CAUGHT PER TRAP PER WEEK IN SIX TRAPPING SYSTEMS REPLICATED SEVEN TIMES OVER A 5 - WEEK PERIOD.

	JT, TML	Sensus, TML	Sensus, B			Sensus, BH			IPMT, NU+B			OBDT, FA-3		
DATE	Male	Male	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
20/12/96	0(0)*	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
26/12/96	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
02/01/97	0(0)	1.43(10)	0(0)	0.14(1)	0.14(1)	0(0)	0(0)	0(0)	0(0)	0.43(3)	0.43(3)	0(0)	0.29(3)	0.29(3)
09/01/97	0(0)	2.86(20)	2(14)	0.29(2)	2.29(16)	0(0)	0(0)	0(0)	0.14(1)	0.84(6)	1.00(7)	0(0)	0.43(3)	0.43(3)
16/01/97	0.29(0)	2.29(16)	0.85(6)	0(0)	0.85(6)	0.14(1)	0(0)	0.14(1)	0(0)	0.14(1)	0.14(0)	0.14(1)	0.43(3)	0.57(4)

*Total number of flies caught in the seven replicates is given in brackets.

TABLE II. TOTAL NUMBER OF MALE AND FEMALE *C. capitata* CAPTURED AT WILDEKRAANS IN PLUMS BY DIFFERENT TRAPPING SYSTEMS FROM DECEMBER 1997 TO JANUARY 1998

Trap system	Total number of flies			Flies/Trap/Day					Relative trap efficiency		
	M[1]	F[2]	TOTAL	M		F		TOTAL	M	F	% F in trap
IPMT, FA-3, wet	23	76	99	0.11	a[3]	0.36	a	0.47	34.85	34.86	95.00
IPMT, FA-3, dry	15	40	55	0.07	ab	0.19	abc	0.26	22.73	18.35	100.00
IPMT, NU+B	5	27	32	0.02	b	0.13	bc	0.15	7.58	12.39	93.10
Tephri, FA-3, dry	12	18	30	0.05	b	0.09	c	0.14	16.67	8.26	94.74
Tephri, FA-3, wet	12	57	69	0.06	ab	0.27	ab	0.33	18.18	26.15	90.48
JT, TML	129	0	129								
Total	195	218	414								
Total less JT, TML	66	218	285						100	100	

[1]M=male; [2] F=female; [3] numbers in columns not followed by the same letter differ significantly from one another at the 5% level

TABLE III. TOTAL NUMBER OF MALE AND FEMALE *C. rosa* CAPTURED AT WILDEKRAANS IN PLUMS BY DIFFERENT TRAPPING SYSTEMS FROM DECEMBER 1997 TO JANUARY 1998

Trap system	Total number of flies			Flies/Trap/Day					Relative trap efficiency		
	M[1]	F[2]	TOTAL	M		F		TOTAL	M	F	% F in trap
IPMT, FA-3, wet	1	4	5	0.005	a[3]	0.019	a	0.02	25.00	30.77	5.00
IPMT, FA-3, dry	0	0	0	0	a	0	a	0.00	0	0	0.00
IPMT, NU+B	1	2	3	0.005	a	0.010	a	0.01	25.00	15.38	6.90
Tephri, FA-3, dry	1	1	2	0.005	a	0.005	a	0.01	25.00	7.69	5.26
Tephri, FA-3, wet	1	6	7	0.005	a	0.029	a	0.03	25.00	46.15	9.52
JT, TML	23	0	23								
Total	27	13	40								
Total less JT, TML	4	13	17						100	100	

[1] M=male; [2] F=female; [3] numbers in columns not followed by the same letter differ significantly from one another at the 5% level

TABLE IV. TOTAL NUMBER OF MALE AND FEMALE *C. capitata* CAPTURED AT BALDRIC IN PEARS BY DIFFERENT TRAPPING SYSTEMS FROM DECEMBER 1997 TO JANUARY 1998

Trap system	Total number of flies			Flies/Trap/Day					Relative trap efficiency		
	M[1]	F[2]	TOTAL	M		F		TOTAL	M	F	% F in trap
IPMT, FA-3, wet	319	922	1241	1.52	ab[3]	4.39	ab	5.91	16.30	24.99	66.52
IPMT, FA-3, dry	238	575	813	1.13	b	2.74	bc	3.87	12.16	15.59	68.62
IPMT, NU+B	136	281	417	0.65	c	1.34	d	1.99	6.95	7.62	72.24
Tephri, FA-3, dry	294	502	796	1.40	b	2.39	cd	3.79	15.02	13.61	72.44
Tephri, FA-3, wet	970	1409	2379	4.62	a	6.71	a	11.33	49.57	38.2	66.00
JT, TML	998	0	998								
Total	2955	3689	6644								
Total less JT, TML	1957	3689	5646						100	100	

[1]M=male; [2] F=female; [3] numbers in columns not followed by the same letter differ significantly from one another at the 5% level

TABLE V. TOTAL NUMBER OF MALE AND FEMALE *C. rosa* CAPTURED AT BALDRIC IN PEARS BY DIFFERENT TRAPPING SYSTEMS FROM 15 DECEMBER 1997 TO JANUARY 1998

Trap system	Total number of flies			Flies/Trap/Day					Relative trap efficiency		
	M[1]	F[2]	TOTAL	M		F		TOTAL	M	F	% F in trap
IPMT, FA-3, wet	341	464	805	1.62	ab[3]	2.21	ab	3.83	24.08	26.48	33.48
IPMT, FA-3, dry	173	263	436	0.82	b	1.25	bc	2.08	12.22	15.01	31.38
IPMT, NU+B	76	108	184	0.36	c	0.51	d	0.88	5.37	6.16	27.76
Tephri, FA-3, dry	159	191	350	0.76	b	0.91	cd	1.67	11.23	10.90	27.56
Tephri, FA-3, wet	667	726	1393	3.18	a	3.46	a	6.63	47.11	41.44	34.00
JT, TML	113	0	113								
Total	1529	1752	3281								
Total less JT, TML	1416	1752	3168						100	100	

[1]M=male; [2] F=female; [3] numbers in columns not followed by the same letter differ significantly from one another at the 5% level

3.2. Year 4 - 1997/98

The number of fruit flies per trap per day (F/T/D), the relative trap efficiency, and the percentage females per trap are given for both *C. capitata* and *C. rosa* on each site in Tables II - V. while the pooled data for both sites is given in Table III.

The results confirmed that populations were low on Wildekraans and high on Baldric (at least 20 times higher than on Wildekraans). Further results and discussion are therefore classified under "low population conditions" and "high population conditions". Based on the Jackson trap data, *C. capitata* outnumbered *C. rosa* on both sites by a factor of about 6 to 8.

3.2.1. Low population conditions (Wildekraans)

The five female-targeted traps always caught as many or more female fruit flies than males of both species. Collectively, approximately three times more females than males of each species were caught (Tables II and III).

The IPMT, FA-3, wet and Tephri, FA-3, wet traps were the most effective in trapping females of both *C. capitata* and *C. rosa*. Of these, the IPMT, FA-3, wet trap caught the most *C. capitata* females and the Tephri, FA-3, wet trap the most *C. rosa* females, but in neither case was the difference between the two trap types significant.

The Tephri, FA-3, dry traps caught the least number of female *C. capitata*, but not significantly fewer than the IPMT, NU+B traps. In the case of *C. rosa,* the IPMT, FA-3, dry traps did not catch any females or males, but there were no significant differences between *C. rosa* females caught in any of the female-targeted traps. The above results are mirrored by the data on relative trap efficiency (Table II and III).

The rank order of female-targeted traps with respect to catches of male *C. capitata* was similar to that for females, with minor variations.

Jackson traps are currently the standard fruit fly trap used in SIT programmes. Compared with the number of male *C. capitata* and *C. rosa* caught in the Jackson traps under low population conditions, the best of the female traps (IPMT, FA-3, wet) appeared to give a reasonable estimation of the *C. capitata* population (60% of Jackson total), but a poor estimation (17%) of the *C. rosa* population.

3.2.2. High population conditions (Baldric)

The five female-targeted traps always caught more female fruit flies than males of both species, collectively, 1.8 times more for *C. capitata,* but only 1.2 times more for *C. rosa* (Table IV and V).

As in the case of low population conditions, the IPMT, FA-3, wet and Tephri, FA-3, wet traps were the most effective in trapping females of both *C. capitata* and *C. rosa* under high population conditions. The Tephri, FA-3, wet trap caught the most females of both species, but not significantly more than the IPMT, FA-3, wet trap. There was also no significant difference between catches in the IPMT, FA-3, wet and IPMT, FA-3, dry traps. The IPMT, NU+B trap caught the fewest female fruit flies of both species, significantly fewer than the Tephri, FA-3, dry traps. The above results are mirrored by the data on relative trap efficiency (Tables IV and V).

The rank order of female-targeted traps with respect to catches of male *C. capitata* was very similar to that for females.

Compared with the number of male *C. capitata* and *C. rosa* caught in the Jackson traps under high population conditions, the best of the female traps (Tephri, FA-3, wet) appeared to give a good estimation (85% of Jackson total) of the *C. capitata* populations, and an excellent estimation (344%) of the *C. rosa* population.

3.2.3. Pooled data (Wildekraans + Baldric)

If the data from the two sites is pooled, the results of trap performance are the same as discussed above for the high population conditions.

4. CONCLUSIONS

4.1. Year 3 - 1996/97

As a result of the low numbers of fruit flies caught in all trapping systems, no significant differences between the systems could be detected.

The IPMT, FA-3, wet trapping system and the OBDT, FA-3 system were the most effective of the traps tested for trapping female *C. capitata* under low population conditions.

The Sensus trap baited with β-caryophyllene did not adequately attract *C. capitata* females under low population conditions.

4.2. Year 4 - 1997/98

With minor variations, *C. capitata* and *C. rosa* reacted in similar ways to the various trapping systems tested in this study.

The traps most attractive to *C. capitata* and *C. rosa* females are the Tephri, FA-3, wet and IPMT, FA-3, wet trapping systems. For *C. capitata*, Tephri, FA-3, wet traps were more effective under high population conditions, while IPMT, FA-3, wet traps were more effective under low population conditions.

The traps least attractive to *C. capitata* and *C. rosa* females were the Tephri, FA-3, dry and IPMT, NU+B traps.

Based on comparisons with male *C. capitata* caught in Jackson traps, the best of the female traps give reasonable estimates of the *C. capitata* populations, depending on size of

population. In the case of *C. rosa*, the estimation is poor under low population conditions, but excellent under high population conditions.

ACKNOWLEDGEMENTS

This research was supported by the Joint FAO/IAEA Division of the United Nations, Vienna, Austria, under Research Contract 9366/R0 and 9366/R1 from 1996 to 1998, for which we are very grateful. We thank Mrs Marita van der Rijst of the ARC-Agrimetrics Institute for advice on the layout of the trials and for the statistical analysis. We are also grateful to the management of Wildekraans and Baldric farms for permission to carry out the trials in their orchards and their cooperation, and to the staff of the Pest Management Division of the ARC-Fruit, Vine & Wine Research Institute for technical assistance.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Standardization of medfly trapping for use in sterile insect technique programmes. Final report of a co-ordinated research programme 1986-1992, IAEA-TECDOC-883, Vienna (1996).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Development of female medfly attractant systems for trapping and sterility assessment, Working material, Second Research co-ordination meeting within the FAO/IAEA co-ordinated research programme held in Funchal, Madeira, Portugal, 20 - 24 January 1997, IAEA-D4-Rc-581, Vienna (1997).

EFFICACY OF FEMALE ATTRACTANT TRAPPING SYSTEMS FOR MEDFLY FOR USE IN SUPPRESSION PROGRAMMES

S.I. SEEWOORUTHUN, S. PERMALLOO, P. SOOKAR
Entomology Division,
Ministry of Agriculture, Fisheries & Cooperatives,
Reduit, Mauritius

Abstract

Several species of fruit flies cause serious losses to fleshy fruits in Mauritius. Due to fruit production being confined mainly to backyard gardens, traditional methods of control do not give satisfactory results. Full cover sprays with chemicals also pose potential environmental and health risks. Alternative control methods were developed and an area-wide control programme was conceived, using bait application to bring down fruit fly population, followed by intensive trapping of males, using pheromones, to keep the population at low levels. An effective attractant system for mass trapping of females integrated into the wide area programme would greatly enhance control. The use of synthetic food-based attractants for trapping *Ceratitis capitata* and other fruit fly species was investigated in two phases and compared with different trapping systems. In the Phase III experiments, a two component lure, ammonium acetate + putrescine (FA-2) and a three component lure, ammonium acetate + putrescine + trimethylamine (FA-3) were tested in different traps and compared with standard liquid protein-baited International Pheromone's McPhail Trap (IPMT). Frutect trap, Tephri-trap and Jackson trap with Trimedlure were also used. The medfly female catch with the FA-3 lure used in the Open Bottom Dry Trap outnumbered the catches in other traps. In Phase IV, the final year of the trial, the FA-3 lure was tested in wet and dry IPMT and Tephri traps. These were compared with IPMT containing NuLure + borax (NU+B) as standard and with locally developed traps. The FA-3 lure gave the highest catches of female medflies in the IPMT with water as retaining device followed by IPMT with DDVP, although catches were not significantly different from IPMT with NU+B.

1. INTRODUCTION

Fruit flies are serious pests of fruits in Mauritius, a small tropical island of 1800 km^2, situated at about 1000 km off the east coast of the African mainland [1]. A total of eight species are present in Mauritius and the damaging species to fleshy fruits are the mango fly, *Bactrocera zonata* Saunders, the Natal fly, *Ceratitis rosa* Karsch, the medfly, *Ceratitis capitata* Wiedemann and the Ber fly, *Carpomya vesuviana* Costa. The latter is restricted to jujube (*Ziziphus jujuba* Lam.) [2, 3]. The melon fly, *B. cucurbitae* Macquart, the most dominant species of fruit fly in Mauritius, is an important pest of cucurbits and has not been recorded from fleshy fruits as in other countries [4, 5]

The medfly presence in Mauritius dates back to 1885 [4]. It was the main species existing until the late 1950s when it was gradually displaced by *C. rosa* and eventually both were displaced by *B. zonata*, as from 1987 [6, 7].

Because fruit production is confined mostly to backyard gardens, little fruit fly control is practise by individual householders. The effectiveness of the control is limited by the fact that the neighbours of concerned householders do not spray their trees, resulting in constant invasion from adjacent gardens. Full cover sprays with chemicals also pose potential environmental and health risks in gardens and for persons applying the sprays [8]. Research on fruit fly control was therefore geared towards development of alternative control methods, which are environment friendly and easily accessible to the public. An area-wide control programme utilizing bait application and male annihilation techniques was initiated in April 1994 and is currently being implemented over one third of the island [9]. Additionally, due to the accidental introduction of the Oriental fruit fly, *Bactrocera dorsalis* in Mauritius in June 1996, an eradication programme against this pest is being run in the southern part, using the

same methods. The National Programme in the North and the eradication programme in the South cover a total area of about 850 km^2 [7].

All lures presently available attract only males and the development of a female attractant system for fruit flies will be a major breakthrough in fruit fly control. Such a system could be integrated in wide area control programmes for suppression of fruit fly populations. Female attractant traps would also give an additional tool for monitoring of populations in a wide area control programme.

1.1. Development of female medfly attractant systems

Trapping systems for fruit flies, whether used for detection, surveillance, monitoring or mass trapping for suppression purposes, presently utilise lures for trapping males or traps baited with protein hydrolysate solution which catch both males and females [10]. Investigations were initiated to develop a female attractant system to trap medfly, which could be used for use in SIT programmes, detection programmes or in suppression programmes [11, 12].

An international network research project for the development of a female attractant system for medfly trapping has been operated under IAEA/FAO, as a Co-ordinated Research Programme (CRP). Trials effected in the final phases of the CRP, that is Phase III and IV are reported here.

2. MATERIALS AND METHODS

2.1. Sites of study - Phases III and IV

Organised orchards are quite rare in Mauritius, and, with about half the island being under chemical treatment and the medfly not being the dominant species, very few ideal sites were available.

2.1.1. Site 1

Site 1 was used for both CRP Phase III (20 December 1996 to 13 February 1997 and Phase IV (24 October 1997 to 18 December 1997).

Field tests were carried out at Pointe aux Sables, a coastal region in the West, where the fruits of the Indian almond tree, *Terminalia catappa* L. and coffee, *Coffea arabica* L. are the main medfly hosts. However, medfly heavily infests hosts other fleshy fruits, such as chilly, *Capsicum annuum* L. and liane poc poc (a wild creeper), *Passiflora suberosa* L. The Indian almond tree is grown mainly for shade and produces a large number of non-edible fruits, which do not receive any chemical treatment. Other probable medfly hosts in the region are Chinese guava, *Psidium cattleianum* Sabine, mango, *Mangifera indica* L., guava, *Psidium guajava* L., jujube, *Ziziphus jujuba* Lam., bullock's heart, *Annona reticulata* L., water apple, *Syzygium samarangense* (Blume) Merr. & Perry, peach, *Prunus persica* (L.) Batsch and carambola, *Averrhoa carambola* L. It should be noted that citrus is not a host of medfly in Mauritius.

Apart from these fruit trees, in general, the vegetation is made up of grasses, logwood trees, *Haematoxylon campechianum* L. and other non-fruit fly host trees, such as custard apple, *Annona squamosa* L., sour sop, *Annona muricata* L., tamarind, *Tamarindus indica* L. and *Casuarina* sp.

The elevation of the region is between 5 to 30 m above sea level. Monthly rainfall records ranged from 0 mm in driest months (May to October) to 265 mm in summer months (November to April) during the past three years.

2.1.2. Site 2

Similarly, Site 2 was used for both CRP Phase III (28 October 1997 to 23 December 1997) and Phase IV (07 January 1998 to 02 March 1998).

Trials were conducted at Bel Ombre, a coastal village in the South, where the fruit trees and vegetation are similar to Site 1. Its elevation is between 3 to 20 m above sea level. Monthly rainfall readings during the past three years ranged from 5mm in driest months as compared to 544 mm in summer months.

2.2. Traps and attractants

2.2.1. Phase III

A two component (FA-2), consisting of ammonium acetate (AA) and Putrescine (P), had been developed and tested in a dry trap during Phase I of the IAEA/FAO CRP for Medfly Female Attractant Studies, in collaboration with USDA/ARS.

A modified trapping system, the Open Bottom Dry Trap (OBDT) was used in Phase II. A third component, trimethylamine (TMA) was added to the food attractants in Phase III. The protocol for this Phase was designed to determine trapping efficiency of the FA-3 (AA, P & TMA), in comparison with FA-2 (AA & P), in OBDT and with the pre-baited Frutect traps. Both FA-2 and FA-3 combinations were also tested in local traps. The locally-designed trap consisted of a round plastic container with lid, of 140 mm in diameter and 105 mm in height. Four holes of 22 mm diameter were made on the sides. Jackson traps with Trimedlure (JT, TML) and McPhail traps with NuLure + borax (NU+B) were used as standards. Tephri traps with NU+B and TML were also included.

A randomised complete block design with 5 blocks consisting of 8 traps per block, was used in backyard situations. The IAEA protocol had 7 treatments, but an eighth treatment was added as Tephri traps were also provided. All traps were hung on *T. catappa* trees, about two m above ground level. Trap catches were recorded twice a week and the traps within a block were rotated sequentially after each reading. Fruits susceptible to medfly attack were collected once a week for data on infestation.

The attractant systems used in the trials were as follows:

- Jackson Trap with sticky insert baited with Trimedlure Plug (JT, TML)
- OBDT with sticky insert baited with FA-2 (OBDT, FA-2)
- OBDT with sticky insert baited with FA-3 (OBDT, FA-3)
- Locally designed trap baited with FA-2 (CC, FA-2)
- Locally designed trap baited with FA-3 (CC, FA-3)
- International Pheromone's McPhail Trap baited with a mixture containing 88 % water, 9 % Nulure and 3 % borax (IPMT, NU+B)
- Frutect trap, which is pre-baited (Frutect)
- Tephri trap baited with a mixture containing 88 % water, 9 % NuLure and 3 % borax and Trimedlure Plug (Tephri, NU+B, TML)

2.2.2. Phase IV

Phase IV of the CRP was targeted at testing the FA-3 synthetic lure in wet and dry traps. Wet traps were IPMT and Tephri traps, both with water, whereas for dry traps IPMT and Tephri traps with DDVP strips were used. The IPMT, NU+B was the standard trap. A local trap with the FA-3 lure and DDVP as insect retaining device was also included for comparison, as well as a JT, TML standard for male medfly catches.

A randomised block design with five blocks consisting of 7 treatments per block was used. The procedures are the same as in Phase III. The trials were conducted according to Protocol for Phase IV of the CRP. Treatments were as follows:

- JT, TML
- IPMT, NU+B
- IPMT baited with FA-3 and water, as a retaining device (IPMT, FA-3, wet)
- IPMT baited with FA-3 and a toxicant plug, DDVP, as a retaining device (IPMT, FA-3, dry)
- Tephri trap baited with FA-3 and a toxicant plug, DDVP, as a retaining device (Tephri FA-3, dry)
- Tephri trap baited with FA-3 and a toxicant plug, DDVP and water, as retaining devices (Tephri, FA-3, DDVP, wet)
- Locally designed trap baited with FA-3 and a toxicant plug, DDVP, as a retaining device (CC, FA- 3, dry)

Observations on the maturity of captured female medflies were carried out.

3. RESULTS

The trapping data for Phase III and IV for Sites 1 and 2 are summarised in Tables I - IV, respectively. Detailed results have been summarised and converted into Fly/Trap/Day (F/T/D). Data for trapping of other fruit flies are given in Tables V - VIII for CRP Phase III and Phase IV, respectively.

Statistical analysis by ANOVA (Table IX -XII) and Duncan's Multiple Range Test have been carried out on log transformed data from female targeted traps and therefore do not include figures from Jackson traps.

3.1. Capture of medflies

In the Phase III trials, results on the efficacy of OBDT, FA-3 were consistent at both sites. This trapping system outcaptured all other traps in the case of female medfly. However, at Site 1 - Pointe aux Sables, there was no significant difference between OBDT, FA-3, OBDT, FA-2, and IPMT, NU+B. At Site 2 - Bel Ombre, the female medflies trapped in OBDT, FA-3, Frutect, and Tephri, NU+B, TML showed no significant difference.

In Phase IV experiments, IPMT , FA-3 caught the highest number of female medflies at both sites. However, there was no significant difference between IPMT, FA-3, wet, IPMT, FA-3, dry, and the standard trap, IPMT, NU+B.

Text cont. on p. 119.

TABLE I. CAPTURE OF *C. capitata* IN PHASE III EXPERIMENT AT POINTE AUX SABLES

Country :	Mauritius
Host :	Indian Almond
Altitude :	5 - 30 metres
Avg. Temp, Min.-Max. :	23.9 - 31.7
Avg. RH, Min.-Max. :	41.7 % - 63.8 %
Trapping period (dates) :	20.12.96 - 13.02.97
No. of Trap Days (# traps per treatment x # days) :	280
Jackson trap capture (# Total F/T/D) :	0.68
% females in Jackson trap ((#Females#Total) * 100) :	19.41 (may be due to contamination)
No. of Jackson trap days (# traps x # days) :	280
Average no. of larvae per kg of fruit :	3.2

Trap/Lure Treatment			Flies per Trap per Day			Relative Trap Efficiency			% Females per Trap
Trap	Bait	Retention	#Males	#Females	#Total	%Males	%Females	%Total	(# fem/#tot)
OBDT	FA-2	sticky insert	0.10	0.18 ab	0.28	12.00	16.23	14.45	64.94
OBDT	FA-3	sticky insert	0.18	0.35 a	0.53	22.67	31.49	27.77	65.54
CC	FA-2	DDVP	0.06	0.07	0.13	7.11	6.82	6.94	56.76
CC	FA-3	DDVP	0.06	0.08 b	0.14	7.56	7.47	7.50	57.50
IPMT	NU+B	water	0.04	0.16 b	0.21	5.33	14.94	10.88	79.31
Frutect	Prebaited	glue	0.08	0.13 b	0.21	10.22	11.69	11.07	61.02
Tephri	TML ,NU +B	water	0.28	0.13 b	0.41	35.11	11.36	21.39	30.70

Means followed by the same letter are not significantly different at P=0.05

TABLE II. CAPTURE OF *C. capitata* IN PHASE III EXPERIMENT AT BEL OMBRE

Country :	Mauritius
Host :	Indian Almond
Altitude :	3 – 20 metres
Avg. Temp, Min.-Max. :	12.76 - 28.7
Avg. RH, Min.-Max. :	57 % - 97 %
Trapping period (dates) :	28.10.97 – 23.12.97
No. of Trap Days (# traps per treatment x # days) :	280
Jackson trap capture (# Total F/T/D) :	7.53
% females in Jackson trap ((#Females#Total) * 100) :	0
No. of Jackson trap days (# traps x # days) :	280
Average no. of larvae per kg of fruit :	2.6

Trap/Lure Treatment			Flies per Trap per Day			Relative Trap Efficiency			% Females per Trap
Trap	Bait	Retention	#Males	#Females	#Total	%Males	%Females	%Total	(# fem/#tot)
OBDT	FA-2	sticky insert	0.35	0.26	0.61	3.80	6.62	4.66	43.27
OBDT	FA-3	sticky insert	0.88	1.13 a	0.88	9.69	28.29	15.35	56.13
CC	FA-2	DDVP	0.21	0.16	0.37	2.27	3.94	2.78	43.14
CC	FA-3	DDVP	0.43	0.36 b	0.43	4.67	9.04	6.00	45.91
IPMT	NU+B	water	0.31	0.4 b	0.31	3.41	10.03	5.43	56.28
Frutect	Prebaited	glue	1.46	0.92 ab	1.46	16.08	23.01	18.19	38.53
Tephri	TML NU – B	water	5.47	0.76 ab	5.47	60.08	19.07	47.59	12.21

Means followed by the same letter are not significantly different at P=0.05

TABLE III. CAPTURE OF *C. capitata* IN PHASE IV EXPERIMENT AT POINTE AUX SABLES

Country :	Mauritius
Host :	Indian Almond
Altitude :	3 - 20 metres
Avg. Temp, Min.-Max. :	19.9oC - 29.4oC
Avg. RH, Min.-Max. :	40% - 99.9%
Trapping period (dates) :	24.10.97 - 18.12.97
No. of Trap Days (# traps per treatment x # days) :	280
Jackson trap capture (# Total F/T/D) :	4.932
% females in Jackson trap ((#Females#Total) * 100) :	0
No. of Jackson trap days (# traps x # days) :	280
Average no. of larvae per kg of fruit :	11.3

Trap/Lure Treatment			Flies per Trap per Day			Relative Trap Efficiency			% Females per Trap
Trap	Bait	Retention	#Males	#Females	#Total	%Males	%Females	%Total	(# fem/#tot)
IPMT	NU+B	water	0.46	0.564 abc	0.46	14.46	16.46	38.11	24.84
IPMT	FA-3	water	1.31	1.218 a	1.31	40.93	35.52	29.85	72.36
IPMT	FA-3	DDVP	0.62	0.714 ab	0.62	19.24	20.83	23.54	57.73
Tephri	FA-3	DDVP	0.40	0.55 bc	0.40	12.46	16.04	4.85	55.00
Tephri	FA-3	DDVP + water	0.31	0.325 c	0.31	9.68	9.48	2.18	33.33
CC	FA-3	DDVP	0.10	0.057	0.16	3.23	1.67	1.46	66.67

Means followed by the same letter are not significantly different at P=0.05

TABLE IV. CAPTURE OF *C. capitata* IN PHASE IV EXPERIMENT AT BEL OMBRE

Country :	Mauritius
Host :	Indian Almond
Altitude :	3 - 20 metres
Avg. Temp, Min.-Max. :	28.1 - 31.7
Avg. RH, Min.-Max. :	78.1 % - 94.4 %
Trapping period (dates) :	07.01.98 - 02.03.98
No. of Trap Days (# traps per treatment x # days) :	280
Jackson trap capture (# Total F/T/D) :	75.18
% females in Jackson trap ((#Females#Total) * 100) :	0
No. of Jackson trap days (# traps x # days) :	280
Average no. of larvae per kg of fruit :	6.7

Trap/Lure Treatment			Flies per Trap per Day			Relative Trap Efficiency			% Females per Trap
Trap	Bait	Retention	#Males	#Females	#Total	%Males	%Females	%Total	(# fem/#tot)
IPMT	NU+B	water	0.05	0.14 ab	0.05	12.38	19.31	15.49	54.86
IPMT	FA-3	water	0.12	0.32 a	0.12	32.38	44.06	38.14	48.10
IPMT	FA-3	DDVP	0.15	0.2 ab	0.15	39.05	27.72	20.06	53.62
Tephri	FA-3	DDVP	0.03	0.04 c	0.03	8.57	5.45	14.31	57.89
Tephri	FA-3	DDVP + water	0.02	0.01 c	0.02	5.71	1.49	9.58	51.12
CC	FA-3	DDVP	0.01	0.01 c	0.01	1.90	1.98	2.42	35.56

Means followed by the same letter are not significantly different at P=0.05

TABLE V. CAPTURE OF DIFFERENT FRUIT FLY SPECIES (IN F/T/D) IN PHASE III EXPERIMENT AT POINTE AUX SABLES

	C. rosa			*B. zonata*			*B. cucurbitae*			*D. ciliatus*		
Trap Type	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
JT, TML	0.100	1.011	1.111	0.000	0.007	0.007	0.000	0.004	0.004	0.000	0.000	0.000
OBDT, FA-2	0.186	0.125	0.311	0.157	0.157	0.314	0.021	0.025	0.046	0.000	0.004	0.004
OBDT, FA-3	0.300	0.182	0.482	0.121	0.079	0.200	0.011	0.043	0.054	0.000	0.004	0.004
CC ,FA-2	0.168	0.211	0.379	0.086	0.071	0.157	0.000	0.014	0.014	0.000	0.000	0.000
CC , FA-3	0.457	0.339	0.796	0.086	0.064	0.150	0.007	0.000	0.007	0.000	0.000	0.000
IPMT, NU+B	0.489	0.332	0.821	0.854	0.479	1.332	0.114	0.089	0.204	0.004	0.007	0.011
Frutect	0.082	0.054	0.136	0.104	0.061	0.164	0.000	0.021	0.021	0.000	0.004	0.004
Tephri , NU+B, TML	0.250	0.518	0.768	0.089	0.064	0.154	0.000	0.007	0.007	0.000	0.000	0.000

TABLE VI. CAPTURE OF DIFFERENT FRUIT FLY SPECIES (IN F/T/D) IN PHASE III EXPERIMENT AT BEL OMBRE

	C.rosa			*B.zonata*			*B.cucurbitae*			*D.ciliatus*		
Trap Type	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
JT, TML	0.007	3.400	3.407	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
OBDT, FA-2	0.079	0.064	0.143	0.000	0.004	0.004	0.011	0.004	0.014	0.011	0.007	0.018
OBDT, FA-3	1.807	0.482	2.289	0.000	0.000	0.000	0.032	0.011	0.043	0.000	0.004	0.004
CC, FA-2	0.404	0.264	0.668	0.004	0.000	0.004	0.014	0.011	0.025	0.000	0.004	0.004
CC, FA-3	0.811	0.632	1.443	0.004	0.000	0.004	0.007	0.004	0.011	0.000	0.000	0.000
IPMT, NU+B	4.161	0.936	5.096	0.014	0.021	0.036	0.321	0.154	0.475	0.032	0.043	0.075
Frutect Pre-baited	1.164	0.700	1.864	0.007	0.011	0.018	0.032	0.043	0.075	0.036	0.029	0.064
Tephri, NU+B, TML	1.661	1.925	3.586	0.004	0.000	0.004	0.054	0.050	0.104	0.000	0.007	0.007

TABLE VII. CAPTURE OF DIFFERENT FRUIT FLY SPECIES (IN F/T/D) IN PHASE IV EXPERIMENT AT BEL OMBRE

	C. rosa			*B. zonata*			*B. cucurbitae*			*D. ciliatus*		
Trap Type	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
JT,TML	0.00	2.79	2.79	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
IPMT, NU+B	2.67	1.03	3.70	0.04	0.01	0.05	0.63	0.24	0.87	0.05	0.03	0.08
IPMT, FA-3, water	3.65	1.69	5.34	0.04	0.03	0.07	0.61	0.44	1.05	0.01	0.02	0.03
IPMT, FA-3, DDVP	5.81	2.52	8.33	0.08	0.07	0.15	0.80	0.27	1.06	0.03	0.02	0.05
Tephri, FA- 3, DDVP	2.46	1.20	3.66	0.01	0.00	0.01	0.07	0.02	0.09	0.00	0.00	0.00
Tephri , FA-3, DDVP, water	0.88	0.45	1.33	0.01	0.00	0.01	0.03	0.02	0.05	0.00	0.00	0.00
CC, FA-3, DDVP	0.33	0.14	0.46	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00

TABLE VIII. CAPTURE OF DIFFERENT FRUIT FLY SPECIES (IN F/T/D) IN PHASE IV EXPERIMENT AT POINTE AUX SABLES

	C. rosa			*B. zonata*			*B. cucurbitae*			*D. ciliatus*		
Trap Type	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
JT, TML	0.000	0.536	0.536	0.000	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000
IPMT, NU+B	0.425	0.211	0.636	0.336	0.064	0.400	0.107	0.071	0.179	0.004	0.000	0.004
IPMT, FA-3, water	0.804	0.393	1.196	0.918	0.271	1.189	0.093	0.050	0.143	0.000	0.004	0.004
IPMT, FA-3, DDVP	0.429	0.307	0.736	0.407	0.214	0.621	0.021	0.032	0.054	0.000	0.000	0.000
Tephri, FA- 3, DDVP	0.179	0.204	0.382	0.150	0.075	0.225	0.007	0.014	0.021	0.000	0.000	0.000
Tephri, FA-3, DDVP, water	0.225	0.225	0.450	0.257	0.100	0.357	0.007	0.046	0.054	0.000	0.000	0.000
CC, FA-3, DDVP	0.079	0.064	0.143	0.032	0.000	0.032	0.004	0.021	0.025	0.000	0.000	0.000

TABLE IX. ANALYSIS OF VARIANCE FOR EFFECTIVENESS OF TRAPPING SYSTEMS FOR FEMALE MEDFLY - PHASE III, POINTE AUX SABLES

	DF	SS	MS	F	Tab F
Block	4	0.288	0.072	1.992	3.86
Treatment	6	1.418	0.236	6.544	3.86
Error	24	0.867	0.036		
Total	34	2.572			
S.E..	0.085		S.E.D..=	0.134	

TABLE X. ANALYSIS OF VARIANCE FOR EFFECTIVENESS OF TRAPPING SYSTEMS FOR FEMALE MEDFLY - PHASE III, BEL OMBRE

	DF	SS	MS	F	Tab F
Block	4	1.299	0.325	4.480	3.86
Treatment	6	2.414	0.402	5.547	3.86
Error	24	1.740	0.073		
Total	34	5.453			
S.E.	0.120		S.E.D.=	0.190	

TABLE XI. ANALYSIS OF VARIANCE FOR EFFECTIVENESS OF TRAPPING SYSTEMS FOR FEMALE MEDFLY - PHASE IV, BEL OMBRE

	DF	SS	MS	F	Tab F
Block	4	0.493	0.123	1.956	3.86
Treatment	5	4.906	0.981	15.574	3.86
Error	20	1.260	0.063		
Total	29	6.660			
S.E.	0.112		S.E.D.=	0.177	

TABLE XII. ANALYSIS OF VARIANCE FOR EFFECTIVENESS OF TRAPPING SYSTEMS FOR FEMALE MEDFLY - PHASE IV, POINTE AUX SABLES

	DF	SS	MS	F	Tab F
Block	4	0.765	0.191	1.763	3.86
Treatment	5	4.737	0.947	8.735	3.86
Error	20	2.169	0.108		
Total	29	7.672			
S.E.	0.147		S.E.D.=	0.233	

TABLE XIII. MATURITY OF CAPTURED FEMALE MEDFLIES - POINTE AUX SABLES (SITE 1)

Date	IPMT, NU+B		IPMT, water[1]		IPMT, DDVP[1]		Tephri, DDVP[1]		Tephri, water,DDVP[1]		CC, DDVP[1]	
	Mature	Immature	Mature	Immature	Mature	Immature	Mature	Immature	Mature	Immature	Mature	Immature
24/10/97 – 30/10/97	14	10	15	9	10	8	9	4	18	11	3	1
31/11/97 – 06/11/97	20	11	3	2	17	8	17	8	16	9	2	1
07/11/97 – 13/11/97	18	10	17	14	16	9	4	2	4	3	5	2
14/11/97 – 20/11/97	20	5	13	8	15	10	1	0	5	3	0	0
21/11/97 – 27/11/97	10	7	9	8	4	2	8	5	8	4	0	0
28/12/97 – 04/12/97	6	3	5	2	7	7	8	4	16	2	2	0
05/12/97 – 11/12/97	5	2	2	1	6	3	2	2	1	0	0	0
12/12/97 – 18/12/97	5	3	4	2	14	10	1	0	0	1	0	0
Percentage	65.8	34.2	59.7	40.3	61.0	39.0	66.7	33.3	67.3	32.7	75.0	25.0

[1] FA-3 lure used as bait

TABLE XIV. MATURITY OF CAPTURED FEMALE MEDFLIES - BEL OMBRE (SITE 2)

Date	IPMT, NU+B		IPMT, water[1]		IPMT, DDVP[1]		Tephri, DDVP[1]		Tephri, water,DDVP[1]		CC, DDVP[1]	
	Mature	Immature	Mature	Immature	Mature	Immature	Mature	Immature	Mature	Immature	Mature	Immature
07/01/98 - 13/01/98	4	3	9	7	8	2	2	1	0	0	1	1
14/01/98 - 20/01/98	6	3	17	12	3	2	0	0	0	0	2	0
21/01/98 - 27/01/98	7	2	4	2	4	2	3	0	0	0	0	0
28/01/98 - 02/02/98	3	1	18	11	9	7	3	0	1	0	0	0
03/02/98 - 09/02/98	5	2	3	2	8	4	2	0	1	0	0	0
10/02/98 - 16/02/98	2	0	2	0	1	1	0	0	1	0	0	0
17/02/98 - 23/02/98	0	0	0	0	0	0	0	0	0	0	0	0
24/01/98 - 02/03/98	1	0	2	0	4	1	0	0	0	0	0	0
Percentage	71.8	28.2	61.8	38.2	66.1	33.9	90.9	9.1	100.0	0.0	75.0	25.0

[1] FA-3 lure used as bait

TABLE XV. FRUIT INFESTATION DATA (PHASE III)

No. of larvae/kg. of fruit

	C. capitata		*C. rosa*		*B. zonata*	
	Pte. Aux Sables	Bel Ombre	Pte. Aux Sables	Bel Ombre	Pte. Aux Sables	Bel Ombre
Indian Almond	3.2	2.6	26.8	8.3	55.7	6.9
Mango	Nil	Nil	Nil	8.5	Nil	17.3
Guava	-	-	-	-	-	-

TABLE XVI. FRUIT INFESTATION DATA (PHASE IV)

No. of larvae/kg. of fruit

	C. capitata		*C. rosa*		*B. zonata*	
	Pte. Aux Sables	Bel Ombre	Pte. Aux Sables	Bel Ombre	Pte. Aux Sables	Bel Ombre
Indian Almond	11.3	6.7	14.5	130	104.1	33.3
Mango	Nil	Nil	Nil	Nil	16.5	Nil
Guava	-	-	28.6	-	374.3	-

3.2. Capture of other fruit fly species

Sufficiently large numbers of females of the other ceratitid species, *C. rosa*, were caught in CC, FA-3 traps site one, and in OBDT, FA-3 at the second site. However, at Site 1, catches in IPMT, NU+B were significantly higher. Regarding *B. zonata*, *B. cucurbitae* and *D. ciliatus*, female catches in FA-3 baited traps were generally low as compared to IPMT, NU+B.

