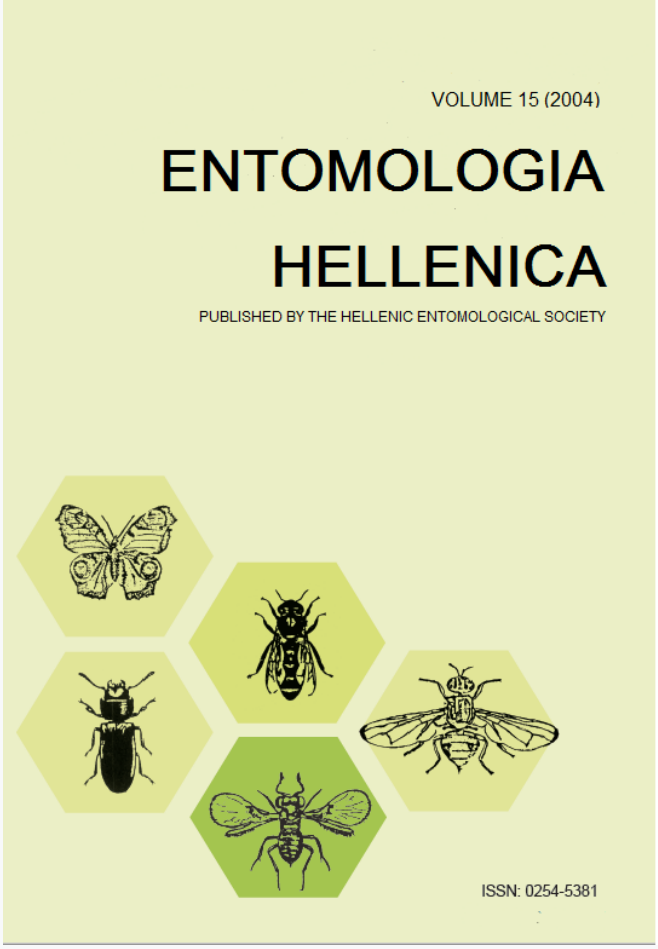
ENTOMOLOGIA HELLENICA

Τόμ. 15 (2004)



Σύγκριση διαφόρων παγίδων και ελκυστικών ουσιών της μύγας της Μεσογείου Ceratitis capitata (Diptera: Tephritidae) σε πειράματα υπαίθρου το φθινόπωρο

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ENTOMOLOGIA HELLENICA **15** (2003-2004)

Comparative field studies of various traps and attractants for the Mediterranean fruit fly *Ceratitis capitata* (Diptera: Tephritidae) in fall

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ABSTRACT

To clarify questions regarding the effectiveness of the many differenttypes of traps and Semiochemicals used for the monitoring and the control of theMediterranean Fruit Fly, *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae), seven trap types, four food attractants, one sex attractant and a combination of food and sex attractant, were evaluated under field conditions in orange orchards in fall. No major differences were observed between trap designs resembling the original McPhail glass trap. The plastic bottle trap of 1,5L volume, with four side openings for one-way fly entrance, proved very efficient when filled with a proteinaceous food attractant Z_1. From the attractants, two of them, Z_1 and Entomela showed the best performance. The combination of food and a sex attractant showed no significant synergistic effects on trap efficiency. The findings allow a better choice among trap types and attractants, available today in the market©, for Medfly monitoring and control.

Introduction

The Mediterranean fruit fly, (Medfly) *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae), infests more than 250 species of fruits and vegetables around the world (Liquido et al., 1991). In Greece, the Medfly causes serious damage to citrus, figs, apples, pears, apricots, peaches and various vegetables.

Cover sprays and, rarely, bait sprays are the main control methods of Medfly populations in Greece. The sprays are usually applied empirically based on thecalendar rather on systematic observations and monitoring of the insect populations. Commercial pressure for the production of fruits and juices without any insect damage or insecticide residues makes it important to find alternative control methods. Thus, effective and long acting mass trapping would help to eliminate or reduce the use of chemical treatments. The Medfly, as with most Tephritid flies of economic importance, strongly responds to stimuli, such as food attractants (Delrio and Ortu 1988, Heath et al., 1995,1997, Zervas

© At present Z_1 is available from G. Zervas for experimental purposes.

1993, Bakri et al., 1998, Epsky et al., 1999, Katsoyannos et al., 1999, Gazit et al. 1998), visual attractants (Cytrynowicz et al., 1982) and sex attractants (Cunningham, 1989). An important role seems to be played by optical and chemical stimuli from the host fruits (Levinson et al., 1990, Katsoyannos, 1987).

A variety of traps combining one or more of the above attractants have been constructed and evaluated in the field for the Medfly, including those with flat yellow surfaces of plastic or wood, delta (triangular), glass McPhail (Michelakis, 1988) and traps of the bottle type with side holes for one-way insect entrance (Zervas, 1994, 1999). Attempts for fly mass trapping with different types of traps and different attractants produced encouraging results. The most satisfactory results as far as efficiency and duration were achieved with the combination of McPhail modified traps with a food attractant and inverted cap traps with trimedlure (TML) as sex attractant (Zervas et al., 1997).

The goal of this work has been to evaluate the various trap types and attractants, in order to develop an efficient method of mass trapping for the control of the Mediterranean fruit fly free of any chemical sprays. The reported experimental data cover the fall season of 3 consecutive years (1997-1999).

Materials and Methods

The experiments took place in orange orchards at Marathon, Attica, with medium size tree of the Navel variety. The choice of orange orchards was based on similarity of tree size and the general condition of the trees. The experimental orchards as well as the adjusted ones were free of any insecticide treatments.The traps were placed in the tree canopy at a height of about 2m, in every other tree of every second row. The captured flies on or inside the traps were counted every 7-10 days (experiments 1998, 1999) or at the end of the experimental period (experiment 1997).

