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

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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 TREATMENTDe,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.