3.3. Maturity of captured medflies

Results for Phase IV are given in Tables XIII and XIV. At both sites, percentage of mature females captured was higher than immature ones.

3.4. Fruit infestation

Fruit infestation data are given in Table XV and XVI. Fruit infestation by medfly was quite low during the period of experimentation. For Phase III, 3.2 and 2.6 medfly larvae were reared per kg of Indian almond fruits at Pointe aux Sables and Bel Ombre, respectively. For Phase IV, an average of 6.7 and 11.3 medfly larvae were obtained per kg of Indian almond fruits from Bel Ombre and Pointe aux Sables, respectively.

Infestation by other fruit fly species was higher than for medfly

4. CONCLUSION

In general, the FA-3 combination showed good attractancy for female medflies. The trapping system using IPMT proved to be superior to the Tephri trap. The FA-3 combination, however, did not perform significantly better than IPMT, NU+B. Consequently, the numbers of female medflies trapped were not sufficiently high to justify the use of the FA-3 as part of

suppression programmes. Nevertheless, it provides an additional tool for monitoring medfly populations.

It is probable that the medfly populations during the experimentation were too low for results to be fully conclusive.

ACKNOWLEDGEMENTS

We are grateful to the IAEA for providing the trapping material and lures, to the Ministry of Agriculture, Fisheries and Cooperatives, Mauritius, for enabling us to carry out the experiment, and to the Meteorological Services for providing us with climatological data. We are thankful to all persons and in particular the following for helping us in one way or the other: Mrs. J. Koody Peerthum, Messrs. B. Gungah, A.R. Soonnoo, P. Jokhun, G. Jhumun, T. Luchman, R. Ramneehorah, D. Dabeedyal & S. Roopchand.

REFERENCES

[1] PERMALLOO, S., Biological and taxonomic studies on parasitoids associated with some Tephritidae (Diptera), PhD Thesis, University of Wales, UK (1989).

[2] ORIAN, A.J.E., MOUTIA, L.A., Fruit flies (Trypetidae) of economic importance in Mauritius, Revue Agricole et Sucrière de L'Ile Maurice **38** (1960).

[3] PERMALLOO, S., et al., An area wide control of fruit flies in Mauritius (Proc. Second Annual Meeting of Agricultural Scientists, Reduit, Mauritius, 1979)(Lalouette, J.A., et al., Eds), Food and Agricultural Research Council (1998).

[4] GILSTRAP, F.E., HART, W.G., Biological Control of the Mediterranean Fruit Fly in the United States and Central America, USDA - ARS Bull. **56** (1987).

[5] WHITE, I.M., ELSON-HARRIS, M.E., Fruit Flies of Economic Significance: their identification and bionomics, CAB International in association with ACIAR, CABI (1992).

[6] HAMMES, C., Projet de lutte contre la mouche du Natal *Pterandrus rosa* (Karsch), Diptera, Trypetidae a L'Ile Maurice, CIRAD, France (1982).

[7] SEEWOORUTHUN, S.I., et al., An attempt at the eradication of the Oriental fruit fly, *Bactrocera dorsalis* (Hendel) in Mauritius (Proc. Second Annual Meeting of Agricultural Scientists, Reduit, Mauritius, 1979)(Lalouette, J.A., et al., Eds.) Food and Agricultural Research Council (1998).

[8] ANON., Fruit fly control in Mauritius, Landell Mills Ltd. Bath, UK for Government of Mauritius (1991).

[9] SOONNOO, A.R., et al., A large scale fruit fly control programme in Mauritius (Proc. Workshop on Problems and Management of Tropical Fruit Flies, Malaysia, 1995)(Chua, T.H., Khoo, S.G., Eds.) (1995) 52 - 60.

[10] EPSKY, N.D., et al., Visual cue and chemical cue interactions in a dry trap with food-based synthetic attractant for *Ceratitis capitata* and *Anastrepha ludens* (Diptera: Tephritidae), Environ. Entomol. **24** (1995) 1387-1395.

[11] HEATH, R.R., et al., Development of a dry plastic insect trap with food-based synthetic attractant for the Mediterranean and the Mexican fruit flies (Diptera: Tephritidae), J. Econ. Entomol. **88** (1995) 1307-1315.

[12] HEATH, R.R., et al., Systems to monitor and suppress Mediterranean fruit fly (Diptera: Tephritidae) populations, Fla. Entomol. **79** (1996) 144-153.

STANDARDIZATION OF *Ceratitis capitata* Wied. (DIPTERA: TEPHRITIDAE) FEMALE TRAPPING FOR USE IN STERILE INSECT PROGRAMMES — CATAMARCA, ARGENTINA, 1995 - 1997

M. VATTUONE
College of Agronomy Sciences,
National University of Catamarca,
Catamarca, Argentina

Abstract

The main objective of the study was to assess *Ceratitis capitata* Wied. (medfly) female trapping with new traps and attractants in varying ecological conditions as part of a co-ordinated international programme. Trials were carried out between 1995 and 1997, using seven types of traps baited with the various combination of sexual and food attractants. Different methods for insects retention were also tested. For these trials, protocols established by the International Atomic Energy Agency were followed. The Jackson Trap with Trimedlure plugs proved to be the most efficient for capture of medfly males, while International Pheromone's McPhail Trap was the most efficient for the capture of females, when used with a combination of all three new attractants (FA-3) consisting of ammonium acetate, putrescine, and trimethylamine plus the toxicant DDVP for insect retention. The new traps and attractants also captured flies belonging to genus *Anastrepha* (Diptera: Tephritidae).

1. INTRODUCTION

Sterile Insect Technique (SIT) control is a strategy that uses sterile insects to provide autocidal control of the same species. This is the most advanced technique known to control the medfly and it is used as part of an Integrated Pest Management program.

Successive releases of sterile males can reduce the wild insect population because sterile males will mate with wild females but there will be no viable progeny. At present in Argentina, sterile females are also released, and, can cause some fruit damage due to oviposition.

Advances in technology in SIT for medflies has made it possible to produce genetic sexing strains where only males are produced for field release. This technology has yet to be implemented in Argentina.

Monitoring is not a method to control pests in itself, but is a procedure to estimate insect field populations both quantitatively and qualitatively. However, large numbers of traps in the field will capture a large quantity of flies and this will have a limited effect on the pest population. For medfly, the principal method of monitoring field populations is with a Jackson Trap baited with Trimedlure (JT, TML). To date, this procedure is the most efficient and internationally accepted, but it captures predominantly males.

Because medfly females, both feral and sterile, can damage fruit, if advanced SIT programs were implemented, then there would be fewer females and the sterile males would have greater chance to mate with feral females. However, to date, there has been no improvement in trapping systems to monitor female medfly populations. For this reason, the IAEA supported the development of a new method of trapping to be used in conjunction with advanced SIT programs where male only strains are used.

The purpose of this work, carried out between 1995 and 1997, was the evaluation of different traps and attractants for capturing *C. capitata* females.

2. GENERAL EXPERIMENTAL CONDITIONS

2.1. General protocol

All trials were performed according to the IAEA protocol, with the only modification that the traps were placed in the northeast side of the plants and not the southeast because of Argentina's geographical position in the Southern Hemisphere. For statistical analysis the number of medflies captured were also transformed according to the IAEA protocol.

2.2. Characteristics of the region

The trials were carried out in Fray Mamerto Esquiú and Capayán, which, together with the Capital and Valle Viejo, constitute what is called the Central Valley of Catamarca. They are a Phytogeographical region known as Arid Chaco. The Central Valley has the following surface area: Capayán - 3.837 km^2 ; Capital - 648 km^2; Fray Mamerto Esquiú - 280 km^2; Valle Viejo - 540 km^2.

No sterile insects are set free in the area.

The area of study is located to the south of the Province of Catamarca, between 28° 20' North Latitude, 28° 65' South Latitude, 66° 15' West Longitude and 65° 45' East Longitude. It is limited by the Sierra de Ambato to the West and the Sierra de Ancasti to the East and altitude above sea level varied between 430 to 660 m.

The climate is arid temperate. Winds are predominantly from the north-northeast with a 90 % frequency and are more intense from August to October at a rate of 30 km/h, and sometimes 110 km/h. Most rainfall occurs during summer and fall, decreasing from north to south and oscillates between 250 and 450 mm annually.

Forests with xerophilous trees are predominant.

In general, soils develop on medium texture sediments among them loess accumulation. Aridisols and Entisols prevail. They are characterized by their low capacity for water retention, low tenor of organic material and an important sand fraction. They are deep soils, without layers that may interrupt the passing of water or the growing of roots. Their main disadvantage is erosion by wind or water.

There are differences between Fray Mamerto Esquiú and Capayán; the first is slightly more humid because it is a valley surrounded by small elevations such as Sierra Graciana to the east and Fariñango to the west. There are also differences in the soil, with that of Fray Mamerto Esquiú being stonier.

The climatic characteristics for the years 1994-97 are shown in Tables XII - XV. They were provided by the Meteorological Station of the National Institute of Agricultural Technology (INTA) in Valle Viejo.

3. FIRST STAGE - 1995

3.1. Materials and methods

The trial took place on two farms in Capayán, one located in Huillapima, and the other in Capayán, on Route N° 38. The beginning of the experiment coincided with the period of low rainfall in the Province of Catamarca and the decrease in the population density of medfly and other tephritid fruit flies. The experiment was conducted from March 28 to June 2, 1995.

Site 1 at Huillapima (Capdevila's plot) contained a crop of mandarin (*Citrus deliciosa* Tenora, variety Común (Common) or Criolla (Native). Trees were 15 yr old. The area of plantation was 24 ha at an altitude of 440 m. There were also 53 grapefruit trees (*Citrus paradisi*) interspersed with mandarins, to the east side of the farm and they were in full production.

Site 2 at Capayán (Cacciato's plot) also contained a crop of mandarin (*C. deliciosa)*, variety Common or Native (Criolla). Trees were 15 yr old. The area of plantation was 13 ha at an altitude of 425 m. This farm had a small collection of citrus, with the following species: mandarin (*Citrus reticulata*), orange (*Citrus sinensis*), grapefruit, and lemon (*Citrus limon*) with only two plants of each variety.

The distance between farms was 11 km. Plantations chosen were representative of the area. Generally, no pesticide treatments were applied. Unfortunately, at Capayán, Supracid (Metidathion) was applied against *Aonidiella aurantii* Maskell (Homoptera: Diaspididae) on April 8, 9 and 15, despite an agreement not to apply chemical treatments. Besides, the pest population density did not justify the treatment and it was not carried out at the right time.

To capture *C. capitata*, the JT and the CBDT were compared. The JT were baited with TML and contained a white sticky insert. The CBDT had a green plastic cylindrical body and was baited with FA-2 attractants and contained a toxicant squares for insect retention.

Statistical design consisted of five lines (A - E) with four traps in each. Trap types were alternated (*e.g.* JT, CBDT, JT, CBDT). They were inspected twice a week and, following each inspection, the traps were rotated sequentially.

At Huillapima, the rows were 56 m apart and the traps 28 m apart in each row. At Capayán, the distance between rows was 54 m and between traps 25 m.

3.2. Results

The captures for each type of trap, expressed as total numbers, and the number of flies per trap per day (F/T/D) for each site are indicated in Tables I and II. Four trial were conducted during 1995: March 28 to April 11; April 14 to April 28; May 2 to May 16; and May 19 to June 2.

Upon evaluation of the traps, it was found that of 86 medflies, 83.7 % were captured by JT, TML (82.5% males and 1.2% females) and 16.3 % were captured by CBDT, FA-2 (3.5% males and 12.8% females). Of the total medflies captured, 47 (54.6 %) were taken at Huillapima and 39 (45.3 %) at Capayán. Of 47 medflies at Huillapima, 38 (80.8 %) were collected in JT, TML - 37 (97.3 %) were males and one was a female (2.6 %). In CBDT, FA-2 traps, 9 medflies were captured (19.1 %) - 6 females (66.6 %) and 3 males (33.3 %). Of the 7 females, 85.71% were captured by CBDT, FA-2 and 14.29% by JT, TML. In total, 39 medflies were collected at Capayán. Of these, 34 (87.1 %) were captured in JT, TML and all were males (100.0 %), whereas 5 (12.8 %) were captured in CBDT, FA-2 and all were females (100.0 %). Infestation percentage was determined once a week in the 53 grapefruit trees at Huillapima, by sampling 10 fruits at random. The infestation rate was always zero. The infestation rate in mandarin (10 fruit average) was also zero.

At Capayán, in mandarin, only at the April 14 sampling was a 10% infestation noted (10 fruit average sample size). In the collection of citrus, the infestation percentage was estimated visually, due to the low number of plants and because there was no authorization from the owner to take fruits. Here the infestation percentage was estimated as follows: orange - 25 %; grapefruit - 15 %; mandarin (*C. reticulata*) 5 % and lemon - 0 %.

3.3. Discussion and conclusions

Field trials were carried out in two mandarin (*C. deliciosa*) plantations only 11 km apart (Huillapima and Capayán), so the climatic and ecological conditions were similar.

The only tephritid fruit fly captured in the trial was *C. capitata.*

Although the period of study was short, the JT, TML captured more flies than the CBDT, FA-2. There was a strong correlation between daily mean temperature and the number of medflies captured (data not shown). This can also be seen in Table I during Period 1 (March 3 - April 11) when 32 *C. capitata* were captured, which represented 37.21 % of the total number, decreasing to 25.58 %, 22.09 % and 15.11 % during periods 2 - 4 (April 14 - 24; May 2 - 16; May 19 - June 2, respectively). During Period 1 the highest daily mean temperatures were recorded.

Towards the end of the period under study, medfly populations tended to increase, and this coincided with an increase in the daily mean temperature. Fruits were also near harvest time.

Temperature is a very important factor because the higher the temperature, the more medfly activity and the more evaporation of the attractant.

TABLE I. *C. capitata* CAPTURED (TOTALS AND F/T/D) AT HUILLAPIMA AND CAPAYÁN IN MANDARIN (330 TRAP DAYS) (03/28/95 - 06/02/95)

Date	HUILLAPIMA (Capdevila's Plot)					CAPAYÁN (Cacciato's Plot)				
	JT, TML		CBDT, FA-2		Total	JT, TML		CBDT, FA-2		Total
	F	M	F	M		F	M	F	M	
03/31/95	0	1	0	0	1	0	3	0	0	3
04/04/95	0	3	0	0	3	0	4	0	0	4
04/07/95	0	3	1	0	4	0	7	1	0	8
04/11/95	0	5	0	0	5	0	4	0	0	4
04/14/95	0	0	2	0	2	0	0	0	0	0
04/18/95	0	7	0	1	8	0	3	0	0	3
04/21/95	0	1	1	0	2	0	0	0	0	0
04/25/95	0	1	0	0	1	0	1	0	0	1
04/28/95	1	1	0	1	3	0	1	1	0	2
05/02/95	0	5	0	0	5	0	2	0	0	2
05/05/95	0	0	1	0	1	0	1	0	0	1
05/09/95	0	2	0	1	3	0	1	0	0	1
05/12/95	0	1	0	0	1	0	0	1	0	1
05/16/95	0	1	1	0	2	0	2	0	0	2
05/19/95	0	2	0	0	2	0	1	0	0	1
05/23/95	0	0	0	0	0	0	1	0	0	1
05/26/95	0	0	0	0	0	0	0	0	0	0
05/30/95	0	1	0	0	1	0	3	2	0	5
06/02/95	0	3	0	0	3	0	0	0	0	0
Total	**1**	**37**	**6**	**3**	**47**	**0**	**34**	**5**	**0**	**39**
F/T/D	**0.003**	**0.112**	**0.018**	**0.009**	**0.142**	**0.000**	**0.103**	**0.015**	**0.000**	**0.118**

TABLE II. *C. capitata* CAPTURED (IN F/T/D) AT HUILLAPIMA AND CAPAYÁN (330 TRAP DAYS) (03/28/95 - 06/02/95)

Date	HUILLAPIMA (Capdevila's Plot)				CAPAYÁN (Cacciato's Plot)			
	JT, TML		CBDT, FA-2		JT, TML		CBDT, FA-2	
	F	M	F	M	F	M	F	M
03/31/95	0	0.07	0.00	0.00	0.00	0.20	0.00	0.00
04/04/95	0	0.15	0.00	0.00	0.00	0.20	0.00	0.00
04/07/95	0	0.20	0.07	0.00	0.00	0.47	0.07	0.00
04/11/95	0	0.25	0.00	0.00	0.00	0.20	0.00	0.00
04/14/95	0	0.00	0.13	0.00	0.00	0.00	0.00	0.00
04/18/95	0	0.35	0.00	0.05	0.00	0.15	0.00	0.00
04/21/95	0	0.07	0.07	0.00	0.00	0.00	0.00	0.00
04/25/95	0	0.05	0.00	0.00	0.00	0.05	0.00	0.00
04/28/95	0.07	0.07	0.00	0.07	0.00	0.07	0.07	0.00
05/02/95	0	0.25	0.00	0.00	0.00	0.10	0.00	0.00
05/05/95	0	0.00	0.07	0.00	0.00	0.07	0.00	0.00
05/09/95	0	0.10	0.00	0.05	0.00	0.05	0.00	0.00
05/12/95	0	0.07	0.00	0.00	0.00	0.00	0.07	0.00
05/16/95	0	0.05	0.05	0.00	0.00	0.10	0.00	0.00
05/19/95	0	0.13	0.00	0.00	0.00	0.07	0.00	0.00
05/23/95	0	0.00	0.00	0.00	0.00	0.05	0.00	0.00
05/26/95	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
05/30/95	0	0.05	0.00	0.00	0.00	0.15	0.10	0.00
06/02/95	0	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.003**	**0.112**	**0.018**	**0.009**	**0.000**	**0.103**	**0.015**	**0.000**

In spite of the low number of medflies captured (86 in all), the CBDT, FA-2 had a high level of selectivity for the capture of females, mainly at Capayán where 100.0 % were females (5 females and 0 males). At Huillapima, however, only 66.6 % were females (6 females and 3 males).

The CBDT, FA-2 captured fewer non-target insects than JT, TML and this selectivity made it easier to handle.

The highest number of non-target insects were captured at Capayán due to the different ways of farm management. At Huillapima, plants suffered lack of irrigation. This did not happen at Capayán, but there were lots of weeds, mainly *Sorghum halepense*, which, added to the high humidity level, increased the population of non-target insects. Nevertheless, this did not become a problem in trap handling.

During the trial, with the CBDT, FA-2, there were no problems with the wind (which sometimes blew hard), predators or ants. Some moisture accumulated at the base of the CBDT, FA-2, although rainfall during the period of study was only 16.5 mm. In general, there were no management problems with the CBDT, FA-2.

There was no way to reach a conclusion (in the first stage) about the efficiency of the CBDT, FA-2 in capturing females because it was not compared to other traps (*e.g.* McPhail which capture insects of the same sex), the low population density of medfly, and because of the short period of study.

4. SECOND STAGE: 1995 - 1996

4.1. Materials and methods

The trial took place on two farms. One was located in Fray Mamerto Esquiú (Pomancillo Oeste). The experiment coincided with the beginning of the rainfall period in Catamarca and an increase in the number of medflies. The other site was a plot that belongs to the National University of Catamarca in Capayán (Colonia del Valle). This trial coincided with the period of low rainfall and a decrease in the population density of medflies.

At Site 1, Fray Mamerto Esquiú - Pomancillo Oeste, the crop was peach (*Prunus persica* L.), variety San Pedro 16 - 23. Trees were 7 yr old. The area of plantation was 3.5 ha at an altitude of 660 m. Experiments were conducted from September 12 to November 17, 1995. To the south of the peach trees, 10 m away, was a 6 ha plantation of quince trees (*Cydonia oblonga* Mill.), but their fruits were not likely to be attacked during the trial period. To the west, 11 m away, were 11 fig trees (*Ficus carica* L.) and 30 m away, was a small plantation of mandarin (85 plants) in five lines (17 plants per line); varieties Común (Common) or Criolla (Native), Satzuma and Murcot. Both the fig trees and the mandarin collection were not in production, so they had no fruits to be attacked.

At Site 2, Capayán - Colonia del Valle (University plot), the crop was mandarin (*C. deliciosa*), variety Común (Common) or Criolla (Native). Trees were 13 yr old. The area of plantation was 4 ha at an altitude of 430 m. Experiments were carried out from March 29 to June 7, 1996. This plot had other fruit trees such as orange - 1 ha; peach - 2 ha; apricot (*Prunus armeniaca* L.) without grafting (used as windbreak), and 10 plants of olive (*Olea europea* L.). There were other crops such as alfalfa (*Medicago sativa* L.), other forage crops and windbreaks with forestry which were not likely to be attacked by medflies. The peach, apricot and olive trees did not have fruits to be attacked when the trial was conducted. The peach plantation selected for the trial was not representative of the region because it had not received agrochemical treatments (fertilizer and pesticides). It is an organic plantation.

No phytosanitary treatment was applied during the trial on the mandarin and oranges trees. During this period, mineral oil was the only treatment applied to control scale insects (Homoptera: Diaspididae). On peach trees, medflies are controlled by toxic baits (in October), but these were not present during the trial. No treatment is applied on apricot (windbreak) which is an important hosts for medflies.

The following traps were used in a comparative way to capture *C. capitata* and other tephritidae: JT, TML; CBDT, FA-2; Open Bottom Dry Trap - an opaque green cylindrical open-bottom trap with yellow sticky insert, and baited with FA-2 (OBDT, FA-2); International Pheromone's McPhail Trap baited with 300 ml of an aqueous solution of 9 % NuLure and 3 % borax (IPMT, NU + B); Steiner Trap baited with FA-2 and containing a toxicant square (ST, FA-2).

Statistical design consisted of five lines (A to E) with five traps each: JT, TML; IPMT, NU + B; CBDT, FA-2; OBDT, FA-2 and ST, FA-2 placed at random. These traps were inspected twice a week and, after each check, were rotated sequentially.

At Fray Mamerto Esquiú, the rows of peach trees were 36 m apart, and the traps were 25 m apart in the rows. At Capayán, the distance between mandarin rows was 35 m, and between traps 28 m.

4.2. Results

Site 1: Fray Mamerto Esquiú

The data from *C. capitata* capture in the first trial are shown in Tables III and IV.

TABLE III. *C. capitata* CAPTURED (TOTALS AND F/T/D) AT POMANCILLO OESTE IN PEACH WITH EACH TYPE OF TRAP (330 TRAP DAY)(09/12/95 - 11/17/95)

Date	JT, TML		F/TD	CBDT, FA-2		F/T/D	OBDT, FA-2		F/T/D	ST, FA-2		F/T/D	IPMT, NU+ B		F/T/D
	F	M		F	M		F	M		F	M		F	M	
09/15/95	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
09/19/95	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00	2	0	0.10
09/22/95	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
09/26/95	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
09/29/95	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
10/03/95	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00	0	1	0.05
10/06/95	0	0	0.00	0	0	0.00	0	0	0.00	1	0	0.07	3	0	0.20
10/10/95	0	0	0.00	0	0	0.00	0	0	0.00	1	0	0.05	2	0	0.10
10/13/95	0	0	0.00	0	0	0.00	0	0	0.00	1	0	0.07	5	2	0.47
10/17/95	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00	4	0	0.20
10/20/95	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00	8	1	0.60
10/24/95	0	0	0.00	0	0	0.00	0	0	0.00	1	0	0.05	50	2	2.60
10/27/95	0	6	0.40	0	0	0.00	0	0	0.00	6	0	0.40	69	2	4.73
10/31/95	0	6	0.30	0	0	0.00	5	0	0.25	4	0	0.20	61	2	3.15
11/03/95	0	34	2.27	2	0	0.13	15	0	1.00	4	0	0.27	261	21	18.80
11/07/95	0	118	5.90	12	1	0.65	2	0	0.10	1	1	0.10	377	32	20.45
11/10/95	0	172	11.47	8	5	0.87	29	1	2.00	2	0	0.13	480	68	36.53
11/14/95	4	325	16.45	36	2	1.90	37	0	1.85	9	1	0.50	522	55	28.85
11/17/95	0	262	17.47	5	1	0.40	17	1	1.20	0	0	0.00	944	99	69.53
Total	**4**	**923**		**63**	**9**		**105**	**2**		**30**	**2**		**2788**	**285**	
F/T/D	**0.012**	**2.797**	**2.809**	**0.191**	**0.027**	**0.218**	**0.318**	**0.006**	**0.324**	**0.091**	**0.006**	**0.097**	**8.448**	**0.864**	**9.312**

TABLE IV. *C. capitata* CAPTURED (IN F/T/D) ATPOMANCILLO OESTE IN PEACH (330 TRAP DAYS) (09/12/95 - 11/17/95)

Date	JT, TML		CBDT, FA-2		OBDT, FA-2		ST, FA-2		IPMT, NU+B	
	F	M	F	M	F	M	F	M	F	M
34956	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34960	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00
34963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34967	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
09/29/95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10/03/95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
10/06/95	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.20	0.00
10/10/95	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.10	0.00
10/13/95	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.33	0.13
10/17/95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00
10/20/95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.07
10/24/95	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	2.50	0.10
10/27/95	0.00	0.40	0.00	0.00	0.00	0.00	0.40	0.00	4.60	0.13
10/31/95	0.00	0.30	0.00	0.00	0.25	0.00	0.20	0.00	3.05	0.10
11/03/95	0.00	2.27	0.13	0.00	1.00	0.00	0.27	0.00	17.40	1.40
11/07/95	0.00	5.90	0.60	0.05	0.10	0.00	0.05	0.05	18.85	1.60
11/10/95	0.00	11.47	0.53	0.33	1.93	0.07	0.13	0.00	32.00	4.53
11/14/95	0.20	16.25	1.80	0.10	1.85	0.00	0.45	0.05	26.10	2.75
11/17/95	0.00	17.47	0.33	0.07	1.13	0.07	0.00	0.00	62.93	6.60
Total	**0.012**	**2.797**	**0.191**	**0.027**	**0.318**	**0.006**	**0.091**	**0.006**	**8.448**	**0.864**

Infestation percentage was determined taking ten fruits at random from ten plants at the beginning of each week. In all cases the result was zero.

The pH of NuLure when just prepared, varied between 8.5 and 8.6; whereas the pH of NuLure recycled weekly varied between 8.3 and 8.5.

Staining of medfly females spermathecae, both in peach and mandarin trials, showed the following unmated females percentages: IPMT, NU+ B - 7.0 %; CBDT, FA-2 - 27.27 %; OBDT, FA-2 - 13.63 %; ST, FA-2 - 21.73 %; JT, TML - 0.0 %.

In the peach trial, 15 larvae/kg of fruit were obtained. In the fruit sample taken in the same place in 1994, 88 larvae/kg of fruit were caught. In all cases the only species obtained was *C. capitata*.

Site 2: Capayán, Colonia del Valle (University plot)

The data from *C. capitata* capture in the second trial are shown in Tables V and VI.

As in the first trial, infestation percentage was determined taking ten fruits at random from ten plants at the beginning of each week. In all cases the result was zero.

The pH of NuLure, when just prepared, varied between 8.8 and 8.9; whereas the pH of NuLure recycled weekly varied between 8.5 and 8.8.

Fruit sampling showed the following results: Mandarin - 1 larva/kg of fruit; Orange - 5 larvae/kg of fruit. The only species obtained was *C. capitata*, the same as in Trial 1.

TABLE V. *C. capitata* CAPTURED (TOTALS AND F/T/D) AT CAPAYÁN, COLONIA DEL VALLE (UNIVERSITY PLOT) IN MANDARIN (350 TRAP DAYS) (03/29/96 - 06/07/96)

Date	JT, TML		F/T/D	CBDT, FA-2		F/T/D	OBDT, FA-2		F/T/D	ST, FA-2		F/T/D	IPMT, NU + B		F/T/D
	F	M		F	M		F	M		F	M		F	M	
04/02/96	0	9	0.60	0	0	0.00	0	0	0.00	0	0	0.00	0	1	0.07
04/05/96	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
04/09/96	0	17	1.13	0	0	0.00	1	0	0.07	0	0	0.00	1	0	0.07
04/12/96	0	7	0.35	0	0	0.00	0	1	0.05	0	0	0.00	1	1	0.10
04/16/96	0	6	0.40	1	0	0.07	0	0	0.00	1	0	0.07	0	0	0.00
04/19/96	0	4	0.20	0	0	0.00	0	0	0.00	0	0	0.00	2	0	0.10
04/23/96	0	3	0.20	0	0	0.00	0	0	0.00	0	0	0.00	2	1	0.20
04/26/96	0	4	0.20	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
04/30/96	0	11	0.73	0	0	0.00	0	0	0.00	1	0	0.07	1	0	0.07
05/03/96	0	4	0.20	0	0	0.00	0	0	0.00	0	0	0.00	4	0	0.20
05/07/96	0	15	1.00	0	0	0.00	0	0	0.00	0	0	0.00	1	0	0.07
05/10/96	0	4	0.20	0	0	0.00	0	0	0.00	0	0	0.00	2	0	0.10
05/14/96	0	18	1.20	0	0	0.00	0	0	0.00	1	0	0.07	1	0	0.07
05/17/96	0	25	1.25	0	0	0.00	0	0	0.00	0	0	0.00	1	1	0.10
05/21/96	0	25	1.67	0	0	0.00	0	0	0.00	2	0	0.13	6	3	0.60
05/24/96	0	11	0.55	1	1	0.10	0	0	0.00	1	0	0.05	7	2	0.45
05/28/96	0	86	5.73	0	0	0.00	0	0	0.00	2	0	0.13	13	5	1.20
06/01/96	0	44	2.20	0	0	0.00	0	0	0.00	1	0	0.05	6	2	0.40
06/04/96	0	27	1.80	0	1	0.07	0	0	0.00	1	1	0.13	0	0	0.00
06/07/96	0	46	3.07	0	0	0.00	0	0	0.00	1	0	0.07	3	0	0.20
Total	**0**	**366**		**2**	**2**		**1**	**1**		**11**	**1**		**51**	**16**	
F/T/D	**0.000**	**1.046**	**1.046**	**0.006**	**0.006**	**0.012**	**0.003**	**0.003**	**0.006**	**0.031**	**0.003**	**0.034**	**0.146**	**0.045**	**0.191**

TABLE VI. *C. capitata* CAPTURED (IN F/T/D) AT CAPAYÁN (UNIVERSITY PLOT) IN MANDARIN (350 TRAP DAYS) (03/29/96 - 06/ 07/96)

Date	JT, TML		CBDT, FA-2		OBDT, FA-2		ST, FA-2		IPMT, NU+B	
	F	M	F	M	F	M	F	M	F	M
04/02/96	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
04/05/96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
04/09/96	0.00	0.85	0.00	0.00	0.05	0.00	0.00	0.00	0.05	0.00
04/12/96	0.00	0.47	0.00	0.00	0.00	0.07	0.00	0.00	0.07	0.07
04/16/96	0.00	0.30	0.05	0.00	0.00	0.00	0.05	0.00	0.00	0.00
04/19/96	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00
04/23/96	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.05
04/26/96	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
04/30/96	0.00	0.55	0.00	0.00	0.00	0.00	0.05	0.00	0.05	0.00
05/03/96	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00
05/07/96	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
05/10/96	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00
05/14/96	0.00	0.90	0.00	0.00	0.00	0.00	0.05	0.00	0.05	0.00
05/17/96	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07
05/21/96	0.00	1.25	0.00	0.00	0.00	0.00	0.10	0.00	0.30	0.15
05/24/96	0.00	0.73	0.07	0.07	0.00	0.00	0.07	0.00	0.47	0.13
05/28/96	0.00	4.30	0.00	0.00	0.00	0.00	0.10	0.00	0.65	0.25
06/01/96	0.00	2.20	0.00	0.00	0.00	0.00	0.05	0.00	0.30	0.10
06/04/96	0.00	1.80	0.00	0.07	0.00	0.00	0.07	0.07	0.00	0.00
06/07/96	0.00	3.07	0.00	0.00	0.00	0.00	0.07	0.00	0.20	0.00
Total	**0.00**	**1.046**	**0.006**	**0.006**	**0.003**	**0.003**	**0.031**	**0.003**	**0.146**	**0.045**

4.3. Discussion and conclusions

In Trial 1, three species of Tephritidae were captured: *C. capitata*, *A. fraterculus* and *A. daciformis*, the last one being the first record in Catamarca. In Trial 2, *C. capitata* and *A. fraterculus* were captured. In all cases, the predominant species was *C. capitata*.

In Trial 1, the trap that captured the largest number of *C. capitata* was the IPMT, NU + B with 72.97 % of all the medflies captured, followed by the JT, TML with 22.01 %, OBDT, FA-2 with 2.54%, CBDT, FA-2 with 1.71%, and ST, FA-2 with 0.76%.

In Trial 2, the trap with the largest number of medflies captured was the JT, TML with 81.15 %, followed by the IPMT, NU + B with 14.85 %, ST, FA-2 with 2.67%, CBDT, FA-2 with 0.89%, and OBDT, FA-2 with 0.44%. The lower percentage of captures in IPMT, NU+B in Trial 2 may be due to temperature effects. Trial 1 was carried out in spring with high ever-increasing temperature, while Trial 2 took place in fall, with lower decreasing temperatures. The lower the temperature, the less evaporation of the attractant, therefore, the fewer number of insects captured.

Taking into consideration the total number of females captured, the trap that captured the greatest number of females was the IPMT, NU+B. During Trial 1, it captured 93.25 %, OBDT, FA-2 captured 3.51 %, CBDT, FA-2 captured 2.11 %, ST, FA-2 captured 1.0 %, and JT, TML captured 0.13 %. In Trial 2, IPMT, NU+ B captured 78.46 %, ST, FA-2 captured

16.92 % OBDT, FA-2 captured 1.54 %, CBDT, FA-2 captured 3.07 %, and JT, TML captured 0.0 %.

In JT, TML, 99 - 100 % of the flies were male. This was an expected result because TML is a specific attractant for *C. capitata* males. JTs captured 4 females on the same day and in the previous to the last revision date (Table III).

In Trial 1, the dry trap that captured the largest number of medflies was OBDT, FA-2 with 2.54 % of the total amount captured (98.13 % females and 1.86 % males), followed by CBDT, FA-2 with 1.71 % (87.5 % females and 12.5 % males). Both traps began capturing *C. capitata* towards the end of the trial, when the medfly population increased. ST, FA-2 captured 0.76 % (93.75 % females and 6.25 % males), although it started capturing medflies at low population densities (Tables III).

In Trial 2, the most efficient dry trap was ST, FA-2 with 2.67 % (91.66 % females and 8.33 % males), whereas CBDT, FA-2 captured 0.89 % (50 % females and 50 % males), and OBDT, FA-2 captured 0.44 % (50 % females and 50 % males).

In Trial 1, the trap with the most Relative Trap Efficiency (RTE) for females of *C. capitata* was IPMT, NU+B with 93.25 %, followed by OBDT, FA-2 with 3.51 %, CBDT, FA-2 with 2.11%, ST, FA-2 with 1.00% and JT, TML with 0.13%. In Trial 2, the RTE was again best in IPMT, NU+B with 78.46 %, followed by ST, FA-2 with 16.92 %, CBDT, FA-2 with 3.08%, OBDT, FA-2 with 1.54%, and JT, TML with 0%.

In Trial 1, 22 *A. fraterculus* were captured, 20 (13 female, 7 male) with IPMT, NU+B, and 1 male with CBDT, FA-2 and 1 female with ST, FA-2. A total of 141 *A. daciformis* were also captured: 36 females and 101 females with IPMT, NU+B; 1 male with CBDT, FA-2; 1 male and 1 female with OBDT, FA-2; and 1 female with ST, FA-2.

In Trial 2, 26 *A. fraterculus* were captured , 23 (11 female, 12 male) with IPMT, NU+B, 2 male with CBDT, FA-2 and 1 female with ST, FA-2.

The trap that captured the greatest number of non-target insects was IPMT, NU+ B. Most were diptera - Muscidae or Lonchaeidae (especially *Carpolonchaea* (*Lonchaea*) *pendula* Bezzi). Some authors consider *C. pendula* part of the fruit fly complex. The most diptera captured were 214 and this was in Trial 1. Although fewer in number, some hymenoptera were also captured - mainly *Polistes canadensis* (L.), a vespid.

In the peach trial, the greatest number of medflies and other insects were captured in the last lines, mainly D and E. This might have been because these trees had not been pruned, and they gave more protection to the insects (data not shown).

In the second trial, the number of non-target insects decreased in all traps due to lower temperatures except for *Euxesta* spp. (Diptera: Ulidiidae) which was captured by the end of the trial (April 6). In the CBDT, FA-2 there were 81, in ST, FA-2 there were 13, and in the OBDT, FA-2 there were none.

The number of *Euxesta* spp. captured by the OBDT, FA-2 was 4. Because of this and the low number of non-target insects captured by this trap, we think that the insects escape because they do not get stuck in the yellow sticky inserts, except when insect populations are large.

JT, TML and dry traps captured fewer non-target insects and were easier to handle in the field. The IPMT, NU+B, on the other hand, was more difficult to handle because it contained a liquid bait.

In Trial I, dry traps showed a high selectivity in the capture of *C. capitata* females. In the second trial, ST, FA-2 maintained this characteristic, whereas in CBDT, FA-2 and OBDT, FA-2 fewer insects were captures and the ratio of males: females was 1:1, although, from the limited number of medflies captured (4 in CBDT, FA-2 and 2 in OBDT, FA-2), no conclusions could be drawn.

There were no problems with predators or ants in the dry traps, but moisture accumulated at the base of CBDT, FA-2 and ST, FA-2 on some days.

During Trial 1, the only trap that had problems because of wind was ST, FA-2 which fell to the ground three times. This difficulty can be easily resolved by changing the hook of the trap.

In general, it can be said that there were no problems with handling the dry traps.

In Trial 1, harvest began on October 17, 1995 with a very low medfly population, mostly males. Due to the fact that this peach variety ripened early and there was a short period of harvest, fruit damage was minor and the twenty five traps deployed in this small orchard could have acted as a control method. In this trial, the maximum F/T/D was 69.53 for IPMT, NU+B, and 17.47 for JT, TML, both in the last revision (Tables III and IV). The maximum index was 1.90 for CBDT, FA-2; 2.00 for OBDT, FA-2; and 0.5 for ST, FA-2 (Tables III and IV). All flies were captured towards the end of the trial when there were very few fruits on the trees.

In Trial 2, harvest began on May 7, 1996 with a low medfly population, mostly females, although there was a larger number of flies than in the previous test by the time of harvest (Tables V and VI). In this trial the total number of medflies was lower, even though population density was more stable through the period. In this case, 25 traps may have also acted as a control method. The maximum F/T/D was 5.73 for JT, TML and 1.20 for IPMT, NU+B, both obtained on the same date (May 28, 1996) near the end of the trial. The maximum index obtained for CBDT, FA-2 was 0.10; for OBDT, FA-2 was 0.07; and for ST, FA-2 was 0.13.

In both trials, medfly populations increased by the end of the period. This coincides with fruit ripening, although fruits were scarce because of the short period of harvesting, mostly in the peach orchard (November 3 - 17 for peach, May 21 to June 6 for mandarin).

5. THIRD STAGE - 1997

5.1. Materials and methods

The trial in the Third Stage was carried out at Huillapima (Capayán) at Mr. Capdevila's farm, the same place where a similar trial was performed in 1995 (First Stage). This farm was chosen because no insecticides are used. Although the medfly population density is low, in the rest of the fruit trees, especially in the last years, chemical treatments are applied against this pest.

The beginning of the experiment coincided with the period of low rainfall in Catamarca and the decrease in the population density of medfly. The observation site was the same as previously described except the plants were two years older. Tests were conducted between April 11 and June 20, 1997.

The following traps were used in a comparative way to capture *C. capitata* and other tephritidae: JT, TML; Tephri trap, baited with TML and water; IPMT, NU + B, baited with 300 ml of an aqueous solution of 9 % NuLure + 3 % borax; FRUTECT trap (Frutect) with one red spherical container with special formulation liquid lure and a yellow sticky display board with hanging cord; OBDT, FA-2 attractants with yellow sticky insert; OBDT, baited with FA-3 attractants - ammonium acetate, putrescine and trimethylamine, and with yellow sticky insert (OBDT, FA-3); ST, FA-2 with an insecticide (piretroid) in the base of the trap to kill insects (ST, FA-2); ST, FA-3 attractants with an insecticide in the base.

Statistical design consisted of five lines (A to E) with eight traps each (JT, TML; Tephri, TML; IPMT, NU+ B; Frutect; OBDT, FA-2; OBDT, FA-3; ST, FA-2; and ST, FA-3 placed at random. The rows of mandarin trees were 35 m apart, and the traps were 28 m apart in the rows.

TABLE VII. *C. capitata* CAPTURED (TOTALS AND F/T/D) ATHUILLAPIMA IN MANDARIN (355 TRAP DAYS) (04/11/97 - 06/20/97)

Date	JT, TML			F/T/D	TEPHRI, TML			F/T/D	IPMT, NU + B			F/T/D	FRUTECT			F/T/D
	F	M	T		F	M	T		F	M	T		F	M	T	
04/15/97	0	2	2	0.1	0	1	1	0.05	3	0	3	0.15	0	0	0	0
04/18/97	0	0	0	0.00	0	0	0	0.00	3	0	3	0.20	0	0	0	0.00
04/22/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
04/25/97	0	0	0	0.00	0	0	0	0.00	2	1	3	0.20	0	0	0	0.00
04/29/97	0	0	0	0.00	0	0	0	0.00	1	0	1	0.05	0	0	0	0.00
05/02/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
05/06/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
05/09/97	0	0	0	0.00	0	0	0	0.00	3	0	3	0.20	0	0	0	0.00
05/13/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
05/16/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
05/20/97	0	0	0	0.00	0	0	0	0.00	1	0	1	0.05	0	0	0	0.00
05/23/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
05/27/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
05/30/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
06/03/97	0	0	0	0.00	0	0	0	0.00	1	0	1	0.05	0	0	0	0.00
06/06/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
06/10/97	0	0	0	0.00	0	1	1	0.05	1	0	1	0.05	0	0	0	0.00
06/13/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
06/17/97	0	1	1	0.05	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
06/20/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
Total	**0**	**3**	**3**		**0**	**2**	**2**		**15**	**1**	**16**		**0**	**0**	**0**	
F/T/D	**0.000**	**0.008**	**0.008**		**0.00**	**0.006**	**0.006**		**0.042**	**0.003**	**0.045**		**0.00**	**0.00**	**0.00**	

TABLE VII. (CONTINUATION)

Date	OBDT, FA- 2			F/T/D	OBDT, FA- 3			F/T/D	ST, FA-2			F/T/D	ST, FA- 3			F/T/D
	F	M	T		F	M	T		F	M	T		F	M	T	
04/15/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
04/18/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
04/22/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
04/25/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
04/29/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
05/02/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
05/06/97	0	0	0	0.00	0	0	0	0.00	1	0	1	0.05	0	0	0	0.00
05/09/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
05/13/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
05/16/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
05/20/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
05/23/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
05/27/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
05/30/97	0	0	0	0.00	1	0	1	0.07	0	0	0	0.00	0	0	0	0.00
06/03/97	0	0	0	0.00	0	0	0	0.00	1	0	1	0.05	0	0	0	0.00
06/06/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
06/10/97	0	0	0	0.00	1	0	1	0.05	0	0	0	0.00	0	0	0	0.00
06/13/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	1	0	1	0.07
06/17/97	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
35600	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
Total	**0**	**0**	**0**		**2**	**0**	**2**		**2**	**0**	**2**		**1**	**0**	**0**	
F/T/D	**0.000**	**0.000**	**0.000**		**0.006**	**0.000**	**0.006**		**0.006**	**0.000**	**0.006**		**0.003**	**0.000**	**0.003**	

TABLE VIII. *C. capitata* CAPTURED (IN F/T/D) ATHUILLAPIMA IN MANDARIN (355 TRAP DAYS) (04/11/97 - 06/20/97)

Date	JT, TML		TEPHRI, TML		IPMT, NU + B		FRUTECT		OBDT, FA-2		OBDT, FA-3		ST, FA-2		ST, FA-3	
	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
04/15/97	0	0.10	0	0.05	0.15	0	0	0	0	0	0	0	0	0	0	0
04/18/97	0	0	0	0	0.20	0	0	0	0	0	0	0	0	0	0	0
04/22/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04/25/97	0	0	0	0	0.13	0.07	0	0	0	0	0	0	0	0	0	0
04/29/97	0	0	0	0	0.05	0	0	0	0	0	0	0	0	0	0	0
05/02/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05/06/97	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0	0	0
05/09/97	0	0	0	0	0.20	0	0	0	0	0	0	0	0	0	0	0
05/13/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05/16/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05/20/97	0	0	0	0	0.05	0	0	0	0	0	0	0	0	0	0	0
05/23/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05/27/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05/30/97	0	0	0	0	0	0	0	0	0	0	0.07	0	0	0	0	0
06/03/97	0	0	0	0	0.05	0	0	0	0	0	0	0	0.05	0	0	0
06/06/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06/10/97	0	0	0	0.05	0.05	0	0	0	0	0	0.05	0	0	0	0	0
06/13/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.07	0
06/17/97	0	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06/20/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F/T/D	**0.000**	**0.008**	**0.000**	**0.006**	**0.042**	**0.003**	**0.000**	**0.000**	**0.000**	**0.000**	**0.006**	**0.000**	**0.006**	**0.000**	**0.003**	**0.000**

5.2. Results

Tables VII and VIII summarize the total capture of *C. capitata* for each type of trap, revision date, number of flies, F/T/D, and male - female relationship.

Infestation percentage was determined taking ten fruits at random from ten plants at the beginning of each week. In all cases, the result was zero (mandarin and grapefruit).

The pH of NuLure, just prepared, varied between 8.4 and 9.4, whereas the pH of NuLure recycled weekly varied between 8.2 and 9.3.

Staining of medfly female spermathecae showed the following unmated female percentage: IPMT, NU + B - 13.33 %; OBDT, FA-3 - 0.0 %; ST, FA-2 - 0.0 %; ST, FA-3 - 0.0 %.

The following traps did not capture any females: Frutect; JT, TML; Tephri, TML; and OBDT, FA-2. In this trial there were zero larva/ kg fruit.

5.3. Discussion and conclusions

Two species of tephritidae were obtained in this trial: *C. capitata* and *A. fraterculus*. The predominant species was *C. capitata.*

The trap that caught the largest number of *C. capitata* was IPMT, NU+B with 61.54 % of the total followed by the JT, TML with 11.54 %. The Tephri, OBDT, FA-3, and ST, FA-2, captured 7.69%, while ST, FA-3 captured 3.85% and OBDT, FA-2, and Frutect captured 0%.

The trap with the most relative efficiency to capture *C. capitata* females was IPMT, NU + B with 75.00 %, followed by OBDT, FA-3 and ST, FA-2 each with 10.00 % and the ST, FA-3 with 5.00 %. The following traps did not capture any females: JT, TML; Frutect; OBDT, FA-2; and Tephri, TML. The Frutect and OBDT, FA-2 did not capture any medflies.

The largest number of F/T/D obtained was 0.20 for IPMT, NU + B (Tables VII and VIII), which indicated that the medfly population density was low.

The Frutect trap had the most handling disadvantages, and dust and small plant residues also stuck to it. The sticky spray apparently had little adhesive power because it captured only a few, small insects. No medflies were captured by this trap.

In general, the capture of non - target insects was low in all traps.

In the trial, eleven *A. fraterculus* (6 females and 5 males) were captured: 9 in the IPMT, NU+B; an one each in OBDT, FA-3 and ST, FA-3. The most efficient was IPMT, NU + B with 81.82 % of the total.

It is important to point out that because of the low population density of medflies, it is difficult to arrive at a conclusion about the efficiency of the traps used in the trial.

6. FOURTH STAGE - 1997

6.1. Materials and methods

The trial in the Stage IV was carried out in Pomancillo Oeste (Fray Mamerto Esquiú) in the same peach plantation as in the Stage II (1995). No agrochemicals are used here. The experiment coincided with the beginning of the rainfall period in Catamarca and an increase in the number of medflies. The observation site has been previously described except the trees were two years older.

The mandarin and fig trees were in full production in 1997 (but not in 1995). However, the mandarin trees did not have fruits when the trial was conducted, and the figs were unlikely to be attacked by fruit flies because they were too small and immature.

The following traps were used in a comparative way to capture *C. capitata* and other tephritids: JT, TML; IPMT as a wet trap, baited with FA-3, with 300 ml of water for retention

and 1 - 2 drops of surfactant (IPMT, FA-3, water); IPMT as a dry trap, baited with FA-3 and DDVP in base for retention (IPMT, FA-3, DDVP); Tephri Trap as a dry trap, baited with FA-3 and DDVP in basket for retention (Tephri, FA-3, DDVP); Steiner Trap, baited with FA-3 and DDVP in base for retention (ST, FA-3, DDVP); IPMT baited with 300 ml of aqueous NU+B (IPMT, NU+ B).

Statistical design consisted of five lines (A to E) with six traps each placed at random (JT, TML; Tephri, FA-3, DDVP; IPMT, FA-3, water; IPMT, FA-3, DDVP; IPMT, NU + B; and ST, FA-3, DDVP). The rows of peach trees were 36 m apart, and the traps were 25 m apart in the rows.

6.2. Results

Tables IX and X summarize the total capture of *C. capitata* for each type of trap, revision date, F/T/D, and male - female relationship. Table XI shows the number of males and females captured per trap and per period for the trial.

Infestation percentage was determined taking ten fruits at random from ten plants at the beginning of each week. In all cases the result was zero.

The pH of NuLure, when just prepared, varied between 6.8 and 7.7, whereas the pH of NuLure recycled weekly varied between 8.1 and 8.7.

Staining of medfly females spermathecae showed the following percentages of unmated females: IPMT, FA-3, water - 16.67 %; Tephri, FA-3, DDVP - 20.51 %; IPMT, FA-3, DDVP - 21.43 %; ST, FA- 3, DDVP - 17.14 %; IPMT, NU+ B - 14.00 %; JT, TML - 0.00 %.

In the trial 25 adults /kg of fruit were obtained. The only species was *C. capitata*, and all from the variety "cuaresmillo".

6.3. Discussion and conclusions

C. capitata and *Anastrepha* spp. were captured during this trial.

In the trial, the trap that captured the largest number of *C. capitata* was IPMT, FA -3, DDVP with 30.44 % of all medflies captured, followed by the IPMT, FA-3, wet with 27.13 %, IPMT, NU+B with 14.43%, Tephri, FA-3, DDVP with 11.55%, JT, TML with 10.10% and ST, FA-3 with 6.35%. Taking into consideration the RTE for females of *C. capitata* captured, the most efficient trap was IPMT, FA-3, DDVP with 32.98 %, followed by IPMT, FA-3, water with 30.47 %, IPMT, NU+ B with 17.00 %, Tephri, FA-3, DDVP with 13.43 %, ST, FA- 3, DDVP with 6.07 %, and JT, TML with 0.05 %.

The JT, TML captured 99 - 100 % males. This was an expected result because TML is a specific attractant for *C. capitata* males. JT, TML captured one female in 425 trap days (Table IX).

During the trial, the only non-target insect captured in great number was *Neomyennis* spp. (Diptera: Pterocallidae). All traps, except JT, TML with only two males, captured this species (975 in IPMT, NU+B; 408 in IPMT, FA-3, water; 1156 with IPMT, FA-3, DDVP, 1529 in Tephri, FA-3, DDVP, and 351 in ST, FA-3, DDVP.

The trap that captured the greatest number of non - target insects was IPMT, NU+B. Most were Diptera of the Muscidae and Lonchaeidae families. Within this last family *Carpolonchaea* (*Lonchaea*) *pendula* Bezzi was the predominant species captured. Some authors consider it as part of the fruit fly complex. Hymenoptera were also captured, mainly *Polistes canadensis* (L.), although in fewer in number than the *Neomyennis* spp.

TABLE IX. *C. capitata* CAPTURED (TOTALS AND F/T/D) ATPOMANCILLOOESTE IN PEACH(425 TRAP DAY) (09/12/97 - 12/05/97)

Date	JT, TML			IPMT, NU + B			IPMT, FA-3, Wet			IPMT, FA-3, DDVP			Tephri, FA-3, DDVP			ST, FA-3, DDVP		
	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T
09/16/97	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
09/19/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09/23/97	0	0	0	0	0	0	1	0	1	0	0	0	0	1	1	0	0	0
09/26/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09/30/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/03/97	0	0	0	0	0	0	0	1	1	0	0	0	1	0	1	0	0	0
10/07/97	0	0	0	1	0	1	0	0	0	1	0	1	-	-	-	0	0	0
10/10/97	0	0	0	3	0	3	1	0	1	2	0	2	0	0	0	0	0	0
10/14/97	0	0	0	6	0	6	7	0	7	4	0	4	7	0	7	0	0	0
10/17/97	0	0	0	7	0	7	4	0	4	2	0	2	2	0	2	1	0	1
10/21/97	0	0	0	22	0	22	19	0	19	10	0	10	4	0	4	6	0	6
10/24/97	0	1	1	33	2	35	86	0	86	29	0	29	6	0	6	3	0	3
10/28/97	1	1	2	65	1	66	69	2	71	34	2	36	75	0	75	17	0	17
10/31/97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35737	0	19	19	40	10	50	48	6	54	64	5	69	37	2	39	14	2	16
35740	0	9	9	7	1	8	49	8	57	18	6	24	71	13	84	15	2	17
35744	0	13	13	11	7	18	63	14	77	13	3	16	26	15	41	6	1	7
11/14/97	0	11	11	0	0	0	35	11	46	10	3	13	10	3	13	4	4	8
11/18/97	0	32	32	7	1	8	37	29	66	36	28	64	10	11	21	2	2	4
11/21/97	0	93	93	19	10	29	38	19	57	86	39	125	17	8	25	14	19	33
11/25/97	0	33	33	72	30	102	43	18	61	165	49	214	17	7	24	12	3	15
11/28/97	0	76	76	52	8	60	86	38	124	160	60	220	10	5	15	7	8	15
35765	0	21	21	15	4	19	63	28	91	65	20	85	0	0	0	28	23	51
35768	0	5	5	11	4	15	18	5	23	23	12	35	1	1	2	4	1	5
Total	**1**	**314**	**315**	**372**	**78**	**450**	**667**	**179**	**846**	**722**	**227**	**949**	**294**	**66**	**360**	**133**	**65**	**198**
F/T/D	**0.002**	**0.739**	**0.741**	**0.875**	**0.183**	**1.058**	**1.569**	**0.421**	**1.990**	**1.698**	**0.534**	**2.232**	**0.692**	**0.155**	**0.847**	**0.313**	**0.153**	**0.466**

TABLE X. *C. capitata* CAPTURED (IN F/T/D) AT POMANCILLO OESTE IN PEACH (425 TRAP DAYS) (09/12/97 - 12/05/97)

Date	JT, TML		IPMT, NU+B		IPMT, FA -3, Wet		IPMT, FA-3, DDVP		TEPHRI, FA-3, DDVP		ST, FA-3, DDVP	
	F	M	F	M	F	M	F	M	F	M	F	M
09/16/97	0	0	0.05	0	0	0	0	0	0	0	0	0
09/19/97	0	0	0	0	0	0	0	0	0	0	0	0
09/23/97	0	0	0	0	0.05	0	0	0	0	0.05	0	0
09/26/97	0	0	0	0	0	0	0	0	0	0	0	0
09/30/97	0	0	0	0	0	0	0	0	0	0	0	0
10/03/97	0	0	0	0	0	0.07	0	0	0.07	0	0	0
10/07/97	0	0	0.05	0	0	0	0.05	0	-	-	0	0
10/10/97	0	0	0.20	0	0.07	0	0.13	0	0	0	0	0
10/14/97	0	0	0.30	0	0.35	0	0.20	0	0.35	0	0	0
10/17/97	0	0	0.47	0	0.27	0	0.13	0	0.13	0	0.07	0
10/21/97	0	0	1.10	0	0.95	0	0.50	0	0.20	0	0.30	0
10/24/97	0	0.07	2.20	0.13	5.73	0	1.93	0	0.40	0	0.20	0
10/28/97	0.05	0.05	3.25	0.05	3.45	0.10	1.70	0.10	3.75	0	0.85	0
10/31/97	-	-	-	-	-	-	-	-	-	-	-	-
11/04/97	0	0.54	1.14	0.28	1.37	0.17	1.83	0.14	1.06	0.06	0.40	0.06
11/07/97	0	0.60	0.47	0.07	3.27	0.53	1.20	0.40	4.73	0.87	1.00	0.13
11/11/97	0	0.65	0.55	0.35	3.15	0.70	0.65	0.15	1.30	0.75	0.30	0.05
11/14/97	0	0.73	0	0	2.33	0.73	0.67	0.20	0.67	0.20	0.27	0.27
11/18/97	0	1.60	0.35	0.05	1.85	1.45	1.80	1.40	0.50	0.55	0.10	0.10
11/21/97	0	6.20	1.27	0.67	2.53	1.27	5.73	2.60	1.13	0.53	0.93	1.27
11/25/97	0	1.65	3.60	1.50	2.15	0.90	8.25	2.45	0.85	0.35	0.60	0.15
11/28/97	0	5.07	3.47	0.53	5.73	2.53	10.67	4.00	0.67	0.33	0.47	0.53
12/02/97	0	1.05	0.75	0.20	3.15	1.87	3.25	1.00	0	0	1.40	1.15
12/05/97	0	0.33	0.73	0.27	1.20	0.33	1.53	0.80	0.07	0.07	0.27	0.07
F/T/D	**2**	**0.739**	**0.875**	**0.183**	**1.569**	**0.421**	**1.698**	**0.534**	**0.692**	**0.155**	**0.313**	**0.153**

TABLE XI. TOTAL NUMBER OF MALES AND FEMALES OF *C. capitata* CAPTURED DURING THE TRIAL PER TRAP AND PER PERIOD IN POMANCILLO OESTE, DEPARTAMENTO FRAY MAMERTO ESQUIÚ. 1997

Period	JT, TML		IPMT, NU + B		IPMT, FA-3, WET		IPMT, FA-3, DDVP		TEPHRI, FA-3, DDVP		ST, FA-3, DDVP	
	F	M	F	M	F	M	F	M	F	M	F	M
I	0	0	1	0	1	0	0	0	0	1	0	0
II	0	0	10	0	8	1	7	0	8	0	0	0
III	1	2	127	3	178	2	75	2	87	0	27	0
IV	0	84	65	19	232	68	141	45	154	44	41	11
V	0	228	169	56	248	108	499	180	45	21	65	54
Total	**1**	**314**	**372**	**78**	**667**	**179**	**722**	**227**	**294**	**66**	**133**	**65**

Periods: I. 09/12 - 09/26; II. 09/30 - 10/14; III. 10/17 - 10/31; IV. 11/04 - 11/18; V. 11/21 - 12/05

In the trial, the greatest number of medflies and other insects captured occurred in the last lines, mainly D and E (data not shown). This may be due to the fact that the trees had not been pruned so they gave more protection to the insects.

Capture in the A line increased by the end of the trial. This was because in the first line of the plantation (to the west) there was a peach variety called "cuaresmillo," where insecticide is not used and fruit is not collected and thus suffered from strong fruit fly attack. It was used only as seed, to be grafted later. This situation was not realized in 1995 because the trial was shorter. From about October 28th, this variety allowed an increase in medfly population and in row A, the closest to this variety, there was an increase the medfly capture. During the last two periods, this was the only fruit available.

The addition of the third attractant (trimethylamine) to lures increased medfly capture, although the selectivity for *C. capitata* females decreased slightly. The results for unmated females were similar, when compared with the trial carried out in 1995, except for IPMT,,NU+B, where selectivity increased. However, it should be noted that the traps were not the same (*i.e.*,CBDT and OBDT were not used).

In general, there were no problems with the traps management, but dry traps were easier to manipulate in the field than those which used liquids for means of insect retention. There were also no problems with predators. The only inconvenience was that a small accumulation of water at the base of the dry traps on rainy days.

For unknown reasons, a Tephri trap was found once on the ground (10/07/97). On October 31st, the field activities could not be fulfilled (Tables IX and X).

The only trap, where insects caught suffered significant decomposition problems was the IPMT, FA-3, wet, mainly in spring when temperatures began increasing. At the end of the trial, with high temperatures and in this trap, there were found, besides medflies in good conditions, just the wing of *C. capitata* so the sex could not be identified. *Anastrepha* spp., however, did not suffer decomposition. The decomposition problems with arthropods, when using water as means of retention, did not occur at low temperatures.

In peach, the harvest started on October 3rd, 1997, with a very low medfly population (Table IX) and was finished on October 24th (22 days). There was a very low population of *C. capitata*, mainly of males, so fruit suffered very little harm. Additionally, the 30 traps placed in this small fruit orchard could have acted as a control method. The trials during 1995 (330 trap day) and 1997 (425 trap day), were carried out in the same orchard (Pomancillo Oeste) and they started on the same date (September 12th). However, the trials did not last the same length of time and the same traps were not compared. The appearance of females of *C. capitata* occurred faster than males (in both trials). This was probably because males need different environmental conditions to appear. In both trials the harvest was carried out with a very low male population.

The maximum indexes of F/T/D in the trial were: IPMT, FA-3, DDVP: 14.67; IPMT, FA-3, wet: 8.26; JT, TML: 6.20; Tephri, FA-3, DDVP:5.60; IPMT, NU+B: 5.10 and ST, FA-3, DDVP: 2.55. These indexes are the sum of F/T/D of females and males of Table X. The maximum indexes were obtained at the end of the trial, without fruit on the trees, except for the "cuaresmillo" variety.

During the trial 444 flies of genus *Anastrepha* (Diptera: Tephritidae) were caught and more than 90 % were *A. fraterculus*. The most efficient trap for the capture of *Anastrepha* spp. was IPMT, NU+B with 315 flies (70.94 %), followed by IPMT, FA-3,wet with 73 flies (16.44 %), IPMT, FA- 3, DDVP with 28 flies (6.31 %), ST, FA-3, DDVP with 26 flies (5.86 %), and Tephri, FA-3, DDVP with 2 flies (0.45 %). The ST, FA-3, DDVP caught 26 *Anastrepha* spp. (16 females and 10 males) the same day (December 2nd, 1997) in the row A (data not shown).

The highest RTE for capturing females of *Anastrepha* spp. was also IPMT, NU+ B with 71.61 %, followed by IPMT, FA-3,wet with 15.48 %, 7.1% for IPMT, FA-3, DDVP, 5.2% with ST, FA-3, DDVP and 0.6% with Tephri, FA-3, DDVP.

149

TABLE XII. METEOROLOGICAL DATA - 1994 - (METEOROLOGICAL STATION, NATIONAL INSTITUTE OF AGRICULTURAL TECHNOLOGY, VALLE VIEJO)

Month	Max. T. ° C Absolute	Min. T. ° C Absolute	Mean. T. ° C	Max. R.H. Mean (%)	Min. R.H. Mean (%)	Mean R.H. (%)	Wind - km/m Mean	Rain (mm)
JAN.	39.0	16.0	27.4	70.6	37.0	53.8	9.3	115.0
FEB.	37.0	13.0	24.5	80.6	44.9	62.8	9.0	142.8
MAR.	35.0	12.5	23.8	71.9	42.6	57.3	6.1	6.0
APR.	33.0	9.0	22.2	81.6	43.6	62.7	6.6	20.5
MAY	32.0	6.5	18.7	87.7	46.9	67.3	5.7	9.4
JUN.	26.2	-2.0	14.3	82.3	37.0	59.6	5.6	0.5
JUL.	27.2	-6.5	11.3	80.6	39.1	59.8	5.2	10.0
AUG.	31.5	-1.0	16.4	66.9	32.7	49.8	7.5	0.1
SEP.	42.0	-2.5	20.7	65.5	36.3	50.9	8.9	4.0
OCT.	38.5	8.5	22.2	67.7	46.1	56.7	9.2	29.8
NOV.	37.5	13.0	25.2	71.1	39.4	55.3	10.5	23.0
DEC.	42.0	16.5	28.2	68.5	36.4	52.5	10.7	89.0
Annual	**42.0**	**6.5**	**21.2**	**74.6**	**40.2**	**57.4**	**7.9**	**450.1**

TABLE XIII. METEOROLOGICAL DATA - 1995 - (METEOROLOGICAL STATION, NATIONAL INSTITUTE OF AGRICULTURAL TECHNOLOGY, VALLE VIEJO)

Month	Max. T. ° C Absolute	Min. T. ° C Absolute	Mean. T. ° C	Max. R.H. Mean (%)	Min. R.H. Mean (%)	Mean R.H. (%)	Wind - km/m Mean	Rain (mm)
JAN.	40.5	15.0	27.2	74.8	41.4	58.1	9.2	20.3
FEB.	36.7	15.0	25.5	73.6	38.6	56.1	8.0	35.0
MAR.	35.5	14.0	25.9	80.3	44.0	62.2	8.7	45.0
APR.	35.5	4.5	21.6	79.4	38.6	58.8	6.7	0.5
MAY	30.5	2.2	16.4	88.2	42.3	65.3	5.2	13.5
JUN.	27.5	0.5	12.9	87.2	43.7	65.4	5.3	0.1
JUL.	27.7	0.0	11.9	83.5	39.7	61.6	5.0	0.0
AUG.	36.8	-1.0	15.1	75.0	39.4	57.2	6.9	0.0
SEP.	35.5	4.0	18.9	67.2	33.7	50.4	8.2	2.0
OCT.	41.0	9.0	23.3	63.8	33.8	48.8	9.8	2.2
NOV.	40.7	14.0	24.8	64.6	34.4	49.5	10.1	75.7
DEC.	41.1	14.0	28.4	66.5	31.1	48.8	9.6	44.2
Annual	**41.1**	**-1.0**	**21.0**	**75.3**	**38.4**	**56.9**	**7.7**	**238.5**

TABLE XIV. METEOROLOGICAL DATA - 1996 - (METEOROLOGICAL STATION, NATIONAL INSTITUTE OF AGRICULTURAL TECHNOLOGY,VALLE VIEJO)

Month	Max. T. ° C Absolute	Min. T. ° C Absolute	Mean. T. ° C	Max. R.H. Mean (%)	Min. R.H. Mean (%)	Mean R.H. (%)	Wind - km/m Mean	Rain (mm)
JAN.	39.0	15.5	26.5	77.4	36.0	56.7	8.6	64.0
FEB.	39.5	12.0	26.1	78.4	43.1	60.8	10.0	26.0
MAR.	38.0	15.5	25.6	75.3	38.6	57.0	9.1	57.0
APR.	32.0	7.0	19.7	90.2	56.8	73.5	6.8	38.1
MAY	30.7	1.2	18.4	93.7	58.3	76.0	6.6	0.9
JUN.	27.0	-5.0	10.4	98.7	58.7	78.7	3.4	19.0
JUL.	26.6	-4.0	11.9	91.0	46.6	68.8	5.6	0.0
AUG.	41.0	0.5	18.0	79.4	44.7	62.1	7.3	0.0
SEP.	34.5	4.5	18.0	84.3	50.2	67.3	6.7	24.0
OCT.	38.5	9.5	23.7	98.3	42.7	70.5	9.5	8.5
NOV.	31.4	20.5	26.0	90.4	45.5	68.0	14.3	20.4
DEC.	32.6	21.7	27.1	89.5	46.5	68.0	9.8	101.5
Annual	**41.0**	**-5.0**	**20.9**	**87.2**	**47.3**	**67.2**	**8.1**	**359.4**

TABLE XV. METEOROLOGICAL DATA - 1997 - (METEOROLOGICAL STATION, NATIONAL INSTITUTE OF AGRICULTURAL TECHNOLOGY,VALLE VIEJO)

Month	Max. T. ° C Absolute	Min. T. ° C Absolute	Mean. T. ° C	Max. R.H. Mean (%)	Min. R.H. Mean (%)	Mean R.H. (%)	Wind - km/m Mean	Rain (mm)
JAN.	32.6	23.0	27.8	85.0	50.6	67.8	8.1	149.5
FEB.	30.2	19.2	24.7	88.2	52.1	70.1	7.3	84.3
MAR.	31.5	14.8	23.2	88.0	53.1	70.5	8.3	18.3
APR.	30.9	16.6	23.8	84.2	47.4	65.8	7.2	0.0
MAY	25.5	12.4	18.9	88.3	51.4	69.9	6.6	20.5
JUN.	20.3	5.7	12.9	96.1	52.5	74.3	4.4	0.0
JUL.	22.4	7.2	14.8	94.5	48.3	71.4	4.6	0.1
AUG.	29.3	9.6	19.4	84.8	46.6	65.7	3.1	0.5
SEP.	28.3	13.3	20.8	83.2	50.1	66.6	-	0.0
OCT.	28.8	16.2	22.5	83.4	49.2	66.3	-	15.5
NOV.	32.1	19.8	25.9	82.1	47.5	64.8	-	26.9
DEC.	34.1	15.6	24.9	69.8	39.9	54.9	-	54
Annual	**34.1**	**5.7**	**21.6**	**96.1**	**39.9**	**68.3**	**6.2**	**365.6**

ACKNOWLEDGEMENTS

To International Atomic Energy Agency which supported the Research Contract N° 7648/R1.

To Professor Lidia Aguirre de Quevedo and Professor Diana Ovejero (College of Agronomy Sciences, National University of Catamarca) for the translation of this paper into English and for the statistical analysis, respectively.

To R. M. Berlanda, O. D. Luque, C. A. Maldonado, C. N. Palmieri and M. A. Ritacco for collaboration in field and laboratory activities and data processing.

BIBLIOGRAPHY

BATEMAN, M., The ecology of fruit flies, Ann. Rev. Entomol. 17 (1972) 493-511.

BODENHEIMER, F., Flies (Diptera), In Citrus Entomology in the Middle East Holland, W. JUNK, Ed., Groningen. Holland (1951) 89-161.

ROS AMADOR, J. La mosca mediterránea de la fruta *C. capitata* Wied. Biología y métodos de control, Hojas Divulgadoras Ministerio de Agricultura N° 8/88 (1988) 28 pp.

VATTUONE, E., CÓRDOBA, E. Relevamiento de las "moscas de los frutos" en mandarino (*Citrus deliciosa* Tenore). Su distribución y fluctuación poblacional en el Valle Central de la Provincia de Catamarca, In Jornadas Fitosanitarias Argentinas, 7ª, Salta (1989) Memoria. Universidad Nacional de Salta 10 pp.

VATTUONE, E. et al. Ensayo de un nuevo atractivo y trampa para la captura de hembras de *Ceratitis capitata* Wied. (Diptera: Tephritidae), Catamarca, Argentina. In III Jornadas de Información Científico - Técnicas de la Facultad de Ciencias Agrarias, Universidad Nacional de Jujuy y I Jornadas Regionales (1996) Memoria, 127 pp.

MEDFLY (*Ceratitis capitata* Wiedemann) FEMALE ATTRACTANT STUDIES AND DEVELOPMENT OF TRAPPING SYSTEMS FOR STERILITY ASSESSMENT

L.A. VÁSQUEZ, K. SPONAGEL
Fundación Hondureña de Investigación Agrícola (FHIA),
La Lima, Honduras

Abstract

In four years of research, we evaluated different traps (McPhail, Tephri, Closed-bottom dry trap, Open-bottom dry trap, and Frutect), lures (FA-2 and FA-3 synthetic lures composed of ammonium acetate + putrescine, and ammonium acetate + putrescine + trimethylamine, respectively), and insect retention methods (water, sticky inserts, insecticides) to develop a selective trapping system for female Mediterranean fruit fly (*Ceratitis capitata*, Wiedemann) sterility assessment. The trapping systems were compared with protein-baited McPhail traps, which are the standard method for *C. capitata* female capture, during eight to fifteen week trials in coffee and orthanique orange plantations at two different localities in Honduras. Trimedlure-baited Jackson traps were also used as the standard indicator of the *C. capitata* populations. The Closed-bottom trap baited with the two-component synthetic lure captured eight to twelve times fewer *C. capitata* than the Jackson trap. The McPhail trap and the modified Open-bottom trap, both baited with the two-component synthetic lure, captured 1.6 to 3.5 times more *C. capitata* females than the protein-baited McPhail trap. The addition of trimethylamine to the two-component synthetic lure resulted in 9.8 to 15.8 times increases in *C. capitata* female capture over the protein-baited McPhail trap. The presence of water in McPhail or Tephri traps did not affect the capture of *C. capitata* females. Throughout the study, all female-targeted trapping systems captured the same proportion of females.

1. OBJECTIVES

The goals of the Co-ordinated Research Program were to develop attractants for adult female Mediterranean fruit flies (*Ceratitis capitata*, Wiedemann) for use in Sterile Insect Technique (SIT) eradication or control programs and to compare currently used traps to newly-developed, female-targeted, dry traps with synthetic attractants in various host plants under different environmental conditions.

2. MATERIALS AND METHODS

2.1. Description of the experimental regions

The experiments were conducted in two different localities of Honduras. The regions selected were the Comayagua Valley and the Lake Yojoa basin. The Comayagua Valley is Honduras' most important horticultural zone, with substantial areas planted with several fruit fly hosts. Coffee is the favored host crop for *C. capitata* in Honduras and is cultivated mostly in large areas in the mountains bordering the valley. The predominant natural vegetation in the valley is tropical, deciduous, dry forest. Weather in Comayagua is classified as semi-arid. The average annual rainfall is 752 mm per year ranging in average from of 6.7 to 183 mm per month. On average, it rains of 83 days a year. The rainy season extends from June to November, but it rains the most in May and October. The average temperature is 23.8 °C ranging from an average of 17.4 (9.5 °C absolute minimum) to 31.9 °C (37.5 °C absolute maximum). The average relative humidity throughout the year is 67%. The prevailing winds come from the northeast and the east, with low medium wind speeds between 0.4 and 2.2 m/s; it is calm 41.2% of the time. In contrast, the Lake Yojoa basin is a mountainous region, with large plantations of pineapple (non host), coffee (*C. capitata* hosts), citrus (tangerine, sweet orange and grapefruit which are *C. capitata* hosts and Persian lime) and food crops (corn, kidney beans and beans). The predominant natural vegetation is classified as tropical-humid.

Dominant soils are ultisol, entisol and vertisol. Weather in Yojoa is humid with an average annual rainfall of 3,045 mm ranging from 0 to 535 mm per month. On average, it rains 196 days a year. The rainy season extends from May to November, but it rains the most in September. The average temperature is 22.1 °C ranging from an average of 18.0 (11.0 °C absolute minimum) to 30.9 °C (38.8 °C absolute maximum). The average relative humidity throughout the year is 77%. This data is from 1944 to 1997 and was provided by the Direction of Water Resources, Ministry of Natural Resources, Honduras.

2.2. Host plants and experimental sites

All experiments were carried out in coffee (*Coffea arabica* cv. Catuai) plantations except in 1997 when we used an orthanique orange plantation (*Citrus reticulata*) in Yojoa. In Honduras, these host plants usually have moderate to high infestation of *C. capitata*. All the experiments in Comayagua were conducted in the same six to ten-year-old coffee plantation (23 ha). The plantation is not shaded, the terrain is flat, the harvest occurs from September to December, and the trees are planted at 1.6 x 1.0 m. The plantation is in the village Las Mercedes 2 km northeast of Tegucigalpa, at an altitude of 680 m above sea level. For experiments in Yojoa, in 1994, we used a 12 year old coffee plantation (5.6 ha) and, in 1997, we used a 14 year old orthanique orange (*Citrus reticulata*) plantation (10 ha). Both plantations are located in the village La Ceibita, 8 km east from the village of Santa Cruz de Yojoa, Cortés, 115 km north of Tegucigalpa, at an altitude of 280 m above sea level. The coffee plantation is on an inclined terrain, is heavily shaded, the harvest occurs from October to January, and the trees are planted at 1.5 x 2.0 m. The orthanique orange plantation has moderate slopes, is harvested from January to March, and the trees are planted at 6.0 x 5.5 m. For the 1995 and 1996 experiments in Yojoa, we used a lightly shaded 10 to 11 year old coffee plantation located 3 km north of Peña Blanca, 103 km north of Tegucigalpa, at an altitude of 265 m above sea level. The plantation in on a flat terrain, the harvest occurs from October to January and the trees are planted at 2.0 x 1.2 m.

2.3. Description of the female-targeted trapping systems and experimental treatments

All the treatments, including traps and lure combinations per year, are described in Table I. For simplicity, we will use the name in the parenthesis of each treatment description in Table I to identify the treatments in the rest of the tables. All McPhail traps were International Pheromone's McPhail trap.

2.4. Experimental design, data collection and analysis

An experimental site consisted of 2 - 7 treatments placed on 5 lines (A-E) arranged in a randomized complete block design, thus each line represented a block in the experiment. In 1994, each treatment was duplicated in each block. The treatments were located at random within each line at a distance of 25-30 m from each other. The traps were placed on the coffee plants or orthanique trees 2 m above the ground in the southeastern side of the canopy. Twice a week, each trap was examined and the number of female and male *C. capitata* captured was recorded. Except for the 1995 trials, all other experiments carried out in Yojoa lasted for 8 consecutive weeks. The 1995 experiment in Yojoa ran for 15 consecutive weeks. Treatments were rotated sequentially within each line after each check. The traps were evaluated during the morning (9 - 11 a.m.) on the first and fourth day of the week. At each sampling date, water was added to the treatments as needed. Liquid protein attractants (NU+B) were replaced weekly, Trimedlure attractants were replaced every two weeks and the two or three-component, synthetic lure (FA-2 or FA-3) was replaced every four weeks. The attractant used with the Frutect trap was never replaced. The spent materials (water, attractants, foil or clear coverings) were always collected in plastic containers and carefully removed from the experimental sites for disposal.

TABLE I. TREATMENTS USED DURING THE FOUR YEARS OF STUDY FOR DEVELOPMENT OF A FEMALE-TARGETED MEDFLY (*Ceratitis capitata*, Wiedemann) TRAPPING SYSTEMS IN HONDURAS AT COMAYAGUA AND YOJOA FROM 1994 TO 1997

Treatment	Year			
	94	95	96	97
Trimedlure-baited Jackson trap - a triangular 12.7 x 9.5 x 8.5 cm high white cardboard trap with a white sticky insert to capture the flies (T, TML)	X	X	X	X
Protein-baited McPhail trap - a trap with two detachable plastic containers - a transparent top section (12.7 cm long x 16.5 cm diameter) and a yellow bottom section (8 cm long x 17.5 cm diameter) with aninvaginated area (8 cm x 5.5 cm diameter) which allowed for fly entry and created space for a liquid attractant (300 ml of an aqueous solution containing 9% NuLure + 3% borax) (PMT, NU+B)		X	X	X
Frutect trap and lure® (RonPal Ltd. Rishpon, Israel) (Frutect) - a trap with a yellow flat, rhomboidal, sticky surface (29 x 29 cm plastic surface with a 11.5 cm diameter hole in the center). In the center was a dark purple plastic sphere of 11.5 cm diameter containing the lure (Frutect)			X	
Closed-bottom, light green, dry trap with two-component synthetic lure (ammonium acetate + putrescine) and with a toxicant square (Diazinon® + sugar) to capture the flies [1] (CBDT, FA-2)	X	X		
Open-bottom, opaque green, dry trap baited with two-component synthetic lure (ammonium acetate + putrescine) and with a yellow sticky insert to capture the flies [2] (OBDT, FA-2)		X	X	
Open-bottom, opaque green, dry trap baited with three-component, synthetic lure (ammonium acetate + putrescine + trimethylamine) and with a yellow sticky insert to capture the fliesOBDT, FA-3)			X	X
McPhail trap baited with the two-component synthetic lure (ammonium acetate + putrescine) and with 300 ml of water to capture flies (PMT, FA-2, wet)		X	X	
McPhail trap baited with the three-component, synthetic lure (ammonium acetate + putrescine + trimethylamine) and with 300 ml water + 2 drops surfactant to capture flies (PMT, FA-3, wet)			X	X
McPhail trap baited with the three-component, synthetic lure (ammonium acetate + putrescine + trimethylamine) and with a tablet (2mm x 1.5mm x 0.4 mm) of DDVP (synthetic insecticide) to capture flies. (PMT, FA-3, dry)				X
Tephri trap (Agro Alcoy, Alicante, Spain) baited with the three-component, synthetic lure (ammonium acetate + putrescine + trimethylamine) and with 200 ml of water and two drops of surfactant to capture flies. The rap was made of two attachable plastic containers an uppertranslucid section (4.0 cm long x 12.5 cm diameter) which gave support to the trap and a lower yellow section (11.5cm long x 12.5 cm diameter) with aninvagination (4.0 cm x 3.0 cm diameter) which allowed for entry of flies and also created an area to contain liquid attractant. (Tephri, wet)				X
Tephri trap baited with the three-component, synthetic lure (ammonium acetate + putrescine + trimethylamine) and with a tablet (2 mm x 1.5 mm x 0.4 mm) of DDVP (synthetic insecticide) to kill the flies (Tephri, dry)				X

The analysis of variance (ANOVA) was conducted using Minitab, Version 11 [3]. Mean separation procedures were conducted using Duncan's new multiple range test at 95% confidence. To show the differences between FA-2 and FA-3 lures and wet and dry traps, mean linear contrasts between IPMT and OBDT traps in 1996 and IPMT and Tephri traps in 1997 were conducted using Sheffe's method for multiple range with 95% confidence [4]. JT, TML traps are highly selective for *C. capitata* males. Thus, treatments with the Jackson trap were dropped from the analysis of variance, except in 1994, when no female-targeted standard was included. To meet the assumption of normality, data was transformed to $\log_{10}$ [x + 1] or sqrt (x). For the analysis of selectivity of the trapping systems, the sum of females and males captured was calculated for each trap for the whole period. Then, the percentage of females captured per trap was calculated using # females / (# males + # females). Treatments which captured no females during the whole experiment were dropped from the analyses.

3. RESULTS AND DISCUSSION

3.1. Efficiency in capturing adult *C. capitata*

During 1994, we evaluated a newly-developed, light green, CBDT baited with a FA-2 synthetic lure and a toxicant described in [1]. We compared this CBDT with a male-targeted JT. The number of *C. capitata* captured by each treatment is shown in Table II. The JT captured 8 to 12 times more *C. capitata* flies and 6 to 8 times more *C. capitata* females than CBDT (Table II). The poor efficacy observed with the CBDT was thought to be derived from either a faulty trap design, a weak attractant or an ineffective capture device. We concluded that further research was required to test the attractants in other trap types to isolate the trap effect from the lure effect, and to test other improved closed-bottom trap designs with a more effective trapping device.

In 1995, we tested an opaque green trap named the Open-bottom trap (OBDT) with two-component synthetic lure (FA-2) described in [2]. This trap had an open bottom and a yellow sticky insert to capture the flies (Table I). The experiment also included the CBDT tested the previous year and the IPMT. All the traps were baited with the FA-2 to isolate the trap effect from the lure effect. The protein-baited IPMT was also included as the standard, female-targeted trap and the JT as an indicative of the *C. capitata* populations (Table I).

The *C. capitata* population in 1995 measured by the JT capture was 5 to 14 times higher than in the 1994 and 9 times higher in Comayagua than in Yojoa. The CBDT captured similar numbers of *C. capitata* females in both localities, despite the differences in *C. capitata* population density. The OBDT always captured significantly more *C. capitata* females than its predecessor, the CBDT (Table III). The OBDT was also as effective as the IPMT with the same attractant in Yojoa and as the standard in Comayagua. IPMTs and OBDTs with the FA-2 lure, captured more or similar, but never fewer *C. capitata* females than the standard (Table III). We concluded that the CBDT was not fit enough to test again. The FA-2 synthetic attractant was as effective as the standard protein attractant but further improvement would be required to compete in commercial trapping. The OBDT was as effective as the standard IPMT and should be included in further tests.

In 1996, we compared the original two-component, synthetic lure with a new three-component (FA-3) synthetic lure [5]. The new FA-3 lure had the same two-components tested in the first and second year (AA + P) plus trimethylamine (TMA) as the third component.

TABLE II. AVERAGE ±SD OF TOTAL (BOTH SEXES) AND FEMALE *C. capitata* CAPTURE PER TREATMENT AT LAS MERCEDES, COMAYAGUA AND LA CEIBITA, YOJOA FROM APRIL TO DECEMBER 1994

Comayagua				Yojoa			
Treatment	Daily capture[1]		Relative	Treatment	Daily capture[1]		Relative
	Total (both sexes) *C. capitata* capture						
JT, TML	0.0721 ±0.116	a	8	JT, TML	0.0223 ±0.029	a	12
CBDT, FA-2	0.0089 ±0.027	b	1	CBDT, FA-2	0.0018 ±0.006	b	1
F= 103.98 df= 1, 319 P < 0.0001				F= 118.21 df= 1, 319 P < 0.0001			
	Daily capture				Daily capture		
	Female *C. capitata* capture						
JT, TML	0.0282 ±0.052		6	JT, TML	0.0124 ±0.019		8
CBDT, FA-2	0.0046 ±0.016		1	CBDT, FA-2	0.0016 ±0.006		1

[1] Treatments followed by the same letter are not statistically different (ANOVA on sqrt (x) transformed data.

TABLE III. AVERAGE ±SD FEMALE *C. capitata* CAPTURE PER TREATMENT AND BOTH SEXES ±SD CAPTURE IN JACKSON TRAP AT LAS MERCEDES, COMAYAGUA AND PEÑA BLANCA, YOJOA IN 1995

Comayagua				Yojoa			
Treatment	Daily capture[1]		Relative[2]	Treatment	Daily capture[1]		Relative[2]
IPMT, FA-2	1.332 ±1.85	a	1.63	OBDT, FA-2	0.135 ±0.56	a	3.55
IPMT, NU+B	0.818 ±2.03	b	1	IPMT, FA-2	0.122 ±0.28	a	3.21
OBDT, FA-2	0.754 ±2.46	b	0.92	IPMT, NU+B	0.038 ±0.15	b	1
CBDT, FA-2	0.029 ±0.09	c	0.03	CBDT, FA-2	0.027 ±0.1	b	0.71
F= 29.54 df= 3, 319 P < 0.0001				F= 9.52 df= 3, 599 P < 0.0001			
JT, TML	1.064 ±2.55	n/a	n/a		0.110±0.20	n/a	n/a

[1] Treatments followed by the same letter are not statistically different (ANOVA, Duncan's multiple range test on transformed sqrt(x) data, α= 0.05, df = 3, 312 and 592 for Comayagua and Yojoa, respectively).
[2] Relative to the IPMT, NU+B which is the standard female-selective trapping system.

The FA-2 and FA-3 lures were tested in the OBDT and in the IPMT. The Frutect trap and lure (RonPal Ltd. Rishpon, Israel), a newly patented female-selective trapping system, was also tested in this study. As in the previous years, the protein-baited IPMT, NU+B and the JT were included as the female standard trapping system and as the indicator of the *C. capitata* population density, respectively (Table IV).

Ceratitis capitata population density, as measured by the JT captures, was similar in both localities in 1996, but it was 0.4 to 4 times the population of 1995 and 3 to 10 times the population of 1994 (Tables II, III and IV). All the treatments ranked consistently in both localities. The IPMT and the OBDT with either FA-2 or FA-3 synthetic lures captured significantly more *C. capitata* females than any other female-targeted trap and 3.4 to 15.8 times more than the standard (Table IV). On average, the traps with the FA-3 synthetic lure captured 1.9 to 37 times more *C. capitata* females than the traps with only the FA-2 synthetic lure (Table V). Why the OBDT and the IPMT with FA-3 synthetic lures captured 37 times more *C. capitata* females in Yojoa and only 1.9 times more in Comayagua is unknown. The Frutect trap captured significantly fewer numbers of *C. capitata* females than the standard and is thus unfit for further research. We concluded that the FA-3 lure is more effective than the FA-2 lure and the protein attractant (NU+B). Under the conditions of this experiment, the FA-3 synthetic lure can be equally effective if used in IPMT or OBDT.

In 1997, the IPMT and a McPhail derived trap type from Spain, the Tephri trap, were tested with and without water and compared to the OBDT and to the standard IPMT, NU+B. The numbers of *C. capitata* female captured/trap/day are shown in Table VI. The comparisons between the C.capitata female daily capture between wet and dry traps are shown in Table VII. The C. capitata population density, as measured by the JT during 1997, was 378 times higher in Comayagua than in Yojoa, and 106 times higher than the highest population density recorded in previous years. In Yojoa, the population density was 13 times higher than the smallest density population registered in previous years. The addition of water under extreme dry conditions may affect the capture of *C. capitata* females, but, under the conditions of this experiment, this was not so. The addition of water to either the IPMT or the Tephri trap did not affect significatively the number of *C. capitata* females captured. (Table VII). Female *C. capitata* capture was the same, when comparing the IPMT wet trap and the Tephri wet trap to the combination of IPMT, Tephri and dry traps. Thus, we concluded that, under the conditions of this experiment, female *C. capitata* capture is the same between dry and wet traps.

Significant, but not consistent, differences were found between the treatments (Table VI). The OBDT and the IPMT, dry were the most effective treatments in Comayagua. However, the Tephri, wet, the Tephri, dry and the IPMT, dry were the most effective treatments in Yojoa. Lack of consistency in trapping efficiency among the treatments and between localities could stem from the large differences in population densities. Thus, the all-condition effectiveness of a particular trap design is unclear. All traps baited with the FA-3 synthetic lure were 0.4 to 9 times more effective than the standard treatment (Table VI). We concluded that under moderate to low *C. capitata* population densities, the most effective traps are IPMT or Tephri with the FA-3 synthetic lure.

3.2. Selectivity of the different trapping systems

The proportion of females captured in the female-targeted treatments are summarized in Table VIII. *Ceratitis capitata* female capture ranged from 43.3 % to 93.3%. However, these differences were never significant. We concluded that all female-targeted trapping systems used in this study captured the same proportion of females and thus are equally selective.

TABLE IV. MEAN ±SD FEMALE *C. capitata* CAPTURE PER TREATMENT AND BOTH SEXES MEAN ±SD CAPTURE IN JACKSON TRAP AT LAS MERCEDES, COMAYAGUA AND PEÑA BLANCA, YOJOA IN 1996

Comayagua				Yojoa			
Treatment	Daily capture [1]		Relative [2]	Treatment	Daily capture [1]		Relative [2]
IPMT, FA-3	0.354 ±0.42	a	9.8	OBDT, FA-3	0.268 ±0.53	a	15.8
OBDT, FA-3	0.282 ±0.46	a,b	7.8	IPMT, FA-3	0.229 ±0.47	a,b	13.5
IPMT, FA-2	0.204 ±0.36	b,c	5.6	IPMT, FA-2	0.075 ±0.15	b,c	4.4
OBDT, FA-2	0.139 ±0.30	c,d	3.9	OBDT, FA-2	0.057 ±0.16	c	3.4
Frutect	0.071 ±0.16	d,e	2	Frutect	0.036 ±0.14	c	2.1
IPMT, NU+B	0.036 ±0.11	e	1	IPMT, NU+B	0.017 ±0.08	c	1
F= 14.31 df= 5, 479 P < 0.0001				F= 12.07 df= 5, 475 P < 0.0001			
JT, TML	0.246 ±0.32	n/a	n/a		0.229 ±0.37	n/a	n/a

[1] Treatments followed by the same letter are not statistically different (ANOVA, Duncan's multiple range test on transformed $\log_{10}$ (x + 1) data, α= 0.05, df = 3, 470 and 466 for Comayagua and Yojoa respectively).
[2] Relative to IPMT, NU+B which is the standard female-selective trapping system.

TABLE V. MEAN ±SD DAILY *C. capitata* FEMALE CAPTURE COMPARISONS BETWEEN TRAPS WITH FA-2 AND FA-3 SYNTHETIC ATTRACTANTS AT LAS MERCEDES, COMAYAGUA AND PEÑA BLANCA, YOJOA IN 1996

Contrast	Mean ±SD			
	Comayagua	Relative	Yojoa	Relative
IPMT, FA-3 & OBDT, FA-3	0.318 ±0.44	1.9	0.249 ±0.50	37.0
vs.	vs.		vs.	
IPMT, FA-2 & OBDT, FA-2	0.171 ±0.33	1.0	0.066 ±0.15	1.0
	I = 0.204 S = 0.156 df = 5, 473		I = 0.218 S = 0.134 df = 5, 473	

[1] Sheffe's S mean separation procedure on transformed $\log_{10}$ [x + 1] data. Linear contrast of the sum of the selected treatment means; F (0.05; 5, 473)[4].

TABLE VI. AVERAGE ±SD DAILY CAPTURE OF *C. capitata* FEMALES PER TREATMENT AND TOTAL (BOTH SEXES) *C. capitata* CAPTURE IN JT AT LAS MERCEDES, COMAYAGUA AND LA CEIBITA, YOJOA IN 1997

Comayagua				Yojoa			
Treatment	Daily capture [1]		Relative [2]	Treatment	Daily capture [1]		Relative [2]
OBDT, FA-3, dry	216 ±117	a	90	Tephri, FA-3, wet	0.70 ±1.0	a	7
IPMT, FA-3, dry	180 ±190	a,b	80	Tephri, FA-3, dry	0.57 ±1.1	a,b	5
IPMT, FA-3, wet	160 ±195	b	70	IPMT, FA-3, dry	0.57 ±1.0	a,b	5
Tephri, FA-3, wet	70 ±53	c	20	OBDT, FA-3, dry	0.40 ±0.8	b	0.4
Tephri, FA-3, dry	67 ±61	c	20	IPMT, FA-3, wet	0.11 ±0.4	c	1
IPMT, NU+B	21 ±24	d	0	IPMT, NU+B	0.00 ±0.0	c	0
F= 81.88 df= 5, 479 P < 0.0001				F= 10.22 df= 5, 479 P < 0.0001			
JT, TML	113.5 ±93	n/a	n/a	JT, TML	0.30 ±0.8	n/a	n/a

[1] Treatments followed by the same letter are not statistically different (ANOVA, Duncan's multiple range test on transformed data $\log_{10}$ [x + 0.1] and sqrt (x), α= 0.05, df = 5, 479 for Comayagua and Yojoa respectively).
[2] Relative to IPMT, NU+B which is the standard female-selective trapping system.

TABLE VII. MEAN ±SD DAILY *C. capitata* FEMALE CAPTURE COMPARISONS BETWEEN WET AND DRY TRAPS WITH THE SAME ATTRACTANT AT LAS MERCEDES, COMAYAGUA AND LA CEIBITA, YOJOA IN 1997

Contrast	Mean ±SD	
	Comayagua	Yojoa
IPMT, wet + Tephri, wet vs. IPMT, dry + Tephri, dry	76.34 ±81.93 vs. 82.02 ±83.00	00.27 ±0.48 vs. 00.38 ±0.69
	NS	NS

[1] Sheffe's S mean separation procedure on transformed data $\log_{10}$ [x + 0.1] and sqrt(x) for Comayagua & Yojoa respectively. NS, No significant differences where observed. Linear contrast of the sum of the selected treatment means; F (0.05; 6, 473) [4].

TABLE VIII. PERCENTAGE ±SD AND RELATION-FEMALE: MALE OF *C. capitata* CAPTURE PER TREATMENT AT COMAYAGUA AND YOJOA FROM 1994 - 1997

Comayagua			Yojoa		
Treatment	% ±SD	Fem:Mal	Treatment	% ±SD	Fem:Mal
			1994		
CBDT, FA-2	53.2 ±13.0	1.1 : 1	CBDT, FA-2	86.0 ±21.9	7.00 : 1
			1995		
CBDT, FA-2	77.8 ±38.5	3.5 : 1	CBDT, FA-2	93.3 ±14.9	14.0 : 1
IPMT, NU+B	74.6 ±09.5	2.9 : 1	IPMT, NU+B	78.0 ±25.3	4.0 : 1
IPMT, FA-2	71.4 ±06.5	2.5 : 1	IPMT, FA-2	74.2 ±18.7	2.8 : 1
OBDT, FA-2	69.1 ±07.2	2.2 : 1	OBDT, FA-2	67.4 ±10.7	2.4 : 1
F = 0.18 df = 3, 17 P = 0.905	NS		F = 29.54 df = 3, 19 P = 0.129	NS	
			1996		
IPMT, FA-2	81.1 ±16.2	4.3 : 1	OBDT, FA-2	64.7 ±25.6	14.0 : 1
OBDT, FA-3	75.4 ±10.0	3.0 : 1	OBDT, FA-3	61.6 ±15.6	4.0 : 1
IPMT, FA-3	73.4 ±03.3	2.8 : 1	IPMT, FA-2	83.3 ±23.6	4.0 : 1
Frutect	73.3 ±18.1	2.7 : 1	IPMT, FA-3	78.8 ±08.8	2.8 : 1
OBDT, FA-2	59.4 ±16.5	1.5 : 1	IPMT, NU+B	82.0 ±24.9	3.5 : 1
IPMT, NU+B	43.3 ±43.5	0.8 : 1	Frutect	60.8 ±42.9	2.4 : 1
F = 1.84 df = 5, 29 P = 0.150	NS		F = 0.88 df = 5, 29 P = 0.514	NS	
			1997		
IPMT, wet	86.0 ±4.1	6.1 : 1	IPMT, wet	87.5 ±25.0	7.0 : 1
OBDT, dry	85.6 ±2.6	5.9 : 1	Tephri, dry	83.0 ±12.8	4.9 : 1
IPMT, dry	85.2 ±2.5	5.8 : 1	IPMT, dry	82.6 ±17.7	4.7 : 1
Tephri, dry	82.8 ±2.7	5.0 : 1	OBDT, dry	78.6 ±18..0	3.7 : 1
Tephri, wet	83.2 ±1.9	4.8 : 1	Tephri, wet	74.4 ±31.3	2.9 : 1
IPMT, NU+B	82.4 ±1.5	4.7 : 1	IPMT, NU+B	-----	-------
F= 2.53 df= 5, 29 P = 0.062	NS		F= 0.25 df= 4, 23 P = 0.903	NS	

ACKNOWLEDGEMENTS

We would like to thank IAEA and FHIA for their support and interest. We would also like to acknowledge the help of Javier, Arnold, and Wilfredo.

REFERENCES

[1] HEATH, R. R., et al., Development of a "dry" plastic insect trap for monitoring and suppressing populations of the Mediterranean and Mexican fruit flies (Diptera: Tephritidae), J. Econ. Entomol. **88** (1995) 1307 - 1315.

[2] HEATH, R. R., et al., Systems to monitor and suppress Mediterranean fruit fly (Diptera: Tephritidae) populations, Fla. Entomol. **79** (1996) 144-153.

[3] MINITAB, INC., Release 9 handbook, Minitab Inc., State College, PA (1993).

[4] OTT, L., An introduction to statistical methods and data analysis, PWS-Kent Publishing Co. (1988) 835 pp.

[5] HEATH, R. R., et al., Adding methyl-substituted ammonia derivatives to a food-based synthetic attractant on capture of Mediterranean and Mexican fruit flies (Diptera: Tephritidae), J. Econ. Entomol. **90** (1997) 1584-1589.

VÁSQUEZ, L. A., J. DÍAZ. Selección de Sistemas de Trampeo para Hembras Adultas de la Mosca del Mediterráneo *Ceratitis capitata* (Wiedemann), MIP, CATIE, 1998, In press.

EVALUATION OF THE EFFICIENCY OF VARIOUS MEDFLY FEMALE TRAPPING COMBINATIONS IN COSTA RICA IN SUPPORT OF THE STERILE INSECT TECHNIQUE

H. CAMACHO
Laboratorio de investigacion en mosca del Mediterraneo,
Escuela de biologia,
Universidad de Costa Rica,
San José, Costa Rica

Abstract

This report contains information from a four-year research programme co-ordinated by the International Atomic Energy Agency. The objective of the programme was to develop a trapping system for females of the Mediterranean fruit fly (medfly), *Ceratitis capitata* (Diptera: Tephritidae), for practical use in Sterile Insect Technique (SIT) programs and to design and evaluate a trap to obtain eggs from wild female medflies in order to estimate sterility induction in the field population. The study was carried out at two different Agricultural Research Stations of the University of Costa Rica, the Fabio Baudrit Agricultural Research Station (FBS) and Laguna de Fraijanes Agricultural Research Station (LFS), and in a privately-owned coffee and orange plantation in Grecia canton (Coope-Victoria Farm). Female medfly attractants tested were three food based "female"attractants (FA-3), namely ammonium acetate (AA), 1,4 diaminobutane (putrescine) and trimethylamine, all formulated to last at least one month. These attractants were evaluated either in combinations of two (AA + putrescine, termed FA-2) or all three (termed FA-3). The attractants were tested in various traps including the plastic International Pheromone's McPhail traps (IPMT) and Tephri traps, a Spanish trap similar to the IPMT. Traps were used either as a dry trap (provided with DDVP) or a wet trap (provided with water and 0.01% surfactant). Jackson traps with Trimedlure (JT,TML), a routinely used male medfly trapping system, was also used. Trapping experiments conducted in the citrus plantation of the FBS resulted in the following fly/trap/day indices (F/T/D): 7.18 with JT,TML; 4.62 with open bottom dry traps (OBDT) baited with FA-3; 4.18 with OBDT (PVC) baited with FA-3; 7.73 with IPMT baited with FA-3, wet; 8.245 with IPMT baited with FA-3, dry; 5.27 with IPMT baited with NuLure; 4.79 with Tephri baited with FA-3, wet; and 5.42 with Tephri, FA-3, dry. The F/T/D indices at the Coope-Victoria Farm, in coffee, were: 14.35 with JT,TML; 8.65 with OBDT, FA-3; 8.15 with OBDT (PVC), FA-3; 10.52 with IPMT, FA-3, wet; 14.95 with IPMT, FA-3, dry; 9.28 with IPMT, NU+B; 13.99 with Tephri,FA-3, wet; and 14.24 with Tephri, FA-3, dry traps. The final results of these experiments showed that the types of traps and female attractants developed and used in these experiences are good tools to capture female medflies and to evaluate changes and dynamics in the wild female medfly populations when releasing males only strains in SIT programmes. These studies showed that dry IPMTs and Tephri traps, with the FA-3 attractants and DDVP, were the most efficient and practical for capturing wild females in sterile males release programmes.

1. INTRODUCTION

Costa Rica, a tropical country in Central America, has special interest in its fruit production program. Oranges, mangoes and papayas are important fruits to the international market and for internal consumption.

However, fruit flies are serious pests that affect its production. The main fruit flies (Diptera:Tephritidae) in Costa Rica are the medfly *Ceratitis capitata*, the "mango fly" or West Indian Fly *Anastrepha obliqua*, and the papaya fly *Toxotrypana curvicauda*. These flies oviposit in fruit and produce important economic losses.

The University of Costa Rica, with special support from the International Atomic Energy Agency (IAEA), is developing a successful Integrated Fruit Fly Management Project for the control of the medfly and "mango fly".

One purpose of this project was to mass rear and release sterile flies, and, additionally, to rear larval and pupal parasitoids. Its main accomplishments have been to reduce fruit losses to under 1%, to increase the awareness of the growers about the application of these control strategies, and to gain their financial support.

The release of males of a genetic sexing strain (wp+) began in the Sterile Insect Technique (SIT) context, to obviate the consequences of the female's release. To evaluate this program in the field, the ability to capture wild females is of great importance. The focus of the current study was to evaluate the efficiency of the different trap types baited with female attractants in relation with the traditional Jackson traps baited with the male-selective attractant Trimedlure (TML).

2. MATERIALS AND METHODS

2.1. Study sites

The study was carried out at two different Agricultural Research Stations of the University of Costa Rica: Fabio Baudrit Agricultural Research Station (FBS) and Laguna de Fraijanes Agricultural Research Station (LFS), and in a privately-owned coffee and orange plantation in Grecia (Coope-Victoria Farm).

The first site was in San José District, Alajuela Canton (10° 01' N lat; 84° 16' W long; altitude 840m) in a Humid Tropical Forest Transition to Pre-mountain Life Zone as defined in Life Zones World Classification (Holdrige, L., 1969).

There are three citrus orchards in FBS and trap evaluation was carried out in the largest one.

The precipitation is generally very low during November, December, January and February. In recent years, May, June, August and September have been the most rainy months at the FBS site.

The relative humidity has been about 70% from December to April during the last three years at this station, but it was slightly higher in the study area because of artificial irrigation.

The average monthly temperature was essentially constant (22°C) with only small variations from February to April. There was, however, great variation in the amount of sunshine, with 10 hrs average from January to March and a strong decrease from May to September.

The Laguna de Fraijanes Station is in Sabana Grande District, Poas Canton in Alajuela Province (10° 09' N lat; 84° 12' W long; altitude 1850 m). At the station, there is a peach (*Prunus persica*) orchard which is usually affected by the medfly.

The precipitation varied from minimum values of less than 100 mm/month, in February, to maximum 620 mm in September. There were rainy days during all months, but November to February were the driest months in both years. The relative humidity was higher and more constant than at FBS, with an average of 80%.

The temperature is the great meteorological difference between FBS and LFS. At the LFS site, the average monthly temperature was approximately 16 °C during 1995-97. February was the coldest month in both years with 15°C.

The coffee and citrus plantation (Coope-Victoria Farm) is located in Grecia Canton (Alajuela Province). The weather conditions in this site are very similar to those at the FBS site. The plantation is 20 km from FBS and in the same life zone.

2.2. Evaluation periods

Experiments were conducted from January 1995 to February 1998 and there were 4 phases. The first was from January-February 95, the second from November-December 96 and February-March 96, the third from January-February 97, and the fourth in December 97 and January-February 1998.

During these periods, the peach crop finishes in LFS, the sweet oranges and mandarins ripen in FBS and coffee harvest begins in Coope-Victoria Farm. It is a time when there are increases in density in the medfly population.

2.3. Traps

Traps descriptions are given in detail in Annex 1. The cooperators choice trap consisted of a modification of the OBDT using PVC pipe.

2.4. Data

The number of flies captured is expressed as total numbers of flies, total numbers by sex, as flies/trap/day (F/T/D), also by totals and by sex, and by percentages.

3. RESULTS

3.1. Phase I - January -February 1995

During this evaluation period, 1134 medflies were captured: 63.75% were caught in Jackson traps with Trimedlure (JT, TML) and 36.24% in closed bottom dry traps with FA-2 attractants (ammonium acetate + putrescine) (CBDT, FA-2). The traps captured 1113 flies (98.14%) at FBS but only 21 flies (1.85%) at LFS.

There were 723 flies (64.95%) captured in JT, TML in FBS: 715 males (98.89%) and 8 females (1.10%). The CBDT, FA-2 captured 411 flies (36.92%): 329 females (80.04%) and 89 males (21.65%).

Most of the flies (72.13%) were captured in February and fewer (27.86%) in January. The increase in the number of flies caught was similar in both CBDT, FA-2 and JT, TML. It increased from the first to the last evaluation week, but was higher during the rainy days.

The fruit infestation results showed that mandarin was more affected (24-77.5%) than sweet oranges (4.6- 41.36%). The peach infestation could not be evaluated because, during the windy days at LFS, the trees lost all the remaining fruits.

The results from this phase showed clearly that the CBDTs with female attractants are effective in capturing wild medfly females. The JTs traps captured more flies than the dry traps but these were mainly males. However, in the dry traps using female attractant, there also were males (21.65%).

The number of flies captured by the dry traps was not exact. Sometimes, on windy days, many flies were blown away and lost. For this reason it might be necessary to change the bottom of the trap to a plastic container where the captured flies are retained.

3.2. Phase II - 1996

During the second phase, field trials were conducted in the citrus plantation of the FBS during February and March, 1996, and in a citrus and coffee plantation (Coope-Victoria Farm) in Grecia, during November and December, 1996.

Jackson Traps were more attractive for males than the other traps. The plastic Mc Phail Traps (IPMTs) were the most effective for the capture of females.

The total number of flies captured was 2587 at FBS - 714 in JT, TML (all males); 109 in CBDT, FA-2 (19.4% males and 80.5% females); 699 flies in Open Botton Dry Trap with FA-2 attractants (8.72% males and 91.27% females)(OBDT, FA-2), and 984 in IPMT with NuLure + borax (NU+B) (7.52% males and 92.47% females)(Table I).

The total number of flies captured in Coope-Victoria Farm, in coffee, was 278: 10 medflies, 221 *Anastrepha striata*, 42 *A. obliqua* and 1 *A. serpentina*. 87% were captured in IPMT, NU+B 6% in OBDT, FA-2, 5% in CBDT, FA-2, and 1% in JT, TML.

In this phase, the OBDTs and the IPMTs were found to be efficient for capturing female medflies and showed promise for monitoring female medflies in conjunction with a SIT release programme using males only.

TABLE I. NUMBER AND PERCENTAGE OF MEDFLIES CAPTURED IN DIFFERENT BLOCKS AND TRAPS WITH FEMALE ATTRACTANTS AT FABIO BAUDRIT STATION, COSTA RICA, FEBRUARY - MARCH 1996.

		Block						
Trap		**A**	**B**	**C**	**D**	**E**	**TOTAL**	**%**
JT, TML	Total	168	118	255	73	100	714	100
	M/F	168/0	118/0	255/0	73/0	100/0	714/0	100/0
CBDT, FA-2	Total	26	31	59	15	59	190	100
	M/F	5/21	1/30	17/42	2/13	12/47	37/153	19.4/80.5
OBDT, FA-2	Total	104	90	277	104	124	699	100
	M/F	14/90	5/85	22/255	6/98	14/110	61/638	8.72/91.27
IPMT, NU+B	Total	182	157	363	150	132	984	100
	M/F	24/158	13/144	16/347	11/139	10/122	74/910	7.52/92.47
TOTAL		**480**	**396**	**954**	**342**	**415**	**2587**	

The climatic data showed low variability in the relative humidity, and the average, maximum and minimum temperatures were 20, 15 and 32 °C, respectively at the FBS. The precipitation and RH were higher and constant at the Coope-Victoria Farm. AT FBS, it rained only three times in the evaluation period, and at Coope-Victoria, the rain and the temperature decreased during the evaluation period. There were ripening oranges and mandarins during the first six weeks of the period at FBS, and oranges and coffee berries at the Coope-Victoria Farm.

3.3. Phase III - 1997

During this phase, the evaluations were conducted in the same citrus plantation of the FBS from January to May 1997, and in a citrus and coffee plantation at Coope-Victoria Farm during January and February 1997.

The weather showed a low variability in the RH, the average, maximum and minimum temperatures at FBS. Precipitation and RH were higher and constant at Coope-Victoria Farm.

There were ripening oranges and mandarins during the first six weeks of the period in the FBS and oranges and coffee berries were present throughout the experimental period at the Coope-Victoria Farm.

JT, TML traps were found to be more attractive for males than the other traps. The IPMTs with FA-3 attractants (ammonium acetate + putrescine + trimethylamine) were more effective in capturing females than the others traps with FA-2 or FA-3 attractants. The second most effective trap for capturing females was the OBDT with FA-3 attractants.

The total number of medflies captured at FBS (in citrus) was 8732: 1840 (21.07% in JT, TML; 670 in OBDT, FA-2 (7.67%); 2240 in OBDT, FA-3 (25.65%); 859 flies (9.84%) in IPMT, FA-2; 2864 in IPMT, FA-3 (33.88%); and 165 (1.89%) flies in Tephri traps (Table II).

TABLE II. NUMBER OF MEDFLIES AND F/T/D CAPTURED AT FBS, JANUARY 9 - FEBRUARY 27, 1997 - 49 DAYS

TRAP	SEX	TOTAL	F/T/D, by sex	Total/trap	F/T/D
JT, TML	F	11	0.045		
	M	1829	7.465	1840	7.510
OBDT, FA-2	F	619	2.527		
	M	51	0.208	670	2.735
OBDT , FA-3	F	2026	8.269		
	M	214	0.873	2240	9.143
IPMT, FA-2	F	779	3.180		
	M	80	0.327	859	3.506
IPMT, FA-3	F	2717	11.090		
	M	241	0.984	2958	12.073
Tephri, FA-2	F	139	0.567		
	M	26	0.106	165	0.673
Total	F	6291			
Total	M	2441			
TOTAL MEDFLIES		8732		TOTAL F/T/D	35.64

There were 62 other tephritid flies were captured during this trial - 53 *A. striata* (33 females and 20 males); 8 *A. obliqua* (6 females and 2 males); and 1 unidentified *Anastrepha* sp. Of these 54.8% were found in the IPMT, FA-2 trap, 27.4% in IPMT, FA-3, 9.7% in Tephri, 6.5% in OBDT, FA-3 and 1.6% in OBDT, FA-2. None were found in the JT, TML.

The total number of medflies captured in Coope-Victoria Farm (in coffee) was 5237: 2214 (42.28%) in JT, TML; 300 in OBDT, FA-2 (5.73%); and 2723 (51.99%) in OBDT, FA-3 (Table III).

TABLE III. NUMBER OF MEDFLIES AND F/T/D CAPTURED AT COOPE - VICTORIA FARM - JANUARY 13 - FEBRUARY 27, 1997 - 45 DAYS

TRAP	SEX	TOTAL	F/T/D, by sex	Total/trap	F/T/D
JT, TML	F	8	0.036		
	M	2206	9.804	2214	9.840
OBDT, FA-2	F	263	1.169		
	M	37	0.164	300	1.333
OBDT , FA-3	F	2291	10.182		
	M	432	1.920	2723	12.102
IPMT, FA-2	F	0	0		
	M	0	0	0	0
IPMT, FA-3	F	0	0		
	M	0	0	0	0
Tephri, FA-2	F	0	0		
	M	0	0	0	0
Total	F	2562			
Total	M	2675			
TOTAL MEDFLIES		5237			
				TOTAL F/T/D	23.275

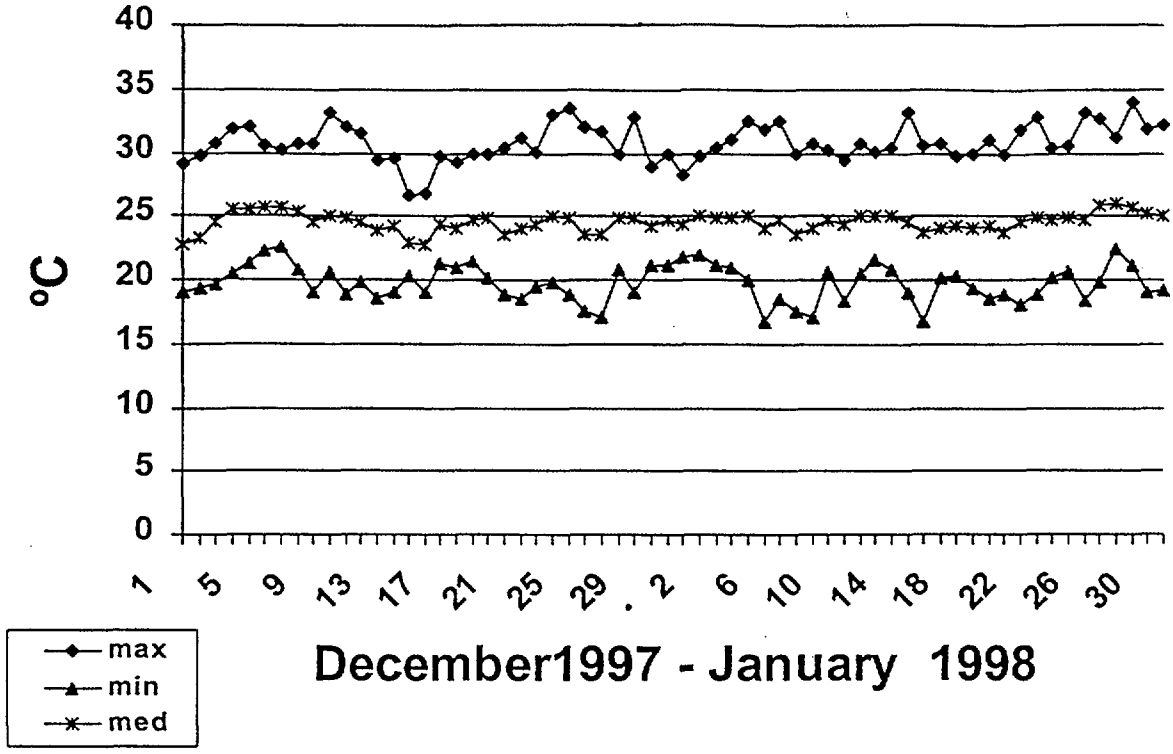
There were 6 other fruit flies captured at Coope-Victoria Farm during this trial - 1 female *A. striata* in OBDT, FA-2; 4 female *A. striata* in OBDT, FA-3; and 1 male *A. striata* in OBDT, FA-3.

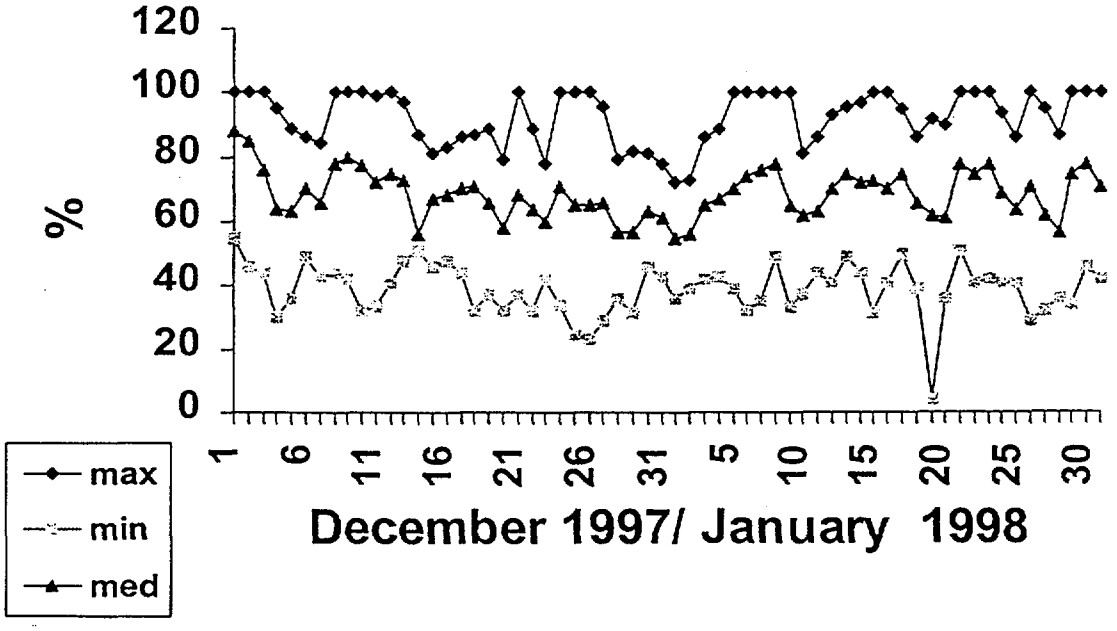
IPMTs and CBDTs were shown to be efficient in the capture of female medflies. They seem to be promising for monitoring female medflies in conjunction with male only SIT programmes.

3.4. Phase IV - 1998

During Phase IV, trapping experiments were conducted in the citrus plantation of the FBS from December 1997 to January 1998, and in a citrus and coffee plantation (Coope-Victoria Farm) during the same time period.

The total number of medflies captured at FBS was 12,327: 1868 flies (14.17%) in JT, TML; 1200 flies in OBDT, FA-3 (9.10%); 1086 flies in OBDT (PVC), FA-3 (8.24%); 2011 flies (15.26%) in IPMT, FA-3,wet; 2142 flies in IPMT, FA-3,dry with DDVP (16.12%); 1404 flies in Tephri, FA-3,dry with DDPV (10.65%); 1371 flies in IPMT, NU+B; and 1245 flies in Tephri, FA-3, wet (Table VI).





At FBS, the JT, TML traps captured more males than the other traps (1667 males, F/T/D Index 7.18). The IPMT, FA-3, dry with DDVP combinations were the most effective in capturing females at FBS (Females/T/D - 5.72). The second most effective traps for capturing females were the IPMT, FA-3, wet traps (Females/T/D - 5.65) (Table IV).

There were 849 other *Anastrepha* flies (mostly *A. avispa*) captured during this trial. Of these 86.8% were found in IPMT, NU+B; 6.6% in IPMT, FA-2, wet; 2.1% each in Tephri, dry and IPMT, FA-3 wet; and 1.9% in Tephri, wet.

The total number of medflies captured at the Coope-Victoria Farm, in coffee, was 24,475. The most effective trap for females was the IPMT, FA-3, dry (Females/T/D - 10.031), followed by Tephri, FA-3, dry (Females/T/D - 9.535), Tephri, FA-3, wet (Females/T/D - 9.073), IPMT, FA-3, wet (7.600), IPMT, NU+B (6.508), OBDT, FA-3 (6.215), and OBDT, PVC, FA-3 (5.950) (Table V).

There were 1100 other *Anastrepha* flies (mostly *A. avispa*) captured. Of these 80.6% were found in IPMT, NU+B; 10.5% in IPMT, FA-3, wet; 3.6% in IPMT, FA-3, dry; 2.3% in Tephri, wet; and 1.4% in Tephri, dry.

The total numbers, as well as the F/T/D Index, are shown in Tables. The number of flies increased in this site because the El Niño phenomenon favors the increase in medfly populations.

TABLE IV. NUMBER OF MEDFLIES AND F/T/D INDEX CAPTURED IN EACH TYPE OF TRAP AT FBS DURING DECEMBER 1997 - JANUARY 1998

TRAP	SEX	TOTAL	F/T/D	Total per trap	FPD Index
JT, TML	F	201	0.77		
	M	1667	6.41	1868	7.18
OBDT, FA-3	F	886	3.41		
	M	314	1.21	1200	4.62
OBDT (PVC), FA-3	F	765	2.94		
	M	321	1.23	1086	4.18
IPMT, FA-3, wet	F	1469	5.65		
	M	542	2.08	2011	7.73
IPMT, FA-3, dry	F	1486	5.72		
	M	656	2.52	2142	8.24
IPMT, NU+B	F	1013	3.90		
	M	358	1.38	1371	5.27
Tephri, FA-3, wet	F	932	3.58		
	M	313	1.20	1245	4.79
Tephri, FA-3, dry	F	995	3.83		
	M	409	1.57	1404	5.40
TOTAL	F	7747			
	M	4580		TOTAL F/T/D	47.41

TABLE V. NUMBER OF MEDFLIES AND F/T/D INDEX CAPTURED IN EACH TYPE OF TRAP ON COOPE-VICTORIA FARM, GRECIA CANTON, COSTA RICA DURING DECEMBER 1997 - JANUARY 1998

TRAP	SEX	TOTAL	F/T/D	Total/trap	FPDIndex
JT, TML	F	120	0.462		
	M	3612	13.892	3732	14.354
OBDT, FA-3	F	1616	6.215		
	M	634	2.438	2250	8.654
OBDT (PVC), FA-3	F	1547	5.950		
	M	571	2.196	2118	8.146
IPMT, FA-3, wet	F	1976	7.600		
	M	760	2.923	2736	10.523
IPMT, FA-3, dry	F	2608	10.031		
	M	1278	4.915	3886	14.946
IPMT, NU+B	F	1692	6.508		
	M	721	2.773	2413	9.281
Tephri, FA-3, wet	F	2359	9.073		
	M	1278	4.915	3637	13.988
Tephri, FA-3, dry	F	2479	9.535		
	M	1224	4.708	3703	14.242
TOTAL	F	14,397			
TOTAL	M	10,078		TOTAL	94.134

4. CONCLUSIONS

The final results of these experiments showed that the types of traps and female attractants developed and used in these experiences are good tools to capture female medflies and to evaluate changes and dynamics in the wild female medfly populations when releasing males only strains in SIT programmes.

These studies show that dry IPMTs and Tephri traps, with the FA-3 attractants and DDVP are the most efficient and practical to capture wild females in sterile males release programmes.

DEVELOPMENT OF ATTRACTANT SYSTEMS FOR TRAPPING FEMALE *Ceratitis capitata* (WIED.) (DIPTERA: TEPHRITIDAE) IN THE SOCONUSCO REGION, CHIAPAS, MEXICO

P. MONTOYA, H. MIRANDA, J. PAXTIAN, H. CELEDONIO, D. OROZCO
Programa Moscamed,
Tapachula, Chiapas, Mexico

Abstract

With the aim of developing a system of attractants and trapping to optimize the capture of female Mediterranean fruit flies, *Ceratitis capitata* (Wied.) as well as other fruit flies, six experiments were carried out during the period 1994 -1997, in a sterile-insect release zone in the Soconusco region of Chiapas, Mexico. Relating to the system of attractants, the evaluation focused on the comparison of food attractants (i.e. ammonium acetate, putrescine and trimethylamine) with standard attractants, such as Trimedlure and liquid hydrolyzed protein. For the trapping system, dry traps (Jackson trap, Open bottom dry trap, etc.) as well as wet traps (McPhail trap, Tephri trap, etc.) were tested alternately with the different kinds of attractants. The experiments were performed in agrosystems of coffee and groves of citrus and mango. Results consistently showed that a combination of ammonium acetate + putrescine + trimethylamine was the best for the capture of female *Ceratitis capitata* (Wied.) when used in traps such as the OBDT and the plastic McPhail trap (IPMT), while for *Anastrepha spp.*, the McPhail trap baited with liquid hydrolyzed protein still appears to be the best option, although the combination of ammonium acetate with putrescine was quite consistent in the trapping of *A. obliqua* and *A. ludens* in traps such as the IPMT.

1. INTRODUCTION

To adequately carry out the operative actions in fruit fly eradication programs which involve Sterile Insect Technique (SIT), it is necessary to rely on an accurate estimate of these insect populations in the field. Trapping occupies a preponderant position in the monitoring of populations, and the detection of females is of even greater relevance if one includes or is planning to use genetic-sexing strains where only males are released [1].

It is known that adult tephritids, especially females, at different stages of physiological development (feeding, mating, egg-laying, etc.), flies respond to different stimuli present in their environment [2]. When monitoring populations in the field, artificial lures are competing against these stimuli, thus attractants must be powerful enough to compete successfully and be also able to correlate to population size, particularly when populations are at low levels.

Some of the first food attractants used with fruit flies were molasses, fermented sugar and yeasts. Subsequently, the use of hydrolyzed proteins was initiated, which, although generally less effective than yeast, are easier to manage and standardize [3]. The smell of the hydrolyzed protein has been the most potent attractant for both sexes, for which reason, a combination of the food odors and another type of attractant (i.e., color, parapheromones and pheromones) can markedly increase the number of fruit flies caught in the traps [4]. At present, emphasis is on the analysis of volatile materials released from food attractants, including protein baits, for combination with visual attractants [5,6]. The volatile components of these mixtures typically contain ammonia, acetic acid [7] and various other volatile attractants [8].

Based on the above, and, on the tendencies which have marked the operative programs which apply the SIT using genetically-sexed strains for control and eradication of the medfly, the main objective of the current study was to develop a trapping system with food attractants exclusively for females, in order to optimize, in a practical way, the systems for detection of fertile females of this species of fruit fly.

2. MATERIALS AND METHODS

2.1. Traps

The different kinds of trap used in this study were:

1) Closed bottom dry trap (CBDT) - a cylindrical trap approximately 20 cm in height made with phosphorescent green acetate with three holes 2.2 cm in dia, and covered at both ends with plastic tops, similar to petri dishes, containing a lethal agent, dimethyl dichlorovinyl phosphate (DDVP)

2) Open bottom dry trap (OBDT) - a cylindrical trap 20 cm in height made with dark green acetate, three holes and a yellow sticky insert hung in the center of the trap

3) Jackson trap (JT) a cardboard triangular prism-shaped trap with faces measuring 9.5 x 12.5 cm, with a sticky white insert

4) McPhail glass trap (McPhail) - a bottle-shaped trap with an invaginated bottom and center orifice

5) McPhail plastic trap (International Pheromone's McPhail Plastic Trap [IPMT]) a two-part trap, with an invaginated yellow base inserted into an upper transparent part

6) Tephri trap - a cylindrical trap with an invaginated yellow base, and four orifices in the upper part and a translucent top

7) Frutect trap - a yellow rhomboid trap (29 x 29 cm), with a spherical red insert containing an attractant from a protein source

The number and type of traps varied in each experiment, as did the attractants used. Several of the traps, such as the IPMT and the Tepri were used as both wet and dry traps, depending on the type of attractant used and the vehicle for catching flies. For each particular trial, we will describe the manner in which each trap was used.

2.2. Attractants

The various attractants tested were: ammonium acetate (AA) which was impregnated in a white patch; putrescine (P) in a silver-covered patch; trimethylamine (TMA) on a white patch; Trimedlure (TML) medfly parapheromone in tablet-shape; NuLure (NU+B) liquid protein attractant; and Captor 300 (CP 300) liquid protein attractant made in Mexico. Triton was used as a surfactant in wet traps.

2.3. Experimental design (standard protocol)

In a design of random blocks, five rows were used (A-E) with a variable number of traps (depending on the experiment). The traps were placed, alternately, every 25 m in trees of standard size and shape; the traps were rotated weekly, and checked twice a week. The rebaiting of the traps which used AA+P+TMA (FA-3) was performed every four weeks. Traps having liquid protein were rebaited every week. For Jackson TML traps, the tablet was changed every two weeks. Sticky inserts were changed once or twice a week depending on the

captures. For collection from the moist traps, a colander, forceps and jar of 70% alcohol were used. All specimens caught were duly labeled and taken to the laboratory for correct identification.

Data from the coordinated experiments are expressed as flies/trap/day (F/T/D). Data were analyzed using a variance analysis with a 95% confidence level, using Tukey's multiple-range test. The analysis were performed using *Statgraphics 7.1* (1993) software.

2.3.1. Description of experiments with standard protocol

Year 1. In 1994, the performance of the CBDT baited with AA+P (FA-2 attractants) was compared with that of the JT baited with TML in a sterile-insect dispersion zone. In each row, the two types of trap were alternated (i.e. row A: JT-CBDT-JT-CBDT; row B: CBDT-JT-CBDT-JT; etc.) until five rows were completed, so that there were 10 traps of each type per grove. The coordinated experiment was carried out simultaneously in a coffee plantation and in a citrus grove, both located in the municipality of Cacahoatán, adjoining the experimental grounds INIFAP-SAGAR "Rosario Izapa" (altitude 435 m; average annual rainfall of 3050 mm; mean temperature 26.1° C [9].

Year 2. In the 1995 trial, the CBDT and OBDT traps (both baited with FA-2), the JT, TML, the IPMT, NU+B and the McPhail glass trap baited with Captor 300 protein were compared, using the five rows (A-E) and alternate placing of the traps. The experiment was carried out on coffee plantations in two localities situated at different altitudes: a) Santo Domingo Commune, at 820 m with an average annual rainfall of 1900 mm. The canopy of the trees was dominated by *Inga spp.* (coffee shade tree) and in the herbaceous stratum, the best-represented families were Compositae, Graminae, Leguminosae, Cruciferae and Labiatae. b) Talquián Commune, at an altitude of 1600 m with an average temperature of 16-25°C and 2500 mm of rainfall. In the selected plantation, coffee trees are mixed with other fruit trees which serve as shade (*Persea americana, Inga spp., Citrus aurantum,* etc.)

Year 3. In 1996, according to standard protocol, at each site, five rows (A-E) were used with seven traps each, with the objective being to evaluate the addition of another component, TMA, to the attractant system (FA-3 attractants). The treatments studied were the following: 1) OBDT trap baited with FA-2; 2) OBDT trap baited with FA-3; 3) IPMT baited with FA-2; 4) IPMT baited with FA-3; 5) McPhail glass trap baited with NU+B; 6) Tephri trap baited with FA-3; and 7) JT baited with TML.

The experimental sites were: a) San José Nexapa plantation, located in the municipality of Tapachula, 22.5 km along the highway to Nueva Alemania at altitude ca. 303 m and having an annual average rainfall of 3150 mm. The mean annual temperature is 26.5°C and the tree canopy is dominated by *Inga spp.* b) The "Don Mario" grove with 6 ha. of "Valenciana" variety oranges, located in the municipality of Tuxtla Chico to one side of the highway which connects the City of Tapachula with the Talismán-El Carmen border. The grove is located at an altitude of 117 m, and has an average annual rainfall of 2088 mm and mean annual temperature of 27.5°C.

Year 4. During 1997, the main objective was to compare some of the trap-attractant combinations as moist and as dry traps. The treatments tested were: 1) The IPMT as a wet trap, baited with FA-3 attractants, plus 300 ml of water and 2 drops of surfactant, 2) The IPMT as a dry trap, baited with FA-3 attractants + DDVP as a lethal agent, 3) the Tephri-trap as a dry trap, baited with FA-3 attractants + DDVP as a lethal agent, 4) the IPMT baited with NU+B; 5) the OBDT trap, baited with FA-3 attractants; and 6) the JT baited with TML.

This experiment was carried out on two coffee plantations which are described as follows: a) The Palmira plantation. Located in the municipality of Cachoatán at the 22.6 km point along the Tapachula-Unión Juárez highway, the plantation is at an altitude of 570 m and has an average annual rainfall of 3683 mm. The mean annual temperature is 25.6 °C. Arabica coffee is grown on the plantation, using for shade, cocoa, citrus and guava (*Psidium sp)* trees, as well as young trees of the *Inga* spp. b) The Monteperla plantation is located in the municipality of Unión Juárez at the 38.2 km point along the highway joining Tapachula to Unión Juárez. It is at an altitude of ca. 1106 m and has a mean annual rainfall of 2408 mm. The average annual temperature is 23.3 °C. Arabica coffee is grown on the plantation, with "chalum" (*Inga* spp.) predominating as shade trees.

2.3.2. Additional experiments

Experiment 1. In order to compare the performance of the OBDT trap baited FA-2 with respect to the JT, TML during the season when the introduction of fertile flies into Mexico is the greatest, a trial was carried out over an eight-week period in the Mexico-Guatemala border region in a sterile insect dispersion zone, where a route of 40 traps was set up along the stretch between Santo Domingo and Unión Juárez, Chiapas. The traps were placed alternately at a distance of approximately 28 m apart, in fruit trees reported as hosts to medfly, and were checked every seven days, changing the attractants every four weeks in the case of OBDT, and every two weeks in the case of the JT. The trapping route began at an altitude of 840 m and finished at 1360 m.

Experiment 2. With the aim of testing the sensitivity of different traps and attractants at differing levels of fly density, the following experiment was carried out. Over an eight-week period, four different densities of *Ceratitis capitata, Anastrepha ludens* and *A. obliqua* (100, 1000, 2500 and 5000 / hectare) were released independently in four groves of Ataulfo mango. The release densities were rotated each week so that each density was evaluated twice in each grove. Likewise, the released insects were marked with a different colorant. Eight different trap-attractant combinations were tried and are listed as follows: 1) JT, TML; 2) JT, FA-3; 3) OBDT, FA-3; 4) IPMT, FA-2; 5) IPMT, FA-3; 6) the Frutect trap with its attractant, 7) the McPhail glass trap with NU+B; 8) the Tephri trap with FA-3, plus water with 2%DDVP. These traps were placed over a hectare according to a wind-vane pattern (N, S, E, W, NE, SE, NW, and SW) and were rotated in their positions twice a week. The point where flies were released was taken as center with a surrounding radius of 50 m for each trap. Three repetitions per grove per week were made to achieve 24 repetitions in 8 weeks.

The groves where the research was carried out correspond to Tere, Jasso, Triple "A" and Andreas, and are located in a coastal zone of the municipality of Tapachula. In this zone the annual rainfall is 2016 mm, the mean annual temperature is 27.5°C and the altitude is 60 m.

3. RESULTS

3.1. Experiments using standard protocol

Year 1. In this first experiment, the CBDT showed a tendency to capture a greater number of *C. capitata* females than males (Table I), where it can be observed that the number of captured females obtained both from the coffee and orange crops are greater in this type of trap. For the genus *Anastrepha,* a similar situation can be observed, with higher F/T/D for females than for males, in both the citrus grove and the coffee plantation.

Year 2. In this experiment, the Jackson trap was the only one to capture exclusively *C. capitata* males, in comparison with the other traps which captured both females and males. (Table II). The CBDT and OBDT traps showed the best tendency to catch females in both

TABLE I. FRUIT FLY SPECIMENS CAPTURED IN JACKSON AND CBDT TRAPS IN THE SOCONUSCO REGION,CHIAPAS, MEXICO - 1994

Host	*Ceratitis capitata*				*Anastrepha distincta*				*Anastrepha ludens*			
Treatment	F	F/T/D	M	F/T/D	F	F/T/D	M	F/T/D	F	F/T/D	M	F/T/D
Orange trees												
JT, TML	66	0.047	502	0.359	0	0.000	0	0.000	0	0.000	0	0.000
CBDT, FA-2	45	0.032	7	0.005	17	0.012	2	0.001	7	0.000	4	0.003
Coffee plants												
JT, TML	20	0.014	2241	1.601	0	0.000	0	0.000	0	0.000	0	0.000
CBDT, FA-2	23	0.016	20	0.014	13	0.009	5	0.004	2	0.000	0	0.000

F/T/D = Flies/Trap/Day; M = males; F = females

localities when compared to the rest of the traps, however it can be seen that the OBDT was quite superior in this sense since it caught close to 43% of all of the female *C. capitata*. While this does not register a significant difference from the other treatments, it does give evidence of a noteworthy superiority of the OBDT trap in this respect. In catching flies of the *Anastrepha* genus, it was observed that the McPhail glass and the IPMT traps baited with hydrolyzed protein represent the best option.

Year 3. The addition of a third attractant to the OBDT and McPhail (IPMT) traps permitted the best captures of female *C. capitata* in this trial (Table III). At the San José Nexapa plantation, it was found that both traps registered the highest MTD, showing significant differences between treatments. At the "Don Mario" grove, the results were similar, the OBDT trap with the three attractants being notably the best.

For *Anastrepha ludens* and *A. obliqua*, the best catches were again made with the McPhail glass trap baited with NU+B, although on this occasion, it was followed in second place by the McPhail plastic trap (IPMT) baited with FA-2, which was the best at catching female *A. obliqua* at the "Don Mario" citrus grove.

Year 4. Again, there were no significant differences in the capture of female *C. capitata* between the various combinations of traps and attractants under study, but once more the OBDT and McPhail moist traps, baited with FA-3 stood out with most elevated FTD (Table IV). The McPhail trap in its dry version, although baited with the same attractants, captured a considerably lesser number of females , which we first attributed to the presence of the lethal agent (DDVP), which may have exerted a repellent effect during the first days of the application.

For the genus *Anastrepha (A. distincta, A. ludens* and *A. striata)*, the McPhail glass trap, baited with NU+B, once again captured the highest number of flies (Table IV).

3.2. Additional experiments

Experiment 1. The total number of catches and F/T/D of female and male *C. capitata* for both types of trap are shown in Table V, where it can be seen that for females that the OBDT proved to be 4.4 times more efficient; nevertheless no fertile specimen of the pest was detected in any of the traps being compared, which was the principal objective of this experiment.

Experiment 2. Although the results in Table VI do not show significant differences between treatments for any of the densities, female catches are consistently higher in all of the traps (except the JT) which used the three food attractants. This is seen most clearly at densities of 1000, 2500 and 5000 flies /ha. The highest sensitivity for detecting flies at low density demonstrated by the JT, TML, for capture of males, followed immediately by the OBDT, FA-3 for capture of females.

TABLE II. FRUIT FLY SPECIMENS CAPTURED IN FIVE COMBINATIONS OF TRAP AND ATTRACTANTS IN THE SOCONUSCO REGION, CHIAPAS, MEXICO - 1995

Locality	*Ceratitis capitata*							*Anastrepha distincta*				*Anastrepha ludens*			
Treatment	F	F/T/D		M	F/T/D			F	F/T/D	M	F/T/D	F	F/T/D	M	F/T/D
Talquián (coffee)															
JT, TML	0	0.000	A	750	2.679		B	0	0.000	0	0.000	0	0.000	0	0.000
CBDT, FA-2	68	0.243	A	42	0.150	A		2	0.007	0	0.000	0	0.000	0	0.000
OBDT, FA-2	127	0.454	A	46	0.164	A		1	0.004	1	0.004	0	0.000	0	0.000
McPhail, Torula yeast	53	0.189	A	43	0.154	A		27	0.096	10	0.036	6	0.021	2	0.007
IPMT, NU+B	42	0.150	A	25	0.089	A		23	0.082	26	0.093	2	0.007	0	0.000
Santo Domingo (coffee)															
JT, TML	0	0.000	A	1,064	3.800	A		0	0.000	0	0.000	0	0.000	0	0.000
CBDT, FA-2	48	0.171	A	23	0.082	A		5	0.018	1	0.004	0	0.000	0	0.000
OBDT, FA-2	102	0.364	A	24	0.086	A		3	0.011	5	0.018	0	0.000	0	0.000
McPhail, Torula yeast	38	0.136	A	26	0.093	A		878	3.136	397	1.418	22	0.079	1	0.004
IPMT, NU+B	56	0.200	A	20	0.071	A		1050	3.750	532	1.900	14	0.050	6	0.021

F/T/D = Flies/Trap/Day; M =males; F =females

TABLE III. FRUIT FLY SPECIMENS CAPTURED WITH SEVEN COMBINATIONS OF TRAPS AND ATTRACTANTS IN COFFEE PLANTS AND VALENCIA ORANGE TREES, IN THE SOCONUSCO REGION, CHIAPAS, MEXICO - 1997

Locality	*Ceratitis capitata*										*Anastrepha ludens*								*Anastrepha obliqua*							
Treatment	F	F/T/D	*			M	F/T/D	*			F	F/T/D	*		M	F/T/D	*		F	F/T/D	*		M	F/T/D	*	
S.J. NEXAPA (coffee)																										
JT, TML	1	0.004	A			135	0.482			C	0	0.000	A		0	0.000	A		0	0.000	A		0	0.000	A	
OBDT, FA-2	34	0.121	A	B		6	0.021	A			1	0.004	A	B	0	0.000	A		1	0.004	A		1	0.004	A	
OBDT, FA-3	88	0.314		B	C	16	0.057	A	B		1	0.004	A	B	0	0.000	A		0	0.000	A		0	0.000	A	
IPMT, FA-2	29	0.104	A	B		5	0.018	A			10	0.036	A	B	3	0.011	A	B	3	0.011	A		4	0.014	A	
IPMT, FA-3	70	0.250	A	B	C	9	0.032	A			1	0.004	A	B	3	0.011	A	B	3	0.011	A		1	0.004	A	
McPhail, NU+B	13	0.046	A			1	0.004	A			16	0.057		B	6	0.021	A	B	4	0.014	A		3	0.011	A	
Tephri, FA-3	40	0.143	A	B		4	0.014	A			3	0.011	A	B	1	0.004	A	B	1	0.004	A		0	0.000	A	
DON MARIO (orange)																										
JT, TML	0	0.000	A			17	0.061			C	0	0.000	A		0	0.000	A		0	0.000	A		0	0.000	A	
OBDT, FA-2	6	0.021	A	B		2	0.007		B	C	0	0.000	A		0	0.000	A		1	0.004	A		0	0.000	A	
OBDT, FA-3	9	0.032	A	B		3	0.011		B	C	0	0.000	A		0	0.000	A		0	0.000	A		0	0.000	A	
IPMT, FA-2	4	0.014	A	B		2	0.007		B	C	4	0.014		B	5	0.018		B	40	0.143		B	14	0.050	A	
IPMT, FA-3	5	0.018	A	B		3	0.011		B	C	5	0.018		B	0	0.000	A		4	0.014	A		2	0.007	A	
McPhail, NU+B	1	0.004	A			0	0.000		B		3	0.011	A	B	0	0.000	A		4	0.014	A		1	0.004	A	
Tephri, FA-3	5	0.018	A	B		0	0.000		B		0	0.000	A		0	0.000	A		3	0.011	A		2	0.007	A	

* same letters are employed when there in no significant difference using ANOVA with Tukey
F/T/D = Flies/Trap/Day; M =males; F =females

TABLE IV. TOTAL FRUIT FLIES CAPTURED/TRAP/DAY IN SIX COMBINATIONS OF TRAPS AND ATTRACTANTS IN TWO COFFEE PLANTATIONS AT TWO DIFFERENT ALTITUDES, IN THE SOCONUSCO REGION, CHIAPAS, MEXICO - 1997

Locality	*Ceratitis capitata*						*Anastrepha ludens*						*Anastrepha distincta*						*Anastrepha striata*					
Treatment	F	F/T/D	*	M	F/T/D	*	F	F/T/D	*	M	F/T/D	*	F	F/T/D	*	M	F/T/D	*	F	F/T/D	*	M	F/T/D	*
PALMIRA (coffee)																								
IPMT, FA-3, wet	44	0.571	A	52	0.675	A	0	0.000	A	0	0.000	A	1	0.013	A	0	0.000	A	0	0.000	A	0	0.000	A
IPMT, FA-3, dry	18	0.234	A	26	0.338	A	1	0.013	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A
Tephri, FA-3, dry	37	0.481	A	51	0.662	A	0	0.000	A	0	0.000	A	0	0.000	A	1	0.013	A	0	0.000	A	0	0.000	A
McPhail, NU+B	6	0.078	A	11	0.143	A	0	0.000	A	0	0.000	A	2	0.026	A	2	0.026	A	0	0.000	A	0	0.000	A
OBDT, FA-3	156	2.026	A	16	0.208	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A
JT, TML	8	0.104	A	828	10.753	B	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A
MONTE PERLA (coffee)																								
IPMT, FA-3, wet	144	1.870	A	52	0.675	A	0	0.000	A	2	0.026	A	97	1.260	A	41	0.532	A	0	0.000	A	3	0.039	A
IPMT, FA-3, dry	37	0.481	A	12	0.156	A	0	0.000	A	0	0.000	A	22	0.286	A	22	0.286	A	0	0.000	A	0	0.000	A
Tephri, FA-3, dry	84	1.091	A	23	0.299	A	0	0.000	A	0	0.000	A	67	0.870	A	12	0.156	A	0	0.000	A	0	0.000	A
McPhail, NU+B	10	0.130	A	6	0.078	A	7	0.091	A	3	0.039	A	266	3.455	B	52	0.675	A	2	0.026	A	3	0.039	A
OBDT, FA-3	169	2.195	A	33	0.429	A	0	0.000	A	0	0.000	A	26	0.338	A	7	0.091	A	0	0.000	A	0	0.000	A
JT, TML	5	0.065	A	442	5.740	B	0	0	A	0	0	A	1	0.013	A	26	0.338	A	0	0	A	0	0	A

* same letters are employed when there in no significant difference using ANOVA with Tukey; F/T/D = Flies/Trap/Day; M =males; F=females

TABLE V. TOTAL *C. capitata* CAPTURED DURING AN EIGHT WEEKS STUDY IN THE STERILE INSECTS DISPERSION ZONE IN THE SOCONUSCO REGION - CHIAPAS

Treatment	# Females	F/T/D females	% female captures	Weekly average by trap	S.E.	
JT, TML	254	0.227	18.25	1.59	0.404	A
OBDT, FA-2	1138	1.016	81.75	7.11	1.782	B

F/T/D = Flies/Trap/Day

TABLE VI. FRUIT FLY SPECIMENS CAPTURED IN EIGHT COMBINATIONS OF TRAPS AND ATTRACTANTS USING 4 LIBERATION DENSITIES (100, 1000, 2500 AND 5000 STERILE ADULTS) ON MANGO, IN THE SOCONUSCO REGION, CHIAPAS, MEXICO - 1997

	ADULTS RELEASED AT A CENTRAL POINT																							
Locality/	100						1000						2500						5000					
Treatment	M	F/T/D	*	F	F/T/D	*	M	F/T/D	*	F	F/T/D	*	M	F/T/D	*	F	F/T/D	*	M	F/T/D	*	F	F/T/D	*
C. capitata																								
JT, TML	9	0.032	A	3	0.011	A	54	0.193	B	6	0.021	A	126	0.450	B	12	0.043	A	158	0.564	B	13	0.046	A
JT, FA-3	1	0.004	A	1	0.004	A	19	0.068	A	2	0.007	A	17	0.061	A	18	0.064	A	29	0.104	A	14	0.050	A
OBDT, FA-3	3	0.011	A	6	0.021	A	15	0.054	A	12	0.043	A	29	0.104	A	15	0.054	A	14	0.050	A	31	0.111	A
IPMT, FA-2	2	0.007	A	0	0.000	A	9	0.032	A	6	0.021	A	14	0.050	A	14	0.050	A	14	0.050	A	11	0.039	A
IPMT, FA-3	1	0.004	A	1	0.004	A	6	0.021	A	18	0.064	A	14	0.050	A	12	0.043	A	19	0.068	A	26	0.093	A
McPhail, NU+B	1	0.004	A	1	0.004	A	1	0.004	A	1	0.004	A	2	0.007	A	1	0.004	A	11	0.039	A	7	0.025	A
Tephri, FA-3	0	0.000	A	1	0.004	A	3	0.011	A	13	0.046	A	11	0.039	A	18	0.064	A	30	0.107	A	27	0.096	A
Frutect	1	0.004	A	0	0.000	A	8	0.029	A	0	0.000	A	9	0.032	A	5	0.018	A	15	0.054	A	11	0.039	A
A. ludens																								
JT, TML	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A
JT,FA-3	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	2	0.007	A	2	0.007	A
OBDT, FA-3	1	0.004	A	2	0.007	A	2	0.007	A	2	0.007	A	3	0.011	A	10	0.036	A	4	0.014	A	3	0.011	A
IPMT, FA-2	14	0.050	A	2	0.007	A	27	0.096	B	9	0.032	B	28	0.100	A	27	0.096	A	50	0.179	A	33	0.118	A
IPMT, FA-3	6	0.021	A	5	0.018	A	10	0.036	A B	3	0.011	A	23	0.082	A	14	0.050	A	50	0.179	A	19	0.068	A
McPhail, NU+B	1	0.004	A	0	0.000	A	1	0.004	A	2	0.007	A	12	0.043	A	11	0.039	A	14	0.050	A	7	0.025	A
Tephri, FA-3	2	0.007	A	0	0.000	A	2	0.007	A	0	0.000	A	2	0.007	A	0	0.000	A	7	0.025	A	10	0.036	A
Frutect	1	0.004	A	2	0.007	A	10	0.036	A B	2	0.007	A	25	0.089	A	12	0.043	A	24	0.086	A	16	0.057	A
A. obliaua																								
JT, TML	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	1	0.004	A	0	0.000	A	0	0.000	A
JT, FA-3	0	0.000	A	1	0.004	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A
OBDT, FA-3	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	0	0.000	A	4	0.014	A	0	0.000	A
IPMT, FA-2	3	0.011	A	3	0.011	A	9	0.032	B	5	0.018	A B	3	0.011	A	1	0.004	A	7	0.025	A	8	0.029	A
IPMT, FA-3	1	0.004	A	3	0.011	A	3	0.011	A B	2	0.007	A B	7	0.025	A	13	0.046	A	6	0.021	A	7	0.025	A
McPhail, NU+B	1	0.004	A	0	0.000	A	1	0.004	A B	0	0.000	A	1	0.004	A	1	0.004	A	2	0.007	A	1	0.004	A
Tephri, FA-3	1	0.004	A	0	0.000	A	2	0.007	A B	2	0.007	A B	3	0.011	A	1	0.004	A	0	0.000	A	1	0.004	A
Frutect	5	0.018	A	3	0.011	A	5	0.018	A B	9	0.032	B	11	0.039	A	1	0.004	A	7	0.025	A	8	0.029	A

* same letters are employed when there in not significant difference using ANOVA with Tukey; F/T/D = fly/trap/day; M = males; F = females.

In the capture of *Anastrepha ludens* the IPMT, FA-2 consistently performed better at all density levels, while, for *A. obliqua*, similar capture data were obtained in the McPhail plastic trap and in the Frutect trap.

We consider that the low proportion of flies captured in all treatments was strongly influenced by rain, since this experiment was performed during the season of heaviest rainfall.

Finally, Figure 1 shows the capture trend for female *C. capitata* in seven trap-attractant combinations on coffee, where the performance of the OBDT, FA-3 once again stands out.

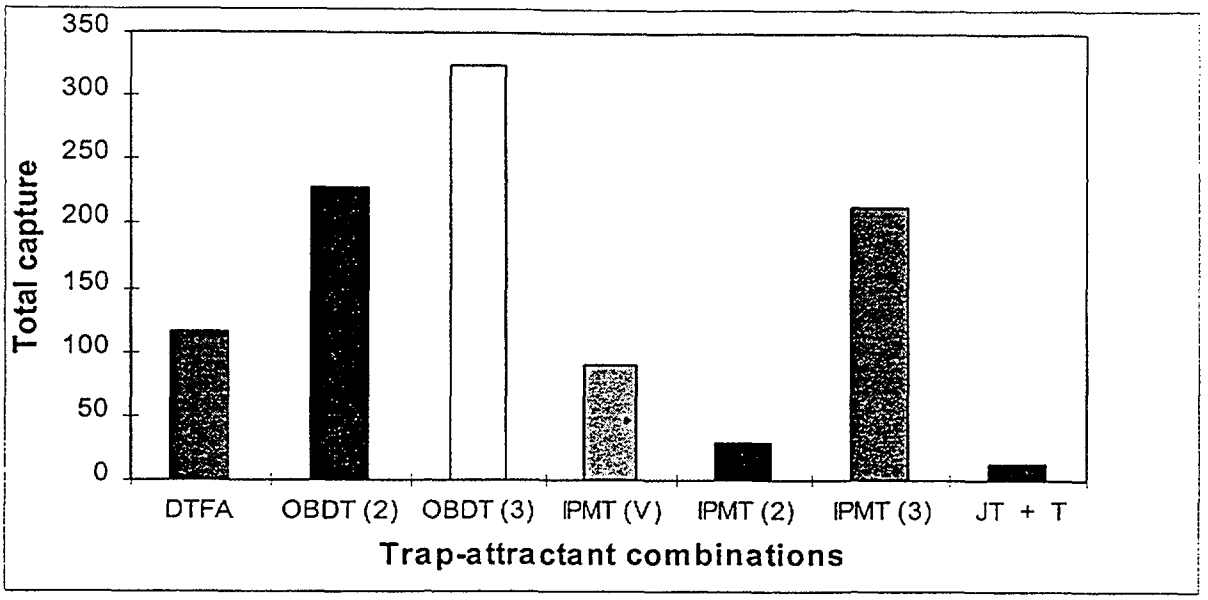


Figure 1.- Female Ceratitis capitata (Wied.) capture trend for 7 trap-attractant combinations, in two experiments on coffee plantations in the Soconusco region of Chiapas, Mexico.

4. DISCUSSION

Over the course of this research program, 13 trap-attractant combinations were evaluated for effectiveness in catching female *C. capitata*. From the results shown, the best option was consistently represented by the OBDT trap baited with FA-3. This trap combines a series of advantages with respect to the others (i.e., the IPMT and the Tephri-trap), also tested with these three attractants. The advantages worthy of mention are: a) it is cheaper, b) it is easier to manage and service, c) it is less frequently stolen and d) it is more efficient.

The OBDT trap includes a very user-friendly (it doesn't stick to skin) yellow insert, which under the highly humid conditions of the Soconusco works very well, although we realize that in semi-desert area with high levels of dust, the results may be very different [10].

The IPMT, FA-3, used as a moist trap, was second in efficiency and was quite superior to this same trap used with the same attractants as a dry trap. This, we believe, to is due to the lethal agent used in the dry trap (DDVP), which caused a repellent effect during the first days after deployment, or perhaps during the last few days its toxicity may be low enough to permit an increase in the number of flies which manage to escape. However, in the first case (IPMT trap moist version) there still remain the major inconveniences which have always been pointed out where the McPhail trap is concerned: the servicing (a supply of water has to be carried to the trap), and the collection and preservation of the specimens captured.

The three component Tephri trap gave a performance similar to that of the IPMT although it was less effective, and showed little difference between the moist and wet modalities. The rest of the treatments demonstrated little efficiency in the capture of female *C. capitata.*

The lack of significant differences among treatments in the capture of these females, may perhaps be related to the fact that the experiments were done with sterile insects, and, according to [11], feral medflies are more attracted to the combination of the three components than sterile flies. We consider that climatic factors, especially the rain, may have affected capture indexes, since several of the experiments were carried out during the rainy season.

As to the capture of flies of the genus *Anastrepha,* we found that the IPMT could be baited with liquid hydrolyzed protein (NU+B or Captor 300) as well as used with FA-2, since in experiments where these attractants were used, it captured comparatively high numbers of female *A. ludens* and *A. obliqua.* The addition of TMA seems to exert a repellent effect on individuals of this genus as opposed to what occurs with *C. capitata,* because, in all cases, fewer *Anastrepha* specimens were captured with three components than with two. Although [12] showed participation of AA in the attraction of *A. ludens,* our data from captures in both the glass McPhail trap and IPMT, baited with hydrolyzed protein, suggest that this alternative continues to be the best option for this species of fruit fly.

REFERENCES

[1] RENDÓN, P., CÁCERES,C., Fundamentos de sexado genético en la mosca del Mediterráneo *Ceratitis capitata* Wied. Memorias del "Curso Regional sobre Moscas de la Fruta y su Control en Areas Grandes con Enfasis en la Técnica del Insecto Estéril," Programa Moscamed-SAGAR, FAO-OEIA, Metapa de Domínguez, Chiapas, México. (1997)

[2] SIVINSKI, J.M., CALKINS, C., Pheromone and parapheromones in the control of tephritids, Fla. Entomol. **69** (1986) 157-168.

[3] LIEDO, J.P., Bases teóricas y conceptos sobre atrayentes, Memorias del "Curso Regional sobre Moscas de la Fruta y su Control en Areas Grandes con Enfasis en la Técnica del Insecto Estéril," Programa Moscamed-SAGAR, FAO-OEIA, Metapa de Domínguez, Chiapas, México (1997) 121-128.

[4] ECONOMOPOULOS, A.P., G.E. HANIOTAKIS, G.E., Advances in attractants and trapping technologies for tephritids, In: CALKINS, C.O., KLASSEN, W., LIEDO, P. (eds.), Fruit Flies and the Sterile Insect Technique, IV International Congress of Entomology, Peking, China (1994) 113-120.

[5] EPSKY, N.D., et al., Visual cue and chemical cue interactions in a dry trap with food-based synthetic attractant for *Ceratitis capitata* and *Anastrepha ludens* (Diptera: Tephritidae), Environ. Entomol. **24** (1995) 1387-1395.

[6] HEATH, R.R., et al., Development of a dry plastic insect trap with food-based synthetic attractant for the Mediterranean and Mexican Fruit Flies (Diptera: Tephritidae), J. Econ. Entomol. **88** (1995) 1307-1315.

[7] KEISER, Y., et al., Mediterranean fruit fly: Attraction of females to acetic acid and acetic anhydride, two chemical intermediates in the manufacture of cue-Lure, and to decaying Hawaiian tephritids, J. Econ. Entomol. **69** (1976) 517-520.

[8] BUTTERY, R.G., et al., Insect attractants: Volatiles of hydrolyzed protein insect baits, J. Agric. Food Chem. **31** (1983) 689-692.

[9] INEGI, Anuario estadístico del estado de Chiapas. Instituto Nacional de Estadística, Geografía e Informática. Aguascalientes, Ags. (1994) 1-20.

[10] BLACK, M.H., et al., Standardization of medfly trapping in The Libyan Arab Jamahiriya during 1987-1991, In: Standardization of medfly trapping for use in sterile insect technique programmes, Final Report, IAEA, Vienna Austria (1996) 29-68.

[11] HEATH, R.R., et al., Systems to monitor and suppress *Ceratitis capitata* (Diptera: Tephritidae) populations, Fla. Entomol. 79 (1996) 145-153.

[12] ROBACKER, D.C., et al., Attractiveness to Mexican fruit flies of combinations of acetic acid with ammonium/amino attractants with emphasis on effects of hunger, J. Chem. Ecol. **22** (1996) 499 - 511.

MEDFLY FEMALE ATTRACTANT TRAPPING STUDIES IN GUATEMALA

F. JERÓNIMO, P. RENDÓN, C. VILLATORO
APHIS-Methods,
Guatemala City, Guatemala

Abstract

Experiments were conducted from 1994 - 1998 to test the attractiveness of combinations of food-based chemicals for *C. capitata* (medfly) in Guatemala. Most studies were done in coffee. The 1995 studies, using the FA-2 attractants (ammonium acetate and putrescine) showed that this combination was attractive for females and had potential for use in conjunction with a SIT program. The 1996 studies at three elevations demonstrated that, in general, these attractants, when used in either the Open Bottom Dry Trap (OBDT), Closed Bottom Dry Trap(CBDT), or International Pheromone's McPhail Trap (IPMT) performed better than the Jumbo McPhail trap(JMT) baited with NuLure and borax (NU+B) for capture of feral females. At the high elevation (1400 m), the IPMT with FA-2 and OBDT with FA-2 were best; at the middle elevation (1100 m), the OBDT, IPMT, and CBDT with FA-2 were best; and at low elevations (659 m), the IPMT with FA-2, JMT with NU+B and OBDT with FA-2 were equal in performance. At the middle elevation, using sterile flies, the OBDT with FA-2 worked best. When experiments were carried out in pear, the traps using the FA-2 attractants captured more female flies than the JMT, NU+B, but not significantly more. During the 1997 trials, a third component, trimethylamine was added to the two component lure (FA-3). This attractant was tested in a number of locally produced traps using 2 l soft drink bottles with different color bottoms. The dry versions of the traps contained a yellow sticky insert. All study sites were at low elevation 600 - 650 m, in coffee, testing both sterile and feral flies. With the feral flies during the first phase of the study at finca San Carlos, there were no significant differences between treatments, at finca San Luis, the clear local trap with sticky insert and the green local trap with sticky insert were best, and at finca Valapraiso, the green local trap with yellow sticky insert and yellow local trap with sticky insert captured more flies. During the second phase of the study, only finca Valparaiso reported significant differences. Here the IPMT, FA-3 with sticky insert and the clear local trap with sticky insert worked best. For sterile flies, the Jackson trap with Trimedlure (JT, TML) and a locally made OBDT, FA-3 with yellow sticky insert were best at finca San Carlos, the JT, TML and the yellow local trap with sticky insert were best at finca San Luis and the JT, TML and the green local trap with yellow sticky inset captured most flies at finca Valparaiso. For some unexplained reason, all wet versions of the traps performed poorly. In pear, the Tephri, FA-3, wet performed best, followed by the wet, yellow local traps without and with the yellow sticky insert, respectively. Trials were also conducted to construct egging devices for sterility assessment. Females did lay eggs into various artificial substrates. However, both mated and unmated feral females laid eggs into agar balls, so, unless mating events are recorded, per cent egg hatch and number of eggs produced per female.

1. INTRODUCTION

This document summarizes work carried out as part of the five year Co-ordinated Research Programme (CRP) on trapping *Ceratitis capitata* Wied. (medfly) sponsored by the IAEA/FAO Joint division. Programme priorities were to develop female attractants for medfly and to evaluate the efficacy of female attractants under field conditions. In addition to the work described by protocol, cooperators were asked to review the following work areas: evaluation of several new trap types; evaluate performance of female attractants in areas subjected to release of sterile insects; and evaluate female attractants in combination with different trap types for the purpose of retaining female medflies for oviposition and thus assess sterility induced in the feral population.

During the first phase of the program (1994), a recently developed trap and female attractant [1], consisting of a combination of ammonium acetate (AA) and putrescine (P), the FA-2 attractants, in a Closed bottom dry trap (CBDT) were tested against the standard male attractant, Trimedlure placed in a Jackson Trap (JT). Testing was conducted at three elevations in the coffee belt of Guatemala.

The 1995/96 studies concentrated on evaluating female attractants in combination with three different trap types - the CBDT, FA-2, an Open bottom dry trap (OBDT) baited with FA-2, the International Pheromone's McPhail Trap (IPMT) with FA-2, and compared these to the JT, TML and a jumbo plastic McPhail trap (JMT) baited with NuLure and borax (NU+B). As previously, evaluations were carried out at three elevations in coffee. Additionally, a trial was conducted in pears.

Further work [1] demonstrated that the addition of trimethylamine (TMA) to the FA-2 attractants (FA-3 attractants) improved the efficacy of the new female lures and this was tested in the various traps. At the second CRP co-ordination meeting, it was discussed that trapping efficiency in various countries was related to finding a suitable trap for each unique situation and cooperators were asked to develop a local trap for use with the FA-3 attractants, and to test the lures in a Spanish modification of the IPMT, the Tephri trap. In Guatemala, we also tested a biodegradable OBDT for use with the lures.

The 1997/98 studies were again conducted at three altitudes in coffee and in a deciduous area. Additional work was performed to determine the efficacy of the FA-3 attractants in wet and dry versions of the IPMT and Tephri traps. Wet traps generally contained water and surfactant, while dry traps contained a plug of DDVP for fly retention. We also developed three local traps and tested these both as wet and dry traps using the FA-3 attractants.

Finally, we tested synthetic lures for detecting the first generation of feral insects in the field. Guatemala will soon be implementing the use of a male only strain in medfly sterile release programs.

Additional experiments were undertaken to devise artificial ovipositional substrates. These substrates were tested in the field, the laboratory and in field cages using sterile and feral flies.

2. 1994 STUDIES

2.1. 1994 materials and methods

Trap evaluation was carried out during the 24th to 47th week (the week of 12 June through 26 November). Traps were evaluated at three different elevations and at four farms (fincas): Mujulia and Culpan (high elevation, 1400 m), El Transito (middle elevation, 1050 m) and Las Delicas (low elevation, 659 m). These sites were in the coffee area of Coatepeque (Dept. of Quetzaltenango) located 240 km southwest of Guatemala city. At all sites, the host was coffee.

Two traps were compared. The CBDT trap consisted of a light green acetate sheet with a color band 12 cm wide. There were holes for insect entry. The acetate sheet was rolled so that a hollow tube was formed and petri dish halves were placed at either end. There was a wire to hang the trap in a tree. For attractants, separate patches of AA+P were attached to the inner sides of the trap. Toxicant squares were used as a killing agent. The other trap tested was the JT, TML and was handled based on a standard MOSCAMED protocol. For the CBDT, re-baiting was done every eight weeks and for the JT, TML, every four weeks.

Statistical analysis was done with analysis of variance (ANOVA) and a pairwise comparison of means (Tukey's test, 95% confidence).

2.2. 1994 results

Results from the 1994 studies are shown in Tables I - IV.

TABLE I. MEDFLY CAPTURES BY CBDT, FA-2 VS. JT, TML AT FINCA MUJULIA, COLOMBA, QUETZALTENANGO - ELEVATION 1400 M

Week of	CBDT, FA-2			JT, TML	
the year	males	females	Total	males	Total
24	104	137	241	436	436
25	68	109	177	336	336
26	14	15	29	144	144
27	32	113	145	158	158
28	29	61	90	120	120
29	48	106	154	193	193
30	70	114	184	212	212
31	151	201	352	309	309
32	175	257	432	125	125
33	108	159	267	103	103
34	119	163	282	277	277
35	65	88	153	615	615
36	77	82	159	430	430
37	49	71	120	561	561
38	9	23	32	236	236
39	7	18	25	83	83
40	16	25	41	35	35
41	23	58	81	56	56
42	15	35	50	21	21
43	15	18	33	37	37
44	40	34	74	64	64
45	15	15	30	54	54
46	7	5	12	59	59
47	9	4	13	33	33

TABLE II. MEDFLY CAPTURES BY CBDT, FA-2 VS. JT, TML AT FINCA CULPAN, COLOMBA, QUETZALTENANGO - ELEVATION 1400 M

Week of	CBDT, FA-2			JT, TML	
the year	males	females	Total	males	Total
24	6	2	8	59	59
25	0	0	0	34	34
26	3	3	6	31	31
27	1	2	3	14	14
28	0	3	3	15	15
29	1	0	1	23	23
30	1	4	5	10	10
31	2	4	6	24	24
32	4	1	5	5	5
33	6	6	12	9	9
34	4	0	4	13	13
35	1	0	1	25	25
36	0	0	0	7	7
37	0	0	0	22	22
38	3	4	7	21	21
39	0	0	0	12	12
40	2	1	3	8	8
41	6	9	15	25	25
42	14	17	31	18	18
43	14	15	29	19	19
44	2	2	4	13	13
45	3	2	5	13	13
46	0	0	0	13	13
47	2	1	3	25	25

TABLE III. MEDFLY CAPTURES BY CBDT, FA-2 VS. JT, TML AT FINCA EL TRANSITO, COLOMBA, QUETZALTENANGO - ELEVATION 1050 M

Week of the year	CBDT, FA-2 males	CBDT, FA-2 females	CBDT, FA-2 Total	JT, TML males	JT, TML Total
24	1	3	4	29	29
25	0	3	3	43	43
26	0	1	1	21	21
27	2	3	5	27	27
28	9	14	23	55	55
29	3	7	10	74	74
30	9	13	22	172	172
31	8	15	23	190	190
32	9	6	15	187	187
33	10	16	26	147	147
34	0	0	0	224	224
35	8	18	26	495	495
36	1	0	1	334	334
37	1	6	7	71	71
38	6	9	15	40	40
39	5	5	10	28	28
40	2	12	14	53	53
41	4	8	12	48	48
42	6	10	16	39	39
43	7	9	16	57	57
44	1	2	3	15	15
45	0	0	0	7	7
46	0	0	0	9	9
47	0	0	0	29	29

TABLE IV. MEDFLY CAPTURES BY CBDT, FA-2 VS. JT, TML AT FINCA LAS DELICIAS, COLOMBA, QUETZALTENANGO - ELEVATION 659 M

Week of the year	CBDT, FA-2 males	CBDT, FA-2 females	CBDT, FA-2 Total	JT, TML males	JT, TML Total
24	0	0	0	52	52
25	1	0	1	55	55
26	0	1	1	22	22
27	0	0	0	21	21
28	0	0	0	9	9
29	0	0	0	22	22
30	0	0	0	13	13
31	0	4	4	25	25
32	0	0	0	35	35
33	3	3	6	40	40
34	0	0	0	50	50
35	0	0	0	28	28
36	0	0	0	15	15
37	0	1	1	23	23
38	4	1	5	43	43
39	2	0	2	20	20
40	1	1	2	19	19
41	2	2	4	37	37
42	2	1	3	16	16
43	0	0	0	14	14
44	1	0	1	6	6
45	0	0	0	13	13
46	1	0	1	27	27
47	0	0	0	19	19

2.3. 1994 study - discussion and conclusions

Results reported here are an outcome of the evaluation of the traps provided (JT, TML and CBDT, FA-2). These traps were assessed at different elevations and different abiotic regimes and fly populations. The analysis of the results shows that, attractants and assessed traps may give a different response according to the abiotic conditions and the population level in the surrounding areas. It has been shown that, in high population conditions, the dry trap used as a monitoring device could be similar to current monitoring systems, based on the use of Jackson traps. No significant differences were observed when dry traps were located at 1400 m and with relatively large fly populations. A different result was observed at the same altitude but with a relatively lower population. In all other localities, total capture of insects was significantly lower possibly because of the population level or as an effect of environmental conditions.

It can be concluded that with the exception of the test conducted at high altitude and under a high population level (in which calibrations would have to be made, the dry trap is giving a different profile of the population and is probably not at this time the correct device for monitoring populations, at least not in the traditional sense.

3. 1995 STUDIES

3.1. 1995 materials and methods

Studies in 1995 were conducted from the week of 19 February through the week of June 18 at three elevations in southwest Guatemala near the Mexican border. Listed from high to low elevation, the fincas were: Culpan (1400 m); El Transito (1100 m) and Las Delicias (659 m). At each finca, a trapping grid of 20 traps was installed. Four lines of five traps each were necessary. The distance between the lines was 50 m and distance between traps along the lines was 40 m. Traps were rotated along the lines at each check period. Trap servicing was conducted on a weekly basis. Re-baiting of traps was conducted as follows: JT, TML, every two weeks; OBDT, FA-2, every four weeks. Weekly servicing of traps included the following: total sterile insect captures in each trap; male and female sterile insect captures in each trap; and total feral flies captured in each trap type. Twelve release points were defined in the trapping grid. Releases of sterile insects were conducted by ground on a weekly basis. Sterile insect density for this study was 3000 adult insects per hectare. The standard strain was utilized in this test (both sexes). Insects were released from paper bags as done by the local action program. An OBDT, FA-2 was tested against the JT, TML.

3.2. 1995 results, discussion, and conclusions

Results from these experiments have been presented elsewhere and are summarized here. It was evident that the JT, TML always captured a higher number of sterile flies at the three elevations when compared to the OBDT, FA-2 trap. Insect identification at the MOSCAMED headquarters in the area clearly demonstrated that the JT, TML required much more time than the dry trap (6 times more) for processing of insect recapture. A close analysis of the collected data is telling us the following: 1) at the low elevation the JT, TML captured an average of 16.6 times more males than the dry trap, while the OBDT, FA-2 captured an average of 358.35 times more females than the JT, TML;2) at the middle elevation, the JT, TML captured 29.55 times more males than the dry trap, while the OBDT, FA-2 captured 996.33 times more females than the JT, TML; and 3) at the high elevation, the JT, TML captured 9.54 times more males than the OBDT, FA-2, while the OBDT, FA-2 captured an average of 1,227 times more

females than the JT, TML. Based on the available information, it is clear that the use of the OBDT, FA-2 would favor the Sterile Insect Technique (SIT) by keeping the males in the target area and also by removing the sterile females from the target population and increasing the probability of more desirable encounters between the sterile males and the wild females.

4. 1996 STUDIES

4.1. 1996 materials and methods - coffee

During 1996, two sets of experiments were conducted. The traps used were: JT, TML; CBDT, FA-2; an Open bottom dry trap (OBDT) also baited with FA-2; IPMT with FA-2 attractants and containing a solution of colored water; and plastic Jumbo McPhail traps baited with NU+B (JMT, NU+B).

Study I evaluated the combination of attractants/trapping devices at three elevations: 1400 m (Finca Mujulia); 1100 m (Finca San Francisco); and 659 m (Finca Las Delicias). Study I was carried out at the end of coffee harvesting season (from the week of February 25 through the week of April 21). At these sites, this time of year is normally dry but some off-season rains occurred. The host availability in the area was low, but the host suitability was adequate for fruit fly population establishment at all work sites. Traps were hung 2 m above the ground. The field array was a grid in which traps were 25 m apart within lines and 50 m between lines. At Finca Mujulia and Finca Delicias, test were conducted with feral flies. At Finca San Francisco, the parallel study included weekly releases of sterile flies (both sexes) and fruit fly parasitoids. This was taken into consideration and assessed traps were also included in this block.

4.2. 1996 results - coffee

Results from the 1996 studies are shown in Tables V - XVI.

TABLE V. MULTIPLE MEAN COMPARISON, TUKEY'S STUDENTIZED RANGE (HSD) TEST OF MALE CAPTURE AT FINCA MUJULIA, 1996 -ELEVATION 1400 M

GROUPINGS*	MEAN	N	TRAP TYPE
A	36.056	9	JT, TML
A B	26.667	9	IPMT, FA-2
A B C	24.333	9	OBDT, FA-2
B C	16.667	9	CBDT, FA-2
C	11.278	9	JMT, NU + B

Alpha= 0.05, df= 40, MSE= 107.294, Critical Value of Studentized Range= 4.039, Minimum Significant Difference= 13.947; * Means with the same letter are not significantly different

TABLE VI. MULTIPLE MEAN COMPARISON, TUKEY'S STUDENTIZED RANGE (HSD) TEST OF FEMALE CAPTURE AT FINCA MUJULIA, 1996 -ELEVATION 1400 M

GROUPINGS*	MEAN	N	TRAP TYPE
A	34.722	9	IPMT, FA-2
A B	33.000	9	OBDT, FA-2
B C	23.278	9	JMT, NU + B
C	17.778	9	CBDT, FA-2
D	6.222	9	JT, TML

Alpha= 0.05, df= 40, MSE= 64.706, Critical Value of Studentized Range= 4.039, Minimum Significant Difference= 10.831; * Means with the same letter are not significantly different

TABLE VII. MULTIPLE MEAN COMPARISON, TUKEY'S STUDENTIZED RANGE (HSD) TEST OF TOTAL CAPTURE (MALES & FEMALES) AT FINCA MUJULIA, 1996 - ELEVATION 1400 M

GROUPINGS*	MEAN	N	TRAP TYPE
A	32.111	9	IPMT, FA-2
A B	29.111	9	OBDT, FA-2
A B C	25.167	9	JT, TML
B C	15.167	9	JMT, NU + B
C	13.444	9	CBDT, FA-2

Alpha= 0.05, df= 40, MSE= 127.162, Critical Value of Studentized Range= 4.0, Minimum Significant Difference= 15.183; * Means with the same letter are not significantly different

TABLE VIII. MULTIPLE MEAN COMPARISON, TUKEY'S STUDENTIZED RANGE (HSD) TEST FOR MALE CAPTURE AT FINCA SAN FRANCISCO, 1996 - ELEVATION 1100 M

GROUPINGS*	MEAN	N	TRAP TYPE
A	37.556	9	JT, TML
B	24.778	9	OBDT, FA-2
B	20.500	9	IPMT, FA-2
B	19.167	9	CBDT, FA-2
B	13.000	9	JMT, NU+B

Alpha= 0.05, df= 40, MSE= 80.469, Critical Value of Studentized Range= 4.039, Minimum Significant Difference= 12.078; * Means with the same letter are not significantly different

TABLE IX. MULTIPLE MEAN COMPARISON, TUKEY'S STUDENTIZED RANGE (HSD) TEST FOR FEMALE CAPTURE AT FINCA SAN FRANCISCO,1996 - ELEVATION 1100 M

GROUPINGS*	MEAN	N	TRAP TYPE
A	30.833	9	OBDT, FA-2
A B	30.000	9	IPMT, FA-2
A B C	23.222	9	CBDT, FA-2
B C	16.500	9	JMT, NU+B
C	14.444	9	JT, TML

Alpha= 0.05, df= 40, MSE= 111.9319, Critical Value of Studentized Range= 4.039, Minimum Significant Difference= 14.245; * Means with the same letter are not significantly different

TABLE X. MULTIPLE MEAN COMPARISON, TUKEY'S STUDENTIZED RANGE (HSD) TEST FOR TOTAL CAPTURE (MALES & FEMALES) AT FINCA SAN FRANCISCO, 1996 - ELEVATION 1100 M

GROUPINGS*	MEAN	N	TRAP TYPE
A	32.056	9	JT, TML
A	27.389	9	OBDT, FA-2
A B	24.944	9	IPMT, FA-2
A B	18.833	9	CBDT, FA-2
B	11.778	9	JMT, NU+B

Alpha= 0.05, df= 40, MSE= 125.097, Critical Value of Studentized Range= 4.039, Minimum Significant Difference= 15.059; * Means with the same letter are not significantly different

TABLE XI. MULTIPLE MEAN COMPARISON, TUKEY'S STUDENTIZED RANGE (HSD) TEST FOR MALE CAPTURE AT FINCA SAN FRANCISCO, 1996 - ELEVATION 1100 M (STERILE FLIES)

GROUPINGS*	MEAN	N	TRAP TYPE
A	41.000	9	JT, TML
B	29.444	9	OBDT, FA-2
C	20.833	9	CBDT, FA-2
C	16.667	9	IPMT, FA-2
D	7.056	9	JMT, NU+B

Alpha= 0.05, df= 40, MSE= 39.873, Critical Value of Studentized Range= 4.039, Minimum Significant Difference= 8.502; * Means with the same letter are not significantly different

TABLE XII. MULTIPLE MEAN COMPARISON, TUKEY'S STUDENTIZED RANGE TEST (HSD) OF FEMALE CAPTURE AT FINCA SAN FRANCISCO, 1996 - ELEVATION 1100 M (STERILE FLIES)

GROUPINGS*	MEAN	N	TRAP TYPE
A	38.444	9	OBDT, FA-2
B	28.167	9	CBDT, FA-2
B	26.833	9	IPMT, FA-2
C	14.611	9	JMT, NU+B
C	6.944	9	JT, TML

Alpha= 0.05, df= 40, MSE= 52.721,Critical Value of Studentized Range= 4.039, Minimum Significant Difference= 9.7763; * Means with the same letter are not significantly different

TABLE XIII. MULTIPLE MEAN COMPARISON, TUKEY'S STUDENTIZED RANGE TEST (HSD) OF TOTAL CAPTURE (MALES & FEMALES) AT FINCA SAN FRANCISCO, 1996 - ELEVATION 1100 M (STERILE FLIES)

GROUPINGS*	MEAN	N	TRAP TYPE
A	41.000	9	JT, TML
B	29.389	9	OBDT, FA-2
C	19.833	9	CBDT, FA-2
C	17.667	9	IPMT, FA-2
D	7.111	9	JMT, NU+B

Alpha= 0.05, df= 40, MSE= 42.169, Critical Value of Studentized Range= 4.039, Minimum Significant Difference= 8.743; * Means with the same letter are not significantly different

TABLE XIV. MULTIPLE MEAN COMPARISON, TUKEY'S STUDENTIZED RANGE TEST (HSD) OF MALE CAPTURE AT FINCA LAS DELICIAS, 1996 - ELEVATION 659 M

GROUPINGS*	MEAN	N	TRAP TYPE
A	40.111	9	JT, TML
B	23.667	9	IPMT, FA-2
B	22.556	9	OBDT, FA-2
B	21.333	9	JMT, NU+B
C	7.333	9	CBDT, FA-2

Alpha= 0.05, df= 40, MSE= 67.065, Critical Value of Studentized Range= 4.039, Minimum Significant Difference= 11.026; * Means with the same letter are not significantly different

TABLE XV. MULTIPLE MEAN COMPARISON, TUKEY'S STUDENTIZED RANGE TEST (HSD) OF FEMALE CAPTURE AT FINCA LAS DELICIAS, 1996 - ELEVATION 659 M

GROUPINGS*	MEAN	N	TRAP TYPE
A	33.000	9	IPMT, FA-2
A	30.556	9	JMT, NU+B
A	30.111	9	OBDT, FA-2
B	13.222	9	CBDT, FA-2
B	8.111	9	JT, TML

Alpha= 0.05, df= 40, MSE= 67.014, Critical Value of Studentized Range= 4.039, Minimum Significant Difference= 11.022; * Means with the same letter are not significantly different

TABLE XVI. MULTIPLE MEAN COMPARISON, TUKEY'S STUDENTIZED RANGE TEST (HSD) OF TOTAL CAPTURE (MALES & FEMALES) AT FINCA LAS DELICIAS, 1996 - ELEVATION 659 M

GROUPINGS*	MEAN	N	TRAP TYPE
A	37.111	9	JT, TML
A B	25.889	9	IPMT, FA-2
B	22.667	9	JMT, NU+B
B	22.444	9	OBDT, FA-2
C	6.889	9	CBDT, FA-2

Alpha= 0.05, df= 40, MSE= 84.472, Critical Value of Studentized Range= 4.039, Minimum Significant Difference= 12.375; * Means with the same letter are not significantly different

4.3. 1996 discussion and conclusions -coffee

4.3.1. High elevation - Finca Mujulia

Based on the data, it was clear that the fruit fly population was fairly high and larval fruit infestation was moderately high. From results obtained at this elevation (Tables V- VII), it can be stated that FA-2 attractants, when combined with the OBDT and the IPMT performed better than the rest of the traps. Figures on feral female capture in OBDTs were higher when compared to JT, TML total captures (males only). The McPhail trap baited with NU+B had a very poor performance at this elevation. Results suggest that at this elevation it would be better to replace JT, TMLs for traps with female attractants, because, under this test condition, it would provide better monitoring of the feral fly population level.

4.3.2. Middle elevation - Finca San Francisco

From trapping studies with feral flies, the data showed that the fruit fly population was low and the host fruit infestation was also low during the study period. When results of female

captures were compared at this elevation (Tables VIII - X for feral flies and Tables XI - XIII for sterile flies), it was clear that the OBDT, FA-2 and IPMT, FA-2 were the most suitable for this type of capture. When statistical comparison of total capture of flies was carried out, the results of such comparisons were similar to the ones obtained with male capture contrast. Thus, although trapping of females is feasible at this elevation, comparison of population numbers based on captures of the different traps would seem different based on the differences in numbers captured for male or female specific traps. At this elevation, the JT, TML captured the highest number of feral flies when compared to the rest of the traps. The OBDT, FA-2 and the IPMT, FA-2 came second and in the same order as for the high elevation. Here again, the JMT, NU+B did not perform well.

Statistical analysis of trap captures with sterile insects of both sexes at this elevation showed that the JT, TML performed best. This would not be a desirable situation for use with sterile male only strains. When captures of females were compared, the OBDT, FA-2 was the most successful. The next best was the CBDT, FA-2. Comparisons of total captures of sterile insects at this elevation followed the same trend as total captures of feral flies. When data on F/T/D for sterile insects were compared, the JT, TML captured 12.5 more flies than the OBDT, FA-2. Previous studies in the same area showed similar results (Jerónimo, unpublished data). This is a factor that should be considered when planning and/or conducting trapping activities in areas under sterile insect release. Conversely, data analysis for sterile female captures under the same circumstances showed that, 22.8, 10.9, 9.0, and 2.88 times more captures for the OBDT, FA-2, the CBDT, FA-2, IPMT, FA-2 JMT, and NU+B. respectively compared to JT, TML. This situation may be desirable when releasing a bisexual strain due to competition for males and, in highly developed agriculture, sterile females attempt oviposition, causing damage to the fruit. Thus, their removal would be beneficial.

4.3.3. Low elevation - Finca Las Delicias

Results have been shown in Tables XIV - XVI. At this elevation, the adult insect populations and larval infestation rates were high. Comparisons of weekly temperatures showed significantly higher temperatures than the other sites. Female capture comparisons showed that traps containing liquids (IPMT, FA-2 and JMT, NU+B) were most suitable for feral population detection. This may be associated with the climatic conditions prevailing in the area. Based on total insect captures, the JT, TML performed best. The FA-2 attractants combined with the IPMT gave the best results but captures in the JMT, NU+B very similar. This was a different result than at the other two sites. This may be an important consideration since, as stated by Ripley (1940) and cited by [2], insects subject to climatic stress tend to search for water even over long distances.

4.4. 1996 materials and methods - deciduous area

Another study, with the same type of traps, was carried out in a deciduous area in Antigua (ca 45 km from Guatemala City) at an altitude of 2100 m. Study II was carried out during May and June1996 in pear. The fruit fly population was low and host availability was low. There were not adequate hosts for fruit fly population build-up. The native pears and peaches had undergone harvesting, and Tennessee pears were very green. The field distribution of traps was similar to Study I.

Jackson traps were re-baited every two weeks. CBDT and OBDT dry traps were re-baited every four weeks. IPMTs with FA-2 and colored water were refilled every week and lures were replaced after four weeks, and IPMTs with NU+B were re-baited every week.

Weekly data collection was carried out, and information gathered included: total insect capture in each trap, fertile and sterile insect captures, captures by sex, host fruit larval infestation, host availability, host suitability and weather parameters.

Statistical analysis carried out consisted in assigning an increasing unitary value (rank) to each of the fly/trap/day (F/T/D) figures for each of the traps (in an increasing order). Analysis of variance was performed on the assigned ranks for each of the figures. This procedure is an approximation of the non-parametric Kruskall-Wallis test [3]. Multiple comparison of means (Tukey's HSD test) followed by ANOVA was carried out. Statistical Analytical System, SAS, was used to perform the calculations [4].

4.5. 1996 results - deciduous area

Results from this study are shown in Tables XVII - XXII.

TABLE XVII. MULTIPLE MEAN COMPARISON, TUKEY'S STUDENTIZED RANGE TEST (HSD) OF MALE CAPTURE AT THE DECIDUOUS AREA (FINCA DUEÑAS), 1996

GROUPINGS	MEAN	N	TRAP TYPE
A	26.000	8	JT, TML
A	22.875	8	OBDT, FA-2
A	21.000	8	IPMT, FA-2
A	18.437	8	CBDT, FA-2
A	14.188	8	JMT, NU+B

Alpha= 0.05, df= 35, MSE= 119.159, Critical Value of Studentized Range= 4.066, Minimum Significant Difference= 15.692; * Means with the same letter are not significantly different.

TABLE XVIII. MULTIPLE MEAN COMPARISON, TUKEY'S STUDENTIZED RANGE TEST (HSD) OF FEMALE CAPTURE AT THE DECIDUOUS AREA (FINCA DUEÑAS), 1996

GROUPINGS	MEAN	N	TRAP TYPE
A	28.500	8	IPMT, FA-2
A	23.625	8	OBDT, FA-2
A	22.000	8	CBDT, FA-2
A	21.375	8	JMT, NU+B
B	7.000	8	JT, TML

Alpha= 0.05, df= 35, MSE= 87.236, Critical Value of Studentized Range= 4.066, Minimum Significant Difference= 13.427; * Means with the same letter are not significantly different

TABLE XIX. MULTIPLE MEAN COMPARISON, TUKEY'S STUDENTIZED RANGE TEST (HSD) OF TOTAL CAPTURE (MALES & FEMALES) AT THE DECIDUOUS AREA (FINCA DUEÑAS), 1996

GROUPINGS	MEAN	N	TRAP TYPE
A	26.750	8	OBDT, FA-2
A B	25.687	8	IPMT, FA-2
A B	20.000	8	CBDT, FA-2
A B	18.812	8	JMT, NU+B
B	11.250	8	JT, TML

Alpha= 0.05, df= 35, MSE= 113.198, Critical Value of Studentized Range= 4.066, Minimum Significant Difference= 15.295; * Means with the same letter are not significantly different

4.6. 1996 discussion and conclusions - deciduous area

At this site, the fruit fly population was very low as was host availability (pears and peaches). Data collected during the eight week period showed that, at this elevation, the JT, TML outperformed others in male capture. However, in contrast to other sites, it was last when total trap captures were considered. Female captures were best achieved by the traps using the FA-2 attractants. At this site, the best female captures were achieved by the IPMT, FA-2, the OBDT, FA-2, the CBDT, FA-2 and the JMT, NU+B, respectively. However there was no significant difference between these treatments.

5. 1997/98 STUDIES

5.1. 1997/98 materials and methods

5.1.1. 1997/98 studies in coffee

The field work covered a period of fourteen weeks (from mid October 1997 to the end of January 1998). These tests were conducted from the last part of the rainy season into the dry season. Field work was carried out at three different coffee fincas: San Carlos Miramar (600 m); Valparaiso (625 m); and San Luis (650 m). All fincas were located in the coffee area in southwestern Guatemala, near the Mexican border. These fincas are located within 2 km of each other. The trapping grid at each finca included 4 lines of 14 traps each. Traps were spaced at 50 m between lines and 25 m between traps. The distribution of treatments along the lines was done randomly. Trap servicing was conducted on a weekly basis. The synthetic lures (FA-3 consisting of separate patches of AA, P, and TMA) in all treatments that included them were replaced every four weeks. The NU+B solution in the IPMT was renewed every week. The TML in the JT was replaced every two weeks. Based on trap handling, this test included two phases. During Phase I (first seven weeks) an odorless dish detergent was used as surfactant in the water for the wet traps and the DDVP block (killing agent) was maintained in its commercial size. During Phase II (last seven weeks), the dish detergent was replaced by Triton, a commercial surfactant. And the DDVP block was reduced to 1/4 its commercial size.

At each site, trap evaluations were made using feral flies and sterile flies. Four weeks before the end of this test, aerial applications of SureDye were initiated in the work area.

Statistical analysis consisted of non-parametric ANOVA followed by multiple mean comparison.

The traps used were:

- IPMT baited with FA-3, water and 3 drops of an odorless dish detergent (IPMT, FA-3, wet)
- IPMT baited with FA-3 and the addition of a yellow sticky insert (IPMT, FA-3, dry)
- Tephri trap baited with FA-3, water and 3 drops of an odorless dish detergent (Tephri, FA-3, wet)
- Tephri trap baited with FA-3 and addition of block of DDVP of commercial size (Tephri, FA-3, dry)
- Local trap I - a 2 l plastic soft drink bottle with a bright green bottom baited with FA-3, water and 3 drops of an odorless dish detergent (CC1, FA-3, wet)
- Local trap I - a 2 l plastic soft drink bottle with bright green bottom baited with FA-3 and the addition of a yellow sticky insert (CC1, FA-3, dry)
- Local trap II - a 2 l plastic soft drink bottle with bright yellow bottom baited with FA-3, water and 3 drops of an odorless dish detergent (CC2, FA-3, wet)
- Local trap II - a 2 l plastic soft drink bottle with bright yellow bottom baited with FA-3 and the addition of a yellow sticky insert (CC2, FA-3, dry)
- Local III - a 2 l plastic soft drink bottle with clear bottom baited with FA-3, water and 3 drops of an odorless dish detergent (CC3, FA-3, wet)
- Local III - a 2 l plastic soft drink bottle with clear bottom baited with FA-3 and the addition of a yellow sticky insert (CC, FA-3, dry)
- Glass McPhail trap baited with NU+B (McPhail, NU+B)
- Glass McPhail trap baited with FA-3, water and the addition of 3 drops of an odorless dish detergent (McPhail, Fa-3, wet)
- OBDT dry trap - a locally made, dark green cardboard sheet, baited with FA-3 and the addition of a yellow sticky insert
- JT, TML

5.1.2. 1997/98 studies in a deciduous area

An additional study was conducted in a deciduous area. Field work was conducted at Santa Lucia Milpas Altas, San Bartolomé Milpas Altas and Magdalena Milpas Altas, Sacatepéquez (35 km from Guatemala City). This area had a wild medfly population. Host fruits were: pears, apples, peaches and some backyard coffee. Three types of traps baited with the FA-3 lure were compared to JT, TML. The IPMT, Tephri, and a local trap were evaluated as wet traps and also as wet traps in combination with a yellow sticky panel (23 x 15 cm) with stickum on both sides. The rationale was that an increase in the capture area would increase trap captures. Traps were distributed along three pre-established trapping routes in the trapping network of the local medfly program. Treatments were distributed randomly along the trapping routes. Five traps of each treatment were incorporated in each trapping route. Trap servicing was performed every week. The synthetic lures were replaced every four weeks. The TML plug was replaced every two weeks. The yellow sticky panel was replaced every week. Treatments included in this test included:

- IPMT, FA-3, wet
- IPMT, FA-3, wet, yellow sticky panel
- Tephri, FA-3, wet

- Tephri, FA-3, wet, yellow sticky panel
- CC1, FA-3, wet
- CC1, FA-3, wet, yellow sticky panel
- JT, TML

5.2. 1997/98 results, discussion, and conclusions

5.2.1. Results in coffee areas

Results are shown in Tables XXIII and XXIV.

Based on non-parametric ANOVA followed by multiple mean comparison, there were significant differences between treatments for sterile insect capture at the three fincas during the two periods of experimentation. The JT, TML and the locally made OBDT, FA-3 with yellow sticky insert performed best for sterile insects at finca San Carlos. The JT, TML and the CC2, FA-3, dry with yellow sticky insert were best at finca San Luis. The JT, TML and the CC1, FA-3dry with yellow sticky insert captured the most insects at finca Valparaiso.

The same statistical analyses were used to compare treatments for effectiveness in capturing feral flies at these sites. Data from the first phase of this study showed there were no significant differences between treatments at finca San Carlos. At finca San Luis, the CC3, FA-3, dry with yellow stick insert and the CC1, FA-3, dry with yellow sticky insert performed best. At finca Valparaiso, the CC1, FA-3, dry with yellow sticky insert and the CC2, FA-3, dry with yellow sticky insert caught more flies. During the second phase of the study, only finca Valparaiso reported significant differences. Here the IPMT, FA-3, dry with yellow stick insert and the CC3, FA-3, dry with yellow sticky insert worked best.

For some unknown reason, all wet traps performed poorly in this test. This observation held for the duration of the two phases. It was thought that there might be a possible negative interaction between liquid lures and temperature in this work area.

In these tests, the odor in all wet traps containing synthetic lures was different than the odor in the dry traps with the same lures.

The aerial application of the SureDye bait started on week 10 of the test. At this time, the feral insect population had declined and no releases of sterile insects were conducted in the work area.

The distribution pattern for the feral insect population varied a lot in this test. Based on field observations, crop management could be the factor governing such behavior as crop management strategies were different on each finca.

Future projects should include a cost/benefit approach to the use of these lures and traps.

The synthetic lured performed better in this test and the lures attracted by sexes of medfly, but were more specific for females. The synthetic lures were also less attractive to sterile insects. The JT, TML outcaptured the other treatments for sterile insect captures at all work sites. At sites where significant differences between treatments for feral populations existed, the local traps baited FA-3 lures performed better.

5.2.2. Results in the deciduous area

The results of this test (Table XXV) confirmed previous findings on the efficacy of the synthetic lures for medfly in this deciduous area. In the test, the Tephri, FA-3, wet without the yellow sticky panel gave the best performance. The CC2, FA-3, wet without the yellow sticky panel was next best, while the CC2, FA-3, wet with yellow sticky panel was third. Traps baited with the FA-3 lures always captured a high percent of females. Based on non-parametric statistical analysis, there were significant differences between treatments

TABLE XXIII. CAPTURE OF FERAL MEDFLIES USING DIFFERENT TYPES OF TRAPS AND LURES (IN F/T/D) IN COFFEE, 1997-98

Trap Type	IPMT	IPMT	Tephri	Tephri	CC1 (green)	CC1 (green)	CC2 (yellow)	CC2 (yellow)	CC3 (clear)	CC3 (clear)	Glass McPhail	Glass McPhail	OBDT	Jackson
Bait	FA-3	FA-3	FA-3	FA-3	FA-3	FA-3	FA-3	FA-3	FA-3	FA-3	NU+B	FA-3	FA-3	TML
	Wet	Insert	Wet	Dry	Wet	Insert	Wet	Insert	Wet	Insert	Wet	Wet	Insert	Insert
Location														
San Carlos Miramar weeks 43-49, 1997	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.02	0.00	0.01	0.00	0.01	0.01	0.01
San Carlos Miramar weeks 50-3, 1997-98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Valparaiso weeks 43-49, 1997	0.12	2.78	0.08	0.54	0.08	4.04	0.22	3.79	0.06	3.43	0.33	0.09	3.40	1.83
Valparaiso weeks 50-3, 1997-98	0.00	0.08	0.00	0.00	0.00	0.05	0.01	0.05	0.00	0.08	0.00	0.00	0.04	0.03
San Luis weeks 43-49, 1997	0.00	0.02	0.00	0.00	0.00	0.03	0.00	0.01	0.00	0.03	0.00	0.00	0.00	0.01
San Luis weeks 50-3, 1997-98	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00

TABLE XXIV. CAPTURE OF STERILE MEDFLIES USING DIFFERENT TYPES OF TRAPS AND LURES (IN F/T/D) IN COFFEE, 1997-98

Trap Type	IPMT	IPMT	Tephri	Tephri	CC1 (green)	CC1 (green)	CC2 (yellow)	CC2 (yellow)	CC3 (clear)	CC3 (clear)	Glass McPhail	Glass McPhail	OBDT	Jackson
Bait	FA-3	FA-3	FA-3	FA-3	FA-3	FA-3	FA-3	FA-3	FA-3	FA-3	NU+B	FA-3	FA-3	TML
	Wet	Insert	Wet	Dry	Wet	Insert	Wet	Insert	Wet	Insert	Wet	Wet	Insert	Insert
Location														
San Carlos Miramar weeks 43-49, 1997	0.34	0.57	0.80	0.92	0.39	0.68	0.67	0.85	1.29	0.61	0.20	0.59	1.01	7.03
San Carlos Miramar weeks 50-3, 1997-98	1.1	0.36	0.66	0.06	0.43	1.37	0.95	0.71	0.40	1.52	0.08	0.13	0.98	9.63
Valparaiso weeks 43-49, 1997	2.1	7.37	3.32	7.70	4.43	14.86	6.18	8.42	9.45	10.50	5.05	3.81	6.67	22.71
Valparaiso weeks 50-3, 1997-98	0.7	2.16	1.50	0.31	0.54	1.95	1.84	1.37	2.31	3.02	0.99	0.26	2.17	8.31
San Luis weeks 43-49, 1997	0.3	0.91	0.43	0.57	0.82	1.06	0.36	1.65	0.61	1.39	0.29	0.57	1.30	3.43
San Luis weeks 50-3, 1997-98	0.2	0.42	0.32	0.09	0.22	0.55	0.28	0.71	0.06	0.72	0.02	0.18	0.77	1.75

TABLE XXV. CAPTURE OF FERAL MEDFLIES IN A STERILE RELEASE PROGRAM USING DIFFERENT TYPES OF TRAPS AND LURES (IN F/T/D) IN A DECIDUOUS AREA, 1997-98

Trap Type	IPMT	IPMT	Tephri	Tephri	CC1 (green)	CC1 (green)	Jackson
Bait	FA-3	FA-3	FA-3	FA-3	FA-3	FA-3	TML
	Wet	Wet +Insert	Wet	Wet + Insert	Wet	Wet + Insert	Insert
	0.015	0.016	0.034	0.007	0.024	0.024	0.005

6. OVIPOSITION STUDIES

6.1. Materials and methods

6.1.1. Field studies 1995-96

The test was conducted in the coffee area of Antigua, Guatemala. The fruit fly population in the area was moderate (0.08 - 0.1 F/T/D). The trapping grid consisted of 2 lines of 4 traps each. Trap lines were located 50 m apart and the distance between traps along the lines was 20 m. All traps were baited with the FA-3 lures. All traps included one purple and one green agar ball wrapped inside a layer of Parafilm™. The diameter of the agar ball was 3 cm. Food (a mixture of sugar and hydrolyzed protein) and water were provided to insects inside the traps. Traps were serviced (replacement of agar balls) every four days. The test included a total of six check periods. At each check, the insects in the traps were removed from the field to make sure only new insects entered the traps during the following period. Agar balls were transported to the laboratory where egg count and egg hatch were recorded. In order to avoid damage to eggs and also to be able to remove all eggs from the agar balls, a dissecting microscope was used.

6.1.2. Laboratory studies 1995-96

The test was conducted at the USDA/APHIS Methods Development Station Laboratory in Guatemala City. Insects for this study were obtained from the Petapa medfly standard (males and females) strain. At eclosion, insects were gathered into two groups - virgin females and virgin couples. Afterwards, insects were held in clear plexiglass cages (20 x 20 x 20 cm). The cages hosted either 200 virgin females or 100 virgin couples. The variable in the test were: egg production from mated insects; and egg production from unmated insects. Insects in this test deposited eggs either in green agar balls or through a fine mesh screen (where the eggs were collected on wet filter paper). There were two cages for each group of insects. In one cage, eggs were collected in agar balls, and, in the other, they were collected on wet filter paper. During the test, food (a mixture of sugar and protein hydrolysate, 3:1) and water were provided to adult insects. Figures on egg hatch for each treatment are based on a total of 1200 eggs (6 check periods, 200 eggs each period). Egg collection was performed every two days. For the green agar ball collection, both parameters (total egg production and percent egg hatch) were recorded. For the fine screen collection, only percent egg hatch from mated and unmated insects was deemed important.

6.1.3. Field cage study

A second study was also conducted. Two types of trap were included - the OBDT and a Mission Dry Trap (clear plastic). Both traps were modified form their original design, namely gluing a fine screen inner funnel to each entrance hole. Modification was necessary to avoid flies leaving the trap, once they had entered. Each trap type was baited with FA-2 attractants. Traps were hung in the top of field cages. Data were collected on the number of insects retained in the trap and the number of females and males in the trap.

The egging device was a small plastic basket (normally used as a holder for the TML plug). The egging devices were wrapped in a layer of Parafilm™ and filled with the specific egging media except for a natural oviposition substrate (grape). The egging devices containing media were randomly distributed inside the trap along a central axis.

Five egging media were evaluated: grape; agar; Alcosorb; G-400; and Fuselerone. All five media were randomly distributed and hung inside the traps. Exposure of egging media, except for grape, was done inside a layer of Parafilm™. Egging media were exposed to flies for two days. The evaluation parameters recorded were: number of oviposition marks on the outside of the device and the number of eggs in the media.

Medflies for this study came from the MOSCAMED rearing facility. Insects were sexually mature when released. The insect density per cage was 100 males and 100 females. Insects were left in the cages for two days to allow them to enter the traps and encourage egg laying.

Five field cages were used in this study (standard quality control field cages). To evaluate the possible effect of external factors on trap performance, cages were divided clockwise into quadrants for trap location. There were four traps per cage, two of each type. Each trap was assigned a position.

6.1.4. Laboratory studies 1997-98

Tests were conducted at the USDA/APHIS Methods Development Station Laboratory in Guatemala City. Insects for this test were obtained from coffee samples collected in southwest Guatemala. At eclosion, insects were separated into two groups - virgin females and virgin couples. Insects were held in clear plexiglass cages (20 x 20 x 20 cm). The cages hosted either 25 virgin females or 25 virgin couples. The age of the insects at the start of the experiment was 12 days. There were a total of two cages for each group of insects. Egg collection was performed in agar balls (3 balls per cage) every two days. Insects were supplied with food (a mixture of protein and sugar) and water. The test included a total of six check periods similar to studies with the laboratory strain. Periodic percent egg hatch was based on samples of 100 eggs for each treatment. In this test, total egg counts were mandatory for both groups of insects.

6.2. Results, discussion and conclusions

6.2.1. Field studies 1995-96

In this experiment, egg collection from feral medflies was successful under open field conditions. Results are summarized in Table XXVI. Retaining chambers for this type of field work show allow sufficient inner space to properly fit the agar ball(s), lures, food, water, and also provide some resting area for the flies. The average percent egg hatch were low when compared to those for laboratory strains. This could be because a portion of the trapped females were virgin insect that laid eggs in the agar balls. This hypothesis was not investigated under field conditions. Based on non-parametric statistical analysis, there was no significant difference between treatments, either for total numbers of eggs collected, or for percent egg hatch.

6.2.2. Laboratory studies

In this test, laboratory reared unmated female medflies produced eggs under laboratory conditions. The average percent egg hatch for mated insect was 91.33%. The average numbers of eggs/female/day for unmated and mated insects were 20 and 15, respectively. These results are summarized in Table XXVII.

TABLE XXVI. NUMBER OF EGGS COLLECTED AND EGGS HATCHED FROM FIELD COLLECTED FERAL MEDFLIES

	Eggs collected	Standard Deviation	Eggs Hatched	Standard Deviation
Purple agar ball	1206	297.3	66.1	24.5
Green agar ball	400	70.1	59.5	20.3

TABLE XXVII. NUMBERS OF EGGS COLLECTED AND EGGS HATCHED FROM LABORATORY STUDIES USING MATED AND UNMATED FEMALE MEDFLIES

	Eggs collected	Standard Deviation	Eggs Hatched	Standard Deviation
Mated Females	15.5	7.9	91.3	3.2
Un-mated females	19.8	10.4	86.3	4.7

6.2.3. Field cage study

Data are shown in Table XXVIII. Both traps attracted and retained adult medflies. The CBDT, F-2 attracted and retained 30% flies than the Mission, FA-2. Because of differences in light intensity and wind direction, there were some positional effects of trap placement. The sex ratios for insects retained in both trap types did not differ and was close to 1:1. The desirability of ovipositional substrate ranked very similarly for both traps. When comparing figures on total egg collection for both traps and for each media, differences were 48%, 76%, 87%, 73%, and 83% for grape, G-400, agar, Alcosorb, and Fuselerone, respectively, favoring the CBDT, FA-2. Thus, the use of the CBDT, FA-2 should be of help for these kind of studies. This combination looks promising when applied to laboratory reared medflies under confined conditions. The egging substrates evaluated here and new ones, considered in future studies, can simplify egg collection.

6.2.4. Egg production by mated and unmated females under laboratory conditions

In this test, unmated feral females did lay eggs into agar balls. Results are shown in Table XXIX. This was an important finding because, during the field test (see *4.5.1.*), we found a lower percent egg hatch when compared to laboratory studies (see *6.2.1.*). We did not find direct evidence that this occurs in a wild population. The above findings should be taken into consideration when interpreting figures for induced sterility, and also when interpreting results obtained in field cage studies where mating events are not recorded. In these studies, the egg production for mated feral females was double that for unmated females. These results were different than those for laboratory reared insects (see *6.2.1.*). Perhaps egg laying behavior has been modified by lab rearing.

TABLE XXVIII. OVIPOSITION INTO VARIOUS SUBSTRATES IN FIELD CAGE STUDY

Ovipositional Substrate Material	Trap Type				Mission/CBDT egg collection ratio
	CBDT		Mission		
	Number of Eggs	Number of Oviposition Marks	Number of Eggs	Number of Oviposition Marks	
Grape	980	117	510	126	0.5204
Agar	112	70	41	12	0.1314
Alcosorb	322	61	86	26	0.2671
G-400	566	86	131	43	0.2314
Fuselerone	265	56	45	12	0.1698

TABLE XXIX. EGG PRODUCTION BY MATED AND UNMATED FEMALES UNDER LABORATORY CONDITIONS

	Average Oviposition in Agar Balls (Eggs/Female/Day)		Average Percent Egg Hatch in Agar Balls	
Check Period	Mated	Unmated	Mated	Unmated
1	4.6	2.77	80.54	0
2	7	2.83	74.02	0
3	16	7.5	79.72	0
4	17.8	7.56	79.01	0
5	15.08	11.26	78.36	0
6	11.64	8	72.39	0
Average	12.02	6.65	77.34	

REFERENCES

[1] HEATH, R.R., EPSKY, N.D., Recent progress in the development of attractants for monitoring the Mediterranean fruit fly and several *Anastrepha* species, Proc. Intl. Symp. on Mgmt. of Insect Pests: Nuclear and Related Molecular and Genetic Techniques, IAEA/FAO, Vienna (1993) 463 - 472.

[2] PROKOPY, R.J., Impact of medfly foraging behavior on trapping and eradication. Proceedings, The medfly in California: Defining critical research (1994) 109-122.

[3] MARTINEZ GARZA, A., Experimentación Agrícola, Métodos estadísticos, Universidad Autónoma Chapingo (1994) 359 pp.

[4] SAS, SAS for Windows, Release 6.10 (1996).

POTENTIAL FOR THE USE OF MALE PHEROMONE COMPONENTS IN FEMALE TRAPPING: A PROGRESS REPORT

P.E. HOWSE, K.L. UNDERWOOD, J.J. KNAPP
School of Biological Sciences,
University of Southampton,
United Kingdom

A. ALEMANY FERRA, M.A. MIRANDA
Depto. de Biologia Ambiental,
Universitat de les Illes Balears,
Palma de Mallorca, Spain

Abstract

Experiments were conducted to determine if reducing the male population using TML traps and pheromone baited traps would enhance female Mediterranean fruit fly capture. Investigations were conducted in citrus plantations in Mallorca. In the first trial (0.36 ha, Son Coll Vey, Palma) Agrisense yellow delta traps were deployed on every third tree in adjacent rows. On each other tree, a TML bait was placed with an insecticide strip containing Dichlorvos. Thus, each of the delta traps was surrounded by a hexagon of TML + insecticide baited trees. The rationale of this experiment was to remove males from the vicinity of pheromone-baited traps and thereby increase the apparency of the female lure. Before the trial, male catches averaged 4.1 per day in TML traps. During the trial, this was reduced to approximately 0.6 males/trap/day. The traps with pheromone (pyrazines in various combinations and ratios) caught around 0.05 females/trap/day. The pheromone traps remained female selective, with a negligible male catch, similar to that in unbaited traps. The most likely cause for the very low female catch may be that insufficient males were removed by the lure and kill devices. In the second trial (0.67 ha, Inca, Mallorca) the proprietor had deployed 83 traps, baited with TML and insecticide, for 18 days prior to the placement of five treatments with six replicates. The delta traps were placed on every third tree, with replicates every third row. The female catch showed a progressive enhancement over a period of 6 weeks, reaching a level about six times that of males in TML traps.

The identification of a plethora of medfly pheromone components opened up exciting possibilities for the development of novel attractant mixtures. On the basis of laboratory tests, these appeared to be powerful tools, but the promise has not followed through to the field where their activity has not been confirmed and results are, at best, capricious.

Over a period of about ten years, trials were carried out based on mixtures containing linalool, one of the principal components of male-produced volatiles [1] together with alkyl pyrazines. A number of pyrazines were identified by Herbert [2] from glandular extracts of sexually mature male flies.

These trials were in mainland Spain [3], the Balearic Islands, Sardinia [4], Mexico [5], Brazil [4], and Morocco (Bakri, unpublished). One very positive result obtained in citrus in Andalucia proved unrepeatable. Other trials with these ingredients were disappointing, sometimes resulting in average catches that were lower than those in unbaited controls. As such, there is no value in reporting them in detail. However, trials in citrus orchards in Sardinia gave catches of females that were more than 50% of catches of males in TML traps, but only in the late season when population densities were high [4].

Field work carried out by Baker et al.[5] in Chiapas, Southern Mexico, produced low catches of medfly, but it was found that the male : female ratio changed with the season, fruit crop, and fruit phenology. Taken together with the evidence from Sardinia, the hypothesis was developed that calling wild flies in the crop could out-compete pheromone lures leading to low female catches.

An alternative hypothesis, that the female catch rate is determined by masking or synergism with host fruit volatiles has not been borne out by results of trials in peach, apricot, opuntia or chirimoya. Although interactions with host volatiles do undoubtedly occur [4], they may be subsidiary to other factors, including the distribution of calling males.

The former hypothesis was tested in Brazil by J.J. Knapp [4]. The male population in a coffee plantation was first reduced by spraying a slow-release lure and kill formulation (Polycore, AgrisenseBCS) containing TML. Yellow sticky pheromone-baited traps were then deployed in the central part of this area. High catches of female medfly were obtained, which exceeded (on a catch per trap basis) the numbers of males caught by TML traps in a neighbouring untreated area.

The influence of TML traps was further investigated in citrus plantations in Mallorca. In the first trial (0.36 ha, Son Coll Vey, Palma) Agrisense yellow delta traps were deployed (six replicates of eight treatments) one every third tree in adjacent rows. On each other tree, a TML bait was placed with an insecticide strip containing Dichlorvos. Thus, each of the delta traps was surrounded by a hexagon of TML + insecticide baited trees. The rationale of this experiment was to remove males from the vicinity of pheromone-baited traps and thereby increase the apparency of the female lure. In these trials, linalool was omitted from the attractant bait because of the difficulty of controlling release rates. Previous trials may have failed because of rapid loss of the more volatile components from lure substrates (R. Heath, personal communication).

Before the trial, male catches averaged 4.1 per day in TML traps. During the trial, this was reduced to approximately 0.6 males/trap/day. The traps with pheromone (pyrazines in various combinations and ratios) caught around 0.05 females/trap/day.

The pheromone traps remained female selective, with a negligible male catch, similar to that in unbaited traps. The most likely cause for the very low female catch may be that insufficient males were removed by the lure and kill devices.

In the second trial (0.67 ha, Inca, Mallorca) the proprietor had placed 83 traps out, baited with TML and insecticide, for 18 days prior to the placement of five treatments with six replicates. The delta traps were placed on every third tree, with replicates every third row. The female catch showed a progressive enhancement over a period of 6 weeks, reaching a level about six times that of males in TML traps. The results of these two trial are shown in Table I.

From comparison of the results above from Brazil and from the two Mallorcan orchards, it appears that reduction of the male population must occur before a female pheromone becomes attractive. If this conclusion is justified, it suggests that the presence of males may indeed interfere with response of females to alternative attractants. There is strong evidence that TML is a leking parapheromone, inducing lek formation at a distance from the source [6]. The action of the TML sources around the treatments in the first Mallorcan trial may therefore have been to encourage leking in the trees next to the treatments, which would then divert females from the artificial attractant sources.

TABLE I. MEDFLY CAPTURES IN CITRUS ORCHARD, MALLORCA, 1996

Trial Weeks 1-3			Trial Weeks 4-6		
	Male	Female		Male	Female
TML (N=6)	0.54	0.29	TML (N=6)	0.11	0.087
Blank(N=6)	0.00793	0.49	Blank (N=6)	0.00793	0.16
All Pheromone Treatments (N=18)	0.00794	0.6	All Pheromone Treatments (N=18)	0.00794	0.39
Best Pheromone Treatment (N=6)	0.00793	0.94	Best Pheromone Treatment (N=6)	0.016	0.63

Although most of the trials that have been conducted so far with pheromone-based attractants have yielded few female flies, the reasons for this are now becoming evident. If prior reduction of male populations is carried out with a suitable TML formulation, the prospects for mass-trapping of females using a pyrazine bait appear to be very promising.

REFERENCES

[1] BAKER, R., et al., Isolation and identification of the sex pheromone of the Mediterranean fruit fly, *Ceratitis capitata* (Wied.), Chem. Commun. **12** (1985) 824-825.

[2] HERBERT, R.H., Studies on the pheromone systems of fruit fly species, Unpublished Ph.D thesis, University of Southampton, UK (1981).

[3] FODA, M.E.M., Chemical communication in the Mediterranean fruit fly *Ceratitis capitata* (Wiedemann), Unpublished Ph.D thesis, University of Southampton, UK (1987).

[4] HOWSE, P.E., KNAPP, J.J., Pheromones for Mediterranean fruit fly: presumed mode of action and implications for trapping techniques. In "Fruit Fly Pests, a world assessment of their Biology and Management," MCPHERON and STECK. (eds.), St. Lucie Press, Florida (1996) 107-113.

[5] BAKER, P.S., et al., Field trials of synthetic sex pheromone components of the Mediterranean fruit fly (Diptera: Tephritidae) in southern Mexico, J. Econ. Entomol. **83** (1990) 2235-2245.

[6] HENDRICHS, J., et al., Sex differences in movement between natural feeding and mating sites and tradeoffs between food consumption, mating success and predator evasion in Mediterranean fruit flies (Diptera: Tephritidae), Oecologia **86** (1991) 223-231.

ANNEXES 1–4

Annex 1

CO-ORDINATED RESEARCH PROGRAMME (CRP) - YEAR FOUR MEDFLY FEMALE ATTRACTANT STUDIES

1. PURPOSE OF TESTS

To obtain data on and to develop a female attractant trapping system for practical use in medfly Sterile Insect Technique eradication or control programmes. Addition of a third synthetic attractant resulted in improvements in medfly capture and medfly specificity in the female-targeted dry trap. Generally traps with water outcaptured dry traps, however preliminary studies indicate that the Tephri-trap, a new McPhail-type trap that is used with DDVP, may be an effective dry trap for medfly capture. Research will be conducted testing the three component synthetic lure in wet and dry traps to differentiate between trap design and presence of water in the trap. These tests will use a McPhail trap with water or with toxicant; a Tephri-trap with toxicant; an open-bottom dry trap or other local trap of the co-operator's choice. These will be compared with a McPhail trap baited with aqueous protein solution as the standard. Some trimedlure-baited Jackson traps will be included as an indicator of population levels to facilitate comparisons among the different sites, although some co-operators will include trimedlure-baited Jackson traps as a co-operator's choice treatment. Studies will be conducted under various environmental conditions and in various host plants.

2. ANTICIPATED RESULTS

The results will be useful in all areas where medfly populations are estimated by trapping and where medfly research is in progress. It is anticipated the development of female-targeted dry traps will contribute significantly by: 1) providing increased information on medfly populations, and 2) enhancement of SIT through the use of female-targeted trapping systems.

3. MATERIALS

The following are materials that may be supplied by the IAEA to the senior investigator of each research contract, depending on the treatments to be included in the protocol:

A. Traps

(1) International Pheromones McPhail trap (IPMT) — plastic version of the McPhail glass invaginated trap.

(2) Tephri-trap (Tephri) — modified version of a McPhail trap that is used with toxicant

(3) Open bottom dry trap (OBDT) — opaque green cylindrical open-bottom trap with yellow sticky paper insert

(4) Jackson trap (JT) — triangular trap with white sticky inserts

B. Lures, etc.

(1) Ammonium acetate (AA) - Lure #1 patch (white)

(2) Putrescine (Putr) - Lure #2 patch (silver)

(3) Trimethylamine (TMA) - Lure #3 patch (white)

(4) NuLure (NL), protein attractant.

(5) Borax (sodium borate)

(6) Trimedlure plugs (TML)

C. Other

(1) Wire hangers (JT)

(2) Tanglefoot (JT)

(3) Petri dishes (OBDT)

(4) Wire hangers (OBDT)

(5) Yellow sticky paper inserts (OBDT)

(6) DDVP Toxicant (IPMT, Tephri)

(7) Surfactant (100 ml of 0.1% triton in water)

4. PLOT SELECTION AND DESIGN

A field site will consist of 5 lines (A–E) of 6 traps each. Initial trap placement within each line should be random. In locations where size of field prevents use of lines, the field plot design will be a randomized complete block, with 5 blocks consisting of 6 traps per block. Traps within a line or block should be rotated sequentially after each sample. All lines or blocks within a site should be placed in similar hosts where possible. Each of these tests will be run for 8 weeks and trap data collected twice a week. There will be two sites selected and, where possible, these sites should have different primary medfly hosts.

In order to reduce random error and increase sensitivity of the tests, the co-operator should conduct these tests in areas of moderate medfly populations and uniform habitat. No tests are to be conducted in areas where insecticide is being applied. An important component of this study will be changes in the medfly population within an area over time and the ability to monitor this change with the female attractants. Therefore, study periods that include the beginning or end of the population peak will be acceptable and the protocol may be extended to 12 weeks to include these periods. All the trap locations within a single site should be uniform. The important consideration, again, is that all the traps within any given site be as uniform as possible. We recognize that complete uniformity is not possible, but obviously heterogenous areas should not be included within the same site. If there is high heterogeneity in the trapping area, the co-operator may shift to a 6 or 12 week protocol in order to have all treatments placed in all sites the same number of times in the study.

5. TRAP PLACEMENT

Traps will be hung one to two meters above the ground in the lower half of the south-eastern part of host tree canopy. The trap should be in a relatively open space with no canopy touching the trap. No traps should be hung in exceptional trees, e.g. at the edge of the orchard, high population sites, very small or very large trees, etc. All traps should be between 25 and 50 meters away from any other traps. In the same line/block trees with traps should be of similar canopy size and density and fruiting condition. During renewal, the old liquid bait of

IPMT traps should always be collected in a plastic canister and not poured on the ground to avoid interference with traps. Used trimedlure plugs or synthetic lures should be collected in a plastic bag and not dispersed on the ground as well.

6. Description of Sites

The co-operator will provide the following general information and data about each site:

(a) A map, drawn to scale, showing all medfly hosts and trap locations.

(b) A general description of the area, including elevation above sea level, vegetation type, monthly rainfall records for the past 2 to 3 years, prevailing wind direction and speed and general medfly infestation data including primary hosts in the area.

7. DATA FOR SITES

The cooperator will provide the following specific information and data for each site (data sheet 3 for A-F and sheet 4 for G):

(a) Daily maximum and minimum temperature[b].

(b) Daily rainfall[b].

(c) Daily maximum and minimum humidity[b].

(d) Daily estimate of wind direction and speed[b].

(e) Once per week, presence of fruit, fruit maturity and suitability for medfly oviposition of major host trees in the test area should be recorded.

(f) Once per week, fruit infestation by medfly should be recorded.

(g) Name of medfly host in which each trap is hung.

[b] Data from local weather stations will be satisfactory, however, the co-operator should indicate the distance between the test site and the weather station.

8. DATA COLLECTION

The co-operator will collect the following data for each weekly test (data sheet 1 for A–C, sheet 2 for D–E, and sheet 3 for F). All traps should be checked twice per week on a regular schedule. All traps should be checked on the same day. However, if this cannot be done, then a regular schedule of checking the traps must be followed, with all traps within a block checked on the same day:

(a) Date trap checked.

(b) Number of male and female medflies captured.

(c) Condition of trap and lure.

(d) Number of males and females of other fruit flies (identify species if possible) captured.

(e) Presence of insects other than fruit flies in large numbers.

(f) Fruit infestation per site. Percentage of main medfly host fruits in the area with live infestation. About 10 fruits picked at random from about 10 trees of each host at the beginning of each week.

9. TRAPS AND PREPARATION

Traps used in all studies:

(a) International Pheromones McPhail trap (IPMT) as a wet trap. Bait with lure #1 patch, lure #2 patch and lure #3 patch. Add 300 ml of water and surfactant (1-2 drops) to base. Water may be added during sampling in arid climates.

(b) International Pheromones McPhail trap (IPMT) as a dry trap. Bait with lure #1 patch, lure #2 patch and lure #3 patch. Place DDVP in base.

(c) Tephri-trap as a dry trap. Bait with lure #1 patch, lure #2 patch and lure #3 patch. Place DDVP in basket.

(d) International Pheromones McPhail trap (IPMT). Bait with 300 ml of a solution containing 9% NuLure, 3% borax, 88% water (by weight). If possible, check bait pH of freshly prepared solution and at the end of each renewal. Water may be added during sampling in arid climates.

Optional traps:

(a) Tephri-trap as a wet trap. Bait with lure #1 patch, lure #2 patch and lure #3 patch. Add 200 ml of water and surfactant (1-2 drops) to the base and place DDVP in basket. Water may be added during sampling in arid climates.

(b) Open bottom dry trap (OBDT). This trap has an open bottom and a yellow sticky insert to capture flies. Bait with lure #1 patch, lure #2 patch and lure #3 patch. Replace yellow sticky inserts at each sample or as needed.

(c) Co-operators choice of local trap. Bait with lure #1 patch, lure #2 patch and lure #3 patch. Use DDVP, sticky insert or water to retain attracted flies. Add surfactant (1-2 drops) to water if used.

(d) Jackson trap (JT) with standard sticky insert. Bait with a trimedlure plug placed in a plastic basket hung inside the trap in the middle of the horizontal wire hanger. Replace standard sticky inserts at each sample or as needed.

10. HANDLING PROCEDURES FOR FOOD-BASED LURES AND YELLOW STICKY INSERTS

The lures provided this year have been commercially produced and are slightly different than lures provided in previous years. The ammonium acetate lures are individually packaged in a white envelope labelled "BioLure." There is a notch along one side to facilitate opening the white envelope. Inside is the square white lure, as has been used in previous studies. Slowly and carefully remove the clear cover labelled "PEEL SLOWLY." Remove the cover in the direction indicated by the arrows, if possible. Some white powder may remain on the clear cover after it is peeled off but the exposed membrane should remain intact.

The putrescine lures are also individually packaged in a white envelope labelled "BioLure." Inside is a rectangular silver lure. On the side opposite the tape strip, peel the silver foil cover away from the lure body. Some foil may be removed from areas outside of the sealed area (edges). This is okay. Caution should be taken to ensure that the foil is not torn around the 5 mm hole in the lure. A brown color is often seen on the foil. The ammonium acetate and putrescine lures can be differentiated by their shape without opening the white envelope.

The trimethyamine lure looks like the ammonium acetate lure, but may not be individually packaged in white envelopes. Instead, they may come in groups of five in plastic wrap. The trimethyamine and the ammonium acetate lures can be easily distinguished by smell (the trimethyamine will smell fishy, the ammonium acetate will smell like acetic acid), however, you may want to add a mark or label to allow you to differentiate them in the field.

Care must be taken not to puncture the lure cavity. If lures are found to be leaking, they should be discarded. Under normal conditions, it the lures are firmly stuck to the trap wall, they will remain attached during the field tests. If environmental conditions cause problems related to attachment of lures, then scientists are urged to provide a method to resolve this problem. In this case, the use of the hole provided in the white patches (ammonium acetate and trimethylamine) can be used to attach, via a wire, the lure to the trap.

Lures should be stored at ambient temperature or refrigerated at a temperature not less than 5°C. Lures stored under these conditions should last at least one year. The food-based attractants (ammonium acetate, putrescine and trimethylamine) and traps that are to be baited with food-based attractants should not be stored near or with TML. Care must be used to ensure that TML does not contaminate the food-based lures during deployment and/or servicing of the traps.

DDVP can be used for up to 8 weeks. If co-operator is running a 12 week study, than the DDVP should be replaced after the first 6 weeks, and new DDVP used for the second 6 weeks. Always use DDVP in a Tephri-trap whether it is being used as a wet or dry trap. Only use DDVP in IPMT when it is used as a dry trap. Use of DDVP and water in an IPMT would be considered a co-operators choice trap, not one of the traps used in all studies.

For a 6 week protocol, do not replace the AA, Putr or TMA during the study. For the 8 week standard protocol, replace the AA, Putr and TMA after the first 4 weeks and use new lures for the second 4 weeks. For a 12 week protocol, replace the AA, Putr and TMA after the first 6 weeks.

Care should be taken regarding the use of the new type of fruit fly adhesive used on the insert for the OBDT. The adhesive, when in contact with paper, leaves, etc. results in a surface that is no longer effective in retaining flies. In addition, sticky inserts should not be placed where water comes into contact with the adhesive. Constant exposure of the inserts to water will result in a gum-like surface. Traps with inserts used in areas with large amounts of rain may show signs of tackiness in the adhesive. If allowed to dry, the adhesive will return to its normal condition. Insects captured on the adhesive panel can be removed using mineral oil. The cover paper on the insert may be re-used for insert retrieval. Take care not to touch the sticky surface of the insert to the lure membranes.

11. DATA ANALYSIS

Data should be summarized by site or by host type and table heading should include site and environmental information, capture in Jackson traps and average number of larvae per kg of fruit (see Table 1). To allow direct comparisons of trapping results among female-targeted traps, capture in these traps should be reported as number of males, females and total flies per trap per day; as relative trap efficiency (i.e. percentage) of males, females and total flies captured among traps; and as percentage of females in the total number of flies captured in each trap. Larval populations in fruit should be reported as number of larvae per kg of fruit.

Analysis of variance should be conducted using data from female-targeted traps (i.e. traps baited with 3FA [Ammonium acetate, putrescine and trimethylamine] or NuLure/borax). Catch in TML-Jackson traps, which are male-targeted, should not be included in the analysis. Data on number of females, males and total flies should be log transformed ($x + 1$) prior to analysis. If the there are large changes in population level during the study, the data should be analyzed as percentage of flies per trap/lure type. Percentage data should be square-root ($x + 0.5$) transformed prior to analysis. Correlation analysis can be used to examine the relationship between each of the environmental variables and number of flies captured.

Copies of data sheets containing all the raw data will be sent to the IAEA so that the data can be analyzed across all countries and hosts.

12. RE-TESTING

Depending on the outcome of initial experiments, additional trials may be requested.

13. EXPLANATION OF TERMS AND NOTES

(a) Trap: 1 of the 6 trap/attractant combinations.

(b) Line/Block: 1 each of the 6 trap types in random positions; traps operated for 8 weeks.

(c) Site: 5 lines/blocks within a primary host plant area.

(d) Study: Duration of the study for Year 4 will be 6-12 weeks.

(e) Use the same trimedlure for a period of 2 weeks only, trimedlure will be replaced 3-6 times for the length of this study.

(f) Use the same synthetic lures #1, #2 & #3 for a period of 4-6 weeks, these lures will be replaced one time during 8-12 week studies and not replaced during 6 week studies.

(g) Replace liquid bait (300 ml) in IPMT traps after 1 week of use, recycle the bait at the mid-week sampling period. When recycling the bait, add water to bring the solution back to 300 ml. Rinse the trap with water before pouring fresh solution.

(h) The surfactant to be shipped to each co-operator is a 0.1% solution (100 mg triton per 100 ml water).

(i) Replace water in wet traps after 1 week of use, recycle the water at the mid-week sampling period. When recycling, add water to bring the solution back to original volume. Rinse the trap at the end of the week. Add surfactant (1-2 drops of the 0.1% solution) to the water.

(j) Always use DDVP in Tephri-traps, whether they are used wet or dry. DDVP should be placed in the basket of the Tephri-trap, it should be placed in the bottom of the IPMT.

(k) Do not use DDVP in IPMT used with water unless this is used as a co-operator's choice trap in the standard protocol or in a side study.

(l) Be very careful to prevent attractant materials from dropping onto the tree or the ground as this confuses the medfly and may reduce the number of medflies captured in the trap.

(m) Use DDVP up to 8 weeks. If running the experiment for 12 weeks, replace the DDVP after 6 weeks.

(n) Replace the sticky inserts (either standard [JT] or yellow [OBDT]) at time of sample or as needed.

14. SIDE EXPERIMENTS

Co-operators at locations that have the ability to obtain information regarding the mated status of the captured female medflies (via dissection and examination of spermathecae for sperm presence) are requested to provide this information. If dissections are not possible, females should be categorized as immature or mature by pulling out the ovipositor and observing the ovaries and egg maturity. In situations where large numbers of female medflies are captured, subsamples of 25 females per site randomly selected among all trapped per trap/attractant per week will be sufficient. Information should be obtained for all 8 weeks of the study and from both sites.

Availability of traps baited with female attractants may allow development of systems to obtain eggs from wild females. This information could be used to follow sterility introduced into the wild medfly population by the release of sterile medflies. Co-operators at locations with populations of wild medflies either with or without SIT release capabilities are encouraged to investigate the potential for egging systems.

The protocols and side studies described above are designed to optimize capture of females. An additional component is the minimization of capture of males. This will be important to minimize removal of released sterile males as well as to optimize development of egging systems. Co-operators at locations with SIT release capabilities are encouraged to investigate male choice among alternative designs of female-baited traps.

TABLE 1. REPRESENTATIVE DATA SUMMARY

Country: ____
Host: ____
Altitude: ____
Avg. Temp, Min-Max: ____
Avg. RH, Min-Max: ____
Trapping period (dates): ____

No. of trap days (# traps per treatment x # days): ____
Jackson trap capture (#Total F/T/D): ____
% females in Jackson trap ([#Females/#Total] * 100): ____
Number of Jackson trap days (# traps x # days): ____
Average number of larvae per kg of fruit: ____

Trap/lure treatment			Flies per trap per day (F/T/D)			Relative trap efficiency			%Females per Trap (#fem/#tot)
Trap	Bait	Retention	#Males	#Females	#Total	%Males	%Females	%Total	
IPMT	NL/bora x	water							
IPMT	3FA	water							
IPMT	3FA	DDVP							
Tephri	3FA	DDVP							
	3FA								
	3FA								
						(sum of each column should equal 100%)			

COORDINATED RESEARCH PROGRAMME ON MEDFLY FEMALE ATTRACTANT
DATA SHEET 1 -Medfly capture

Name of Cooperator _____ Circle Sampling Period I II III IV

Country _____ Circle Line/Block Number A B C D E

Circle Site 1 2 Sampling Period (Dates) _____

TRAP INFORMATION			FRUIT	SEX	INSECTS CAPTURED DURING 14-DAY				
Traps	Lures	Retention							TOTAL
JT	TMLP	sticky	Medfly	_					
				_					
IPMT	NuLure /	NuLure/ borax	Medfly	_					
				_					
IPMT	3FA	Water	Medfly	_					
				_					
IPMT	3FA	DDVP	Medfly	_					
				_					
TEPHRI -TRAP	3FA	DDVP	Medfly	_					
				_					
CC	3FA		Medfly	_					
				_					
CC/ optional	3FA		Medfly	_					
				_					

JT: Jackson Trap (having 1 trap per line/block is optional Notes:
IPMT: International PheromonesMcPhail Trap
TEPHRI-TRAP: modified version of aMcPhail trap that is used withDDVP
CC: Cooperators choice ofTephri-DDVP and water;OBDT and sticky insert or local trap
TMLP: Trimedlure Plug
NuLure/borax - 9%NuLure and 3% borax
3FA: AA-Putr-TMA: Lure #1, Lure #2, Lure #3
DDVP: toxicant plug
Water: used with 1-2 drops surfactant to retain attracted flies
CC/optional: used ifJT-TML not included as a protocol choice

COORDINATED RESEARCH PROGRAMME ON MEDFLY FEMALE ATTRACTANT
DATA SHEET 2 - other fruit fly and other insect capture

Name of Cooperator _____ Circle Sampling Period I II III IV

Country _____ Circle Line/Block Number A B C D E

Circle Site 1 2 Sampling Period (Dates) _____

TRAP INFORMATION			Insect	SEX	INSECTS CAPTURED DURING 14-DAY				
Traps	Lures	Retention							TOTAL
JT	TMLP	sticky		_					
				_					
IPMT	NuLure/ borax	NuLure/ borax		_					
				_					
IPMT	3FA	Water		_					
				_					
IPMT	3FA	DDVP		_					
				_					
TEPHRI-TRAP	3FA	DDVP		_					
				_					
CC	3FA			_					
				_					
CC/ optional	3FA			_					
				_					

JT: Jackson Trap (having 1 trap per line/block is optional Notes:
IPMT: International PheromonesMcPhail Trap
TEPHRI-TRAP: modified version of aMcPhail trap that is used withDDVP
CC: Cooperators choice ofTephri-DDVP and water;OBDT and sticky insert or local trap
TMLP: Trimedlure Plug
NuLure/borax - 9%NuLure and 3% borax
3FA: AA-Putr-TMA: Lure #1, Lure #2, Lure #3
DDVP: toxicant plug
Water: used with 1-2 drops surfactant to retain attracted flies
CC/optional: used ifJT-TML not included as a protocol choice

COORDINATED RESEARCH PROGRAMME ON MEDFLY FEMALE ATTRACTANT
DATA SHEET 3

Name of Cooperator _____ Circle Sampling Period I II III IV

Country _____ Circle Line/Block Number A B C D E

Circle Site 1 2 Sampling Period (Dates) _____

TES	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Max. Temp														
Min. Temp														
Max. RH														
Min. RH														
Rain (mm)														
General														

	Host	Fruit* Presence	Maturity and Suitability for Oviposition	% Fruit Infested
Medfly host fruit	orange			
	mandarin			
	sour orange			
	peach			
	apricot			
	pear			
	fig			
	coffee			

*Record fruit presence in the block as follows:

0 = no fruit
\+ = small number of fruit
++ = many fruit

NOTES:

This characterization should apply to the entire block

COORDINATED RESEARCH PROGRAMME ON MEDFLY FEMALE ATTRACTANT

DATA SHEET 4

Name of Cooperator _____

Country _____

Circle Site 1 2

MAP OF TEST AREA

Scale _____

Locate and identify all medfly hosts and trap locations.

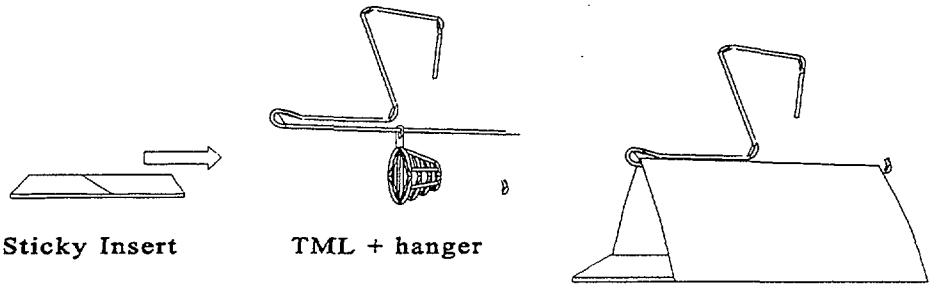
Annex 2.

TREATMENTS USED IN STANDARD PROTOCOL

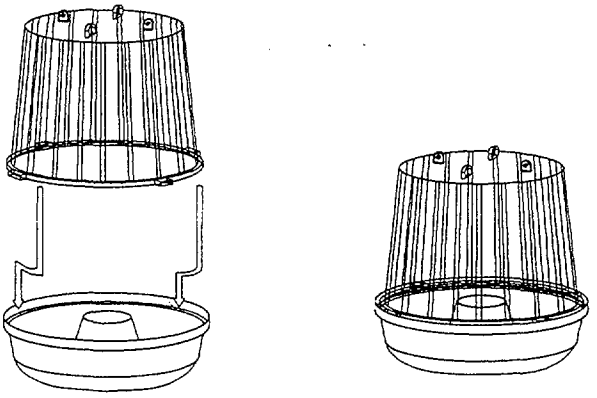
Treatments Used in Standard Protocol	Year			
	94	95	96	97
JT, TML - Jackson Trap, Trimedlure baited	X	X	X	X
IPMT, NU+B - International Pheromone's PlasticMcPhail Trap, protein-baited with 300 ml of an aqueous solution containing 9%NuLure + 3% borax	X	X	X	X
CBDT, FA2 - Closed Bottom Dry Trap with opaque green band, baited with two-component synthetic lure (ammonium acetate +putrescine) and a toxicant square to kill flies	X	X		
OBDT, FA-2 - Open Bottom Dry Trap with opaque green body, baited with two-component synthetic lure (ammonium acetate +putrescine) and a yellow sticky insert to capture the flies		X	X	
IPMT, FA-2 - International Pheromone's PlasticMcPhail Trap baited with the two-component synthetic lure (ammonium acetate +putrescine) and 300 ml of water to capture flies		X	X	
Frutect® - Sticky trap pre-baited withproteinaceous material			X	
OBDT, FA-3 - Open Bottom Dry Trap with opaque green body, baited with three-component, synthetic lure (ammonium acetate +putrescine + trimethylamine) and a yellow sticky insert to capture the flies			X	X
IPMT, FA-3, wet - International Pheromone's PlasticMcPhail Trap baited with the three-component, synthetic lure (ammonium acetate +putrescine + trimethylamine) and 300 ml water + 2 drops surfactant to capture flies			X	X
IPMT, FA-3, dry - International Pheromone's PlasticMcPhail Trap baited with the three-component, synthetic lure (ammonium acetate +putrescine + trimethylamine) andDDVP (synthetic insecticide) to capture flies				X
Tephri, FA-3, wet - Tephri Trap baited with the three-component, synthetic lure (ammonium acetate + putrescine + trimethylamine) and 200 ml of water and two drops of surfactant to capture flies				X
Tephri, FA-3, dry - Tephri Trap baited with the three-component, synthetic lure (ammonium acetate + putrescine + trimethylamine) andDDVP (synthetic insecticide) to kill the flies				X

ILLUSTRATIONS OF THE TRAPS USED IN THE STANDARD PROTOCOL

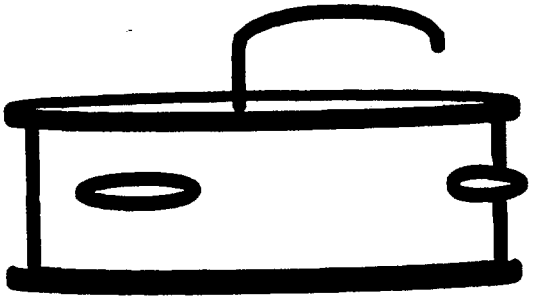
IT, TML (Trimedlure-baited Jackson trap) - This trap consisted of a triangular 12.7 x 9.5 x 8.5 ıigh white cardboard trap with a white sticky insert to capture the flies.



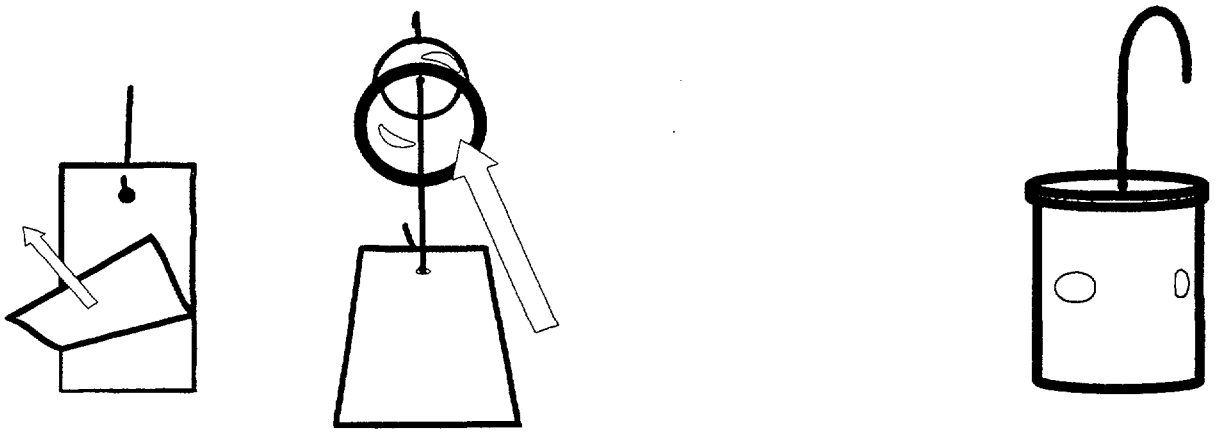
PMT (International Pheromone's McPhail trap) - This was a trap with two detachable plas :ontainers - a transparent top section (12.7 cm long x 16.5 cm diameter) and a yellow bottom secti 8 cm long x 17.5 cm diameter) with an invaginated area (8 cm x 5.5 cm diameter) which allowed : ly entry and created space for a liquid attractant. Synthetic lures were place on walls of the t :ylinder.



:BDT (Closed Bottom Dry Trap) - The dry trap body was a fluorescent green painted plastic sh hat formed a 15 cm long, 9 cm diameter, cylindrical container having three 2 cm diameter holes 1 ısect access. The bottom and the top of the trap consisted of two removable plastic petri dishes. T raps also contained a small toxicant square consisting of methomyl® + sugar to kill attracted flies.

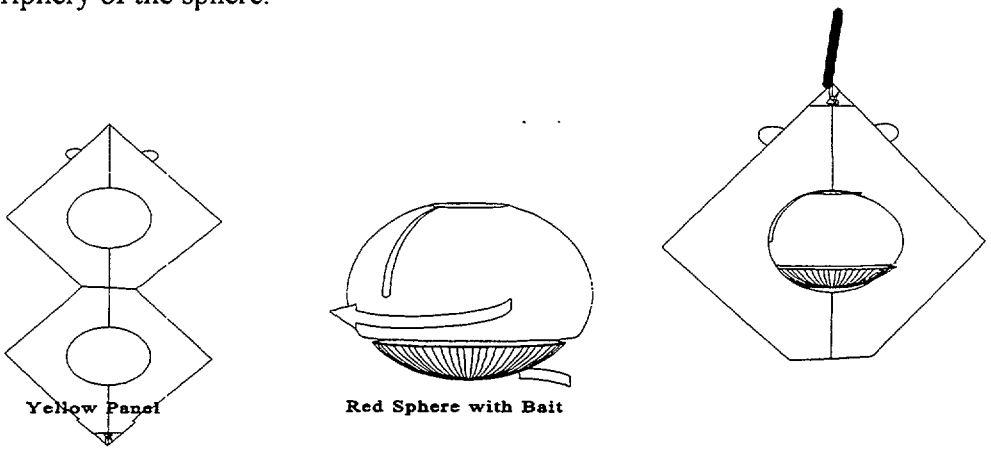


)BDT (Open Bottom Dry Trap) - The body of this dry trap was a green plastic sheet that formed 5 cm long, 9 cm diameter, cylindrical container having three 2 cm diameter holes for insect acce: 'he top of the trap was made from a plastic petri dish. A yellow sticky paper insert with a pre-appli dhesive was used to retain attracted flies.

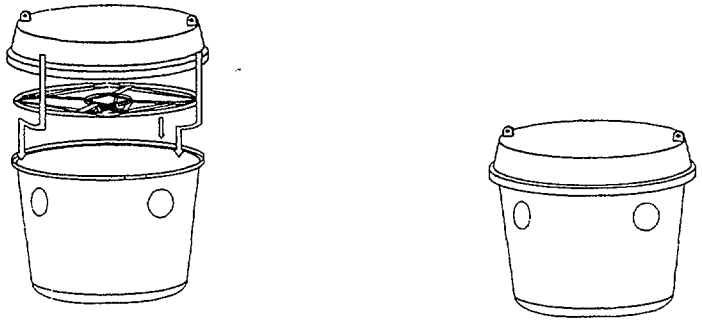


Sticky Insert

'rutect - This trap was a yellow sticky coated 40x40 cm panel with a dark red, 12.5 cm diamet phere, attached to the center of the panel. The sphere was pre-baited with a proteinaceous attracta laced in its interior, which was dispersed to the exterior via a sponge which formed a 1.0 cm band ı ıe outside periphery of the sphere.



'ephri - This trap was made of two attachable plastic containers. There was an upper transluc ection (4.0 cm long x 12.5 cm diameter) which gave support to the trap and a lower yellow secti 11.5cm long x 12.5 cm diameter) with an invaginated area (4.0 cm x 3.0 cm diameter) that allow or entry of flies and also created an area to hold liquid attractant.



Annex 3

COST ESTIMATE OF TRAPPING MATERIALS

Trapping devices and attractants tested in the present co-ordinated research programme under standard protocol included:

- JT , TML. (Jackson trap, Trimedlure baited)
- IPMT, NU+B (International Pheromone's Plastic McPhail Trap, protein-baited with 300 ml of an aqueous solution containing 9%NuLure + 3% borax)
- CBDT, FA-2 (Closed Bottom Dry Trap with opaque green band, baited with two-component synthetic lure, ammonium acetate +putrescine, and a toxicant square)
- OBDT, FA-2 (Open Bottom Dry Trap with opaque green trap body baited with two-component synthetic lure, ammonium acetate + putrescine, and with a yellow sticky insert to capture the flies)
- IPMT, FA-2 (International Pheromone's Plastic McPhail Trap baited with the two-component synthetic lure, ammonium acetate +putrescine, and 300 ml of water to capture flies)
- Frutect® (Sticky trap pre-baited withproteinaceous bait)
- OBDT, FA-3 (Open Bottom Dry Trap with opaque green trap body, baited with three-component synthetic lure, ammonium acetate + putrescine + trimethylamine, and a yellow sticky insert to capture the flies)
- IPMT, FA-3, wet (International Pheromone's Plastic McPhail Trap baited with the three-component, synthetic lure, ammonium acetate + putrescine + trimethylamine, and 300 ml water + 2 drops surfactant to capture flies)
- IPMT, FA-3, dry (International Pheromone's Plastic McPhail Trap baited with the three-component synthetic lure, ammonium acetate + putrescine + trimethylamine, and DDVP (synthetic insecticide) to capture flies)
- Tephri, FA-3, wet (Tephri trap baited with the three-component synthetic lure, ammonium acetate + putrescine + trimethylamine, and 200 ml of water and two drops of surfactant to capture flies)
- Tephri, FA-3, dry (Tephri trap baited with the three-component synthetic lure, ammonium acetate + putrescine + trimethylamine, and DDVP (synthetic insecticide) to kill the flies)

The prices below are estimates of material prices in US dollars based on information available in 1998. The listed price does not reflect discount with a large purchase. The country named in parentheses was the source of the material.

Traps/materials	Estimates of purchase price per unit in US dollars*
Jackson trap	*1.20 (USA)*
Jackson sticky insert	0.15 (UK)
Jackson trap hanger	0.16 (UK)
Trimedlure plug	1.30 (UK)

Basket for Trimedlure plug	0.50 (UK)
Open bottom dry trap - materials only	0.40 (Guatemala)
Yellow insert - precoated with stickum	0.32 (US)
McPhail plastic trap, clear cylindrical top and yellow bottom	7.50 (UK)
NuLure (1 liter)	2.10 (US)
Borax (1 kg)	29.40 (US)
DDVP insecticide dispenser	0.15 (US)
Two component synthetic lure (ammonium acetate +putrescine)	2.75 (US)
Three component synthetic lure (ammonium acetate +putrescine + trimethylamine)	3.50 (US)
Tephri trap	6.50 (Spain)
Frutect® Sticky trap pre-baited withproteinaceous bait	

Annex 4

SUMMARY OF RESULTS OBTAINED DURING LAST YEAR OF CRP IN COUNTRIES HAVING WILD MEDFLIES. COLUMNS LABELED TRAP - LURE - RETENTION INDICATES THE MOST EFFICACIOUS FEMALE MEDFLY TRAPPING SYSTEM.

Country	Host	Months of Tests	Temperature Min. - Max.	AVG Temp	Rain Total (mm)	R.H. Min. - Max	Trap	Lure - Retention	Average Flies/ Trap/ Day
Greece Site 1	Mandarin, Orange, lemon	8 - 9	20.5 - 28.8	27	0	57 - 63	IPMT	FA-3/Wet	4.9
Greece Site 1	Mandarin, Orange, lemon	8 - 9	20.5 - 28.8	27	0	57 - 63	IPMT	FA-3/Wet	8.5
Turkey Site 1	Mandarin	10-11	4.0 - 26.4	16		37 - 93	Tephri	FA-3/Wet	3.9
Turkey Site 2	Peach, Quince, Mandarin	9 - 11	6.9 - 29.2	19		26.5 - 98	Tephri	FA-3/Dry	9.05
Spain Site 1	Mango	9 -11	8.7 - 33.6	20	171	23.6 - 95.3	Tephri	FA-3/Wet	23.2
Spain Site 2	Orange (Navelate)	9 -11	8.7 - 33.6	20	171	23.6 - 95.3	Tephri	FA-3/Wet	16.3
Spain Site 3	Chirimoya	9 -11	8.7 - 33.6	20	171	23.6 - 95.3	Tephri	FA-3/Dry	12.0
Spain Site 4	Orange (Valencia)	9 -11	8.7 - 33.6	20	171	23.6 - 95.3	Tephri	FA-3/Dry	1.9
Portugal Site 1	Citrus	5 - 7	13 - 22	20	57	45 - 95	Tephri	FA-3/Dry	1.23
Portugal Site 2	Citrus	10 - 11	18 - 22	18	248		IPMT	FA-3/Dry	10.41
Morocco Site 1	Argan	7 - 9	17 - 30			54.7 - 97.7	IPMT	FA-3/Wet	24
Morocco Site 2	Citrus	7 - 9	17 - 30			54.7 - 97.7	IPMT	FA-3/Wet	23
Israel Site 1	Citrus	7 -8	19 - 29		0	53.5 - 72.7	Tephri	FA-3/Dry	91.1
Israel Site 2	Mango	5 -7	22.2 - 37.9		0	14.8 - 37.7	IPMT	FA-3/Wet	0.27

Country	Host	Months of Tests	Temperature Min. - Max.	AVG Temp	Rain Total (mm)	R.H. Min. - Max	Trap	Lure - Retention	Flies/ Trap/ Day
Mallorca Site 1	Citrus	10 - 12					IPMT	FA-3/Dry	0.01
Mallorca Site 2	Citrus	4 - 5					Tephri	FA-3/Wet	0.028
South Africa Site 1	Plum	12 -1	10 - 25		80		IPMT	FA-3/Wet	0.47
South Africa Site 2	Pear	12 -1	12 - 29		0		Tephri	FA-3/Wet	11.33
Mauritius Site 1	Indian Almond	1 - 3	28.2 - 31.7			78.1 - 94.4	IPMT	FA-3/Wet	1.31
Mauritius Site 2	Indian Almond	1 - 3	19.9 - 29.4			40 - 99	IPMT	FA-3/Wet	0.22
Costa Rica Site 1	Citrus	12 - 1	15 - 24	22		40 - 100	PMT	FA-3/Dry	8.24
Costa Rica Site 2	Citrus + Coffee	12 - 1	15 - 24	22		40 - 100	PMT	FA-3/Dry	14.95
Honduras Site 1	Coffee	10 - 1	17 - 31.9	24		45 -100	OBDT	FA - 3	216
Honduras Site 2	Coffee		18 - 30.9	22.1		60 - 100	Tephri	FA-3/Wet	0.76
Guatemala Site 1	Coffee	10 -2					CC2*	Insert	0.02
Guatemala Site 2	Coffee	10 -2					CC1*	Insert	4.04
Guatemala Site 3	Coffee	10 -2					CC1*	Insert	0.03
Guatemala Site 4	Pear	10 -2					Tephri	FA-3/Wet	0.034

* Co-operators choice, see document for details.

BIBLIOGRAPHY

BAKRI, A., HADIS, H., EPSKY, N.D., HEATH, R.R., HENDRICHS, J., Female *Ceratitis capitata* (Diptera: Tephritidae) capture in a dry trap baited with a food-based synthetic attractant in an argan forest in Morocco: I – Low population field test. Canadian Entomol. **130** (1998) 349–356.

EPSKY, N.D., HEATH, R.R., Exploiting the interactions of chemical cues and visual cues in behavioral control measures for pest tephritid fruit flies, Fla. Entomol. **81** 3 (1998) 273–282.

EPSKY, N.D., et al., Field evaluation of female-targeted trapping systems for *Ceratitis capitata* (Diptera: Tephritidae) in seven countries, J. Econ. Entomol. (in press).

EYLES, D.K., DU PLESSIS, N., BARNES, B.N., "Development of female medfly, *Ceratitis capitata* (Wiedemann) attractant systems for trapping and sterility assessment in South Africa", Area-Wide Management of Fruit Flies and Other Major Insect Pests (Tan, K.H., ed.) (in press).

GAZIT, Y., ROSSLER, Y., EPSKY, N.D., HEATH, R.R., Trapping females of the Mediterranean fruit fly (Diptera: Tephritidae) in Israel: comparison of lures and trap types, J. Econ. Entomol. (in press).

HEATH, R.R., EPSKY, N.D., DUEBEN, B.D., MEYER, W.L., Systems to monitor and suppress *Ceratitis capitata* (Diptera: Tephritidae) populations, Fla. Entomol. **79** 2 (1996) 144–153.

HEATH, R.R., EPSKY, N.D., DUEBEN, B.D., RIZZO, J., FELIPE, J., Adding methyl-substituted ammonia derivatives to food-based synthetic attractant on capture of the Mediterranean and Mexican fruit flies (Diptera: Tephritidae), J. Econ. Entomol. **90** 6 (1997) 1584–1589.

KATSOYANNOS, B.I., HEATH, R.R., PAPADOPOULOS, N.T., EPSKY, N.D., HENDRICHS, J., Field evaluation of Mediterranean fruit fly (Diptera: Tephritidae) female selective attractants for use in monitoring, mass trapping and sterile insect technique programs, J. Econ. Entomol. (in press).

KATSOYANNOS, B.I., PAPADOPOULOS, N.T., HEATH, R.R., HENDRICHS, J., KOULOUSSIS, N.A., Evaluation of synthetic food-based attractants for female Mediterranean fruit flies (Dipt., Tephritidae) in McPhail type traps, J. Appl. Entomol. (in press).

KATSOYANNOS, B.I., PAPADOPOULOS, N.T., KOULOUSSIS, N.A., Mediterranean Fruit Fly Female Attractant Studies in Support of the Sterile Insect Technique: Trapping Experiments Conducted on the Island of Chios, Greece. IAEA/FAO technical report (in preparation).

KATSOYANNOS, B.I., PAPADOPOULOS, N.T., KOULOUSSIS, N.A., HEATH, R.R., HENDRICHS, J., Development of a system of assessing the fertility of *Ceratitis capitata* in SIT programs, J. Econ. Entomol. (in press).

KATSOYANNOS, B.I., PAPADOPOULOS, N.T., LOULOUSSIS, N.T., HEATH, R.R., HENDRICHS, J.A., Method of assessing the fertility of wild *Ceratitis capitata* (Diptera: Tephritidae) females for use in sterile insect technique programs, J. Econ. Entomol. (in press).

ROS, J.P., A general view of recent advances on attractants and traps against *Ceratitis capitata* Wied. (Diptera: Tephritidae). Fruit Flies of Economic Importance, IOBC Bulletin **20** 8 (1997)

ROS, J.P., et al., Ensayos para el control de la mosca mediterránea de la fruta *Ceratitis capitata* Wied. Mediante técnicas que limiten los tratamientos insecticidas, Bol. San. Veg. Plagas **22** (1996) 703–710.

ROS, J.P., et al., Evaluación en campo de varios atrayentes de hembras de la mosca mediterránea de la fruta *Ceratitis capitata* Wied. (Diptera: Tephritidae). Bol. San. Veg. Plagas. **23** (1997) 393–402.

ROS, J.P., GARIJO, C., NAVARRO, L., CASTILLO, E., Ensayos de campo con un nuevo atrayente de hembras de la mosca mediterránea de la fruta *Ceratitis capitata* Wied. (Diptera: Tephritidae), Bol. San. Veg. Plagas **22** (1996) 151–157

ROS, J.P., WONG, E., CASTRO, V., CASTILLO, E., La Trimetilamina: un efectivo potenciador de los atrayentes Putrescina y Acetato Amónico para capturar hembras de la mosca mediterránea de la fruta *Ceratitis capitata* Wied.(Diptera: Tephritidae), Bol. San. Veg. Plagas. **23** (1997) 515–521.

VASQUEZ, L.A., Evaluación de trampas húmedas y secas para la captura selectiva de hembras adultas de la mosca del mediterráneo *Ceratitis capitata* (Wiedemann). Manejo Integrado de Plagas, CATIE (in press)

VASQUEZ, L.A., DIAZ F.J., Selección de métodos para captura de hembras de *Ceratitis capitata*, Manejo Integrado de Plagas, CATIE **49** (1998) 42–50.

LIST OF PARTICIPANTS

Alemany, A.	Universitat de les Illes Baleurs, Edifici Darwein, Campus Universitari, Cra. de Valldemossa, km 7.5, E-07071 Palma de Mallorca Balears, Spain e-mail: dbsaat@ps.uib.es
Bakri, A.	Faculty of Science Semlalia, University of Cadi Ayyad, B.P. S/15 Marrakech 40 000, Morocco e-mail: bakri@cybernet.net.mar
Barnes, H.	ARC-Fruit, Vine and Wine Research Institute, Private Bag X5013, Stellenbosch, 7599 South Africa e-mail: brian@infruit2.agric.za
Camacho, H.	Laboratorio de Investigacion en Mosca del Mediterráeo, Escuela de Biologia, Universidad de Costa Rica, Costa Rica e-mail: hernanc@cariari.ucr.ac.cr
Epsky, N.	Center for Medical, Agricultural and Veterinary Entomology, USDA-ARS, 1700 SW 23rd Drive, Gainesville, Florida 32602, United States of America e-mail: afn27201@freenet.ufl.edu
Gazit, Y.	Biological Control Institute, Citrus Marketing Board of Israel, P.O. Box 80, Bet Dagan 50250, Israel e-mail: yogazit@netvision.net.il
Heath, R.	Center for Medical, Agricultural and Veterinary Entomology, USDA-ARS, 1700 SW 23rd Drive, Gainesville, Florida 32602, United States of America e-mail: Bheath@gainesville.usda.ufl.edu
Hendrichs, J.	Insect and Pest Control Section, International Atomic Energy Agency, P.O. Box 100, A-1400 Vienna, Austria e-mail: j.hendrichs@iaea.org
Howse, P.	Chemical Entomology Unit, School of Biological Sciences, University of Southampton, SO16 7PX, United Kingdom e-mail: P.E.Howse@soton.ac.uk
Jerónimo, F.	Moscamed Programme, 6a Calle 1-36, Zona 10, Edificio Valsari, Of. 203, Guatemala City 01010, Guatemala e-mail: ppq@guate.net

Katsoyannos, B.	Department of Agriculture, University of Thessaloniki, GR-540 06 Thessaloniki, Greece e-mail: katsoy@agro.auth.gr
Lindquist, D.	Entomology Consultant, Friedlgasse 25/2, A-1190 Vienna, Austria e-mail: DLINDQUIST1@compuserve.com
Montoya, P.	Programe Moscamed, DGSV-SARH, 2da. Ave. Sur no. 5 Altos, C.P. 30700 Tapachula, Chiapas, Mexico e-mail: moscamed@acnet.net
Pereira, R.	Programe Madeira-Med, Estrada Eng° Abel Veira, 9135 Camacha — Madeira, Portugal e-mail: madeira.ram@dra.mailpac.pt
Ros Amador, J.P.	Instituto Nacional de Investigaciones Agrarias, Carretera Coruña Km. 7, Apdo. 8111, E-28020 Madrid, Spain e-mail: ros@inia.es
Rössler, Y.	Biological Control Institute, Citrus Marketing Board of Israel, P.O. Box 80, Bet Dagan 50250, Israel e-mail: rossler@netvision.net.il
Vásquez, L.	Fundación Hondureña de Investigación Agricola, Apdo. 20607, San Pedro Sula, Honduras e-mail: lav@simon.intertel.hn
Vattuone, E.	Facultad de Ciencias Agrarias, Universidad Nacional de Catamarca, Avda. Belgrano y Maestro Quiroga St., 4700 Catamarca, Argentina
Zümreoglu, A.	Plant Protection Research Institute, Zirai Mücadele Arastirma Enstitüsü, 35040 Bornova, Izmir, Turkey