A completely randomized block design was used with 9-10 replicates, except experimental C11, 1999, which had 5 replicates.Seven trap types, four food attractants, one male attractant and a combination of food and male attractants were included in the trials.

Trap types

1. McPhail traps made of plastic[1]. The trap is divided in upper (transparent) and lower (yellow) halves fastened together with a volume of 600 ml. Insects enter the trap through an opening in its lower half, having a diameter of 4cm.
2. McPhail traps yellow plastic with a volume of 300 ml[2].
3. Glass and plastic trap[3] consisting of two parts connected together: one glass vase ca. 500ml and a plastic yellow part with a side entrance of 3 cm diameter.
4. Paper folded traps[3] consisting of two parts: a flask of a volume of 300ml, having underneath a 17.5X24.5 cm, light green paper folded down to the middle to form a roof. The flask has a specially functioning stopper with a support system, for serving the trap.
5. Paper envelope[4], 15X20cm, of light green color, lined inside with a waterproof plastic membrane containing ammonium bicarbonate. This trap has been used for the control of the olive fruit fly (*Bactrocera oleae*) with satisfactory results (Broumas *et al.*, 1998). This trap combines food attractant with a sex attractant as well as a toxic factor (insecticide) on its surface acting as a killing agent.

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[1] "Standard", E. Pantelakis, Athens, Greece.
[2] G. Gianadakis, Chania, Crete, Greece.
[3] "ELKOFON"., Phytophyl, G. Stavrakis, Shimatari Viotias, Greece.
[4] "ECO TRAP"., VIORYL Limited., Athens, Greece.

For the assessment of trap's attractiveness, sticky glue of long duration was placed on the trap's surface.

6.Colorless plastic bottle trap[1], with a volume of 1.5L, a base diameter of 8cm and a height of 30cm, with four side holes of a diameter of 1.5cm, supplied with horizontal tubes for the one-way insect entrance, at a height of 20cm from the base (Zervas 1994, 1999).

7. Dry trap[5] with Trimedlure (TML) as attractant and DDVP[8] as killing agent.
The trap is constructed from a colorless 1.5L plastic bottle with a rectangular opening in one of the side walls and with a receptor for the collection of the dead flies (Zervas *et al.*, 1997).

Attractants

1.Dacus bait 100[6]. A water solution of the attractant (9%) with borax (3%) inside the following trap types: McPhail, glass-plastic, paper folded and plastic flask.

2.Entomela 12 SL[3]. A special attractant for fruit flies with a 50% protein decomposition products, used in the glass-plastic and paper folded traps.

3. Ammonium bicarbonate in ECO-TRAP[4] traps with 70 gr in each trap.

4. Attractant with the code number Z_1 [5], which belongs to the category of food attractants, in a solution of (1%) attractant and (3%) borax, is a product of enzymatically hydrolyzed food attractant of plant origin.

5.Trimedlure in a dispenser[7] with 2 gr a.i. and with 1gr a.i. (VIORYL S.A. Athens, Greece). The dispensers were placed in plastic flasks (no. 7 trap) without the use of aqueous solution or sticky glue (trap of the dry type). The attracted insects were killed using DDVP (VAPONA)[8]

The combinations of traps and attractants tested were as follows:

1997 Experiment A. (September 1-November 15)

1.Type McPhail, the volume of the McPhail trap was 600ml and only the underneath half of the trap was of yellow color and Dacus bait 100 (MI+DB)

2.Type McPhail, the volume of the McPhail trap was 300ml and the whole trap was of yellow color and Dacus bait 100 (MII+DB)

3.Glass-plastic and Dacus bait 100 (GP+DB)

4.Paper folded and Dacus bait 100 (PF+DB)

5.Colorless plastic flask, and Dacus bait 100 (CP+DB)

6.Glass-plastic and Entomela (GP+E)

7.Paper folded and Entomela (PF+E)

8.ECO-TRAP, and Ammonium bicarbonate (ET+AB)

9.Colorless plastic bottle and Z_1 (CP+ Z_1)

10.Colorless plastic flask (Dry trap), and (2gr./trap) TML[#] (CP+2TML)

11.Colorless plastic flask (Dry trap) and (1gr./trap) TML[#] (CP+1TML)

1998 Experiment B.I. (22 October-10 December)

1.Glass-plastic and Entomela (GP+E)

2. ECO-TRAP and Ammonium bicarbonate (ET+AB)

3. Colorless plastic bottle and Z_1 (CP+ Z_1)

4.Colorless plastic flask (Dry trap), and (2gr/trap) TML (CP+2TML)

5.Colorless plastic flask (Dry trap), and (1gr/trap) TML (CP+1TML)

6.ECO-TRAP, and Ammonium and (1gr/trap) TML (ET+AB+1TML)

1998 Experiment B.II. (23 October-10 December)

1.Glass-plastic and Entomela (GP+E)

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[5] Zervas, Demokritos, Athens, Greece

[6] Alesis S.A., Thesaloniki, Greece

[7] Agrisence, ®

[8] D.D.V.P. (20% a.i. dichlorvos), tablets

[#] TML, stands for Trimedlure

2.ECO-TRAP and Ammonium bicarbonate bicarbonate (ET+AB)
3.Colorless plastic bottle and Z_1 (CP+ Z_1)

1999 Experiment C.I. (24 September-30 December)
1.Glass-plastic and Entomela (GP+E)
2.ECO-TRAP and Ammonium bicarbonate (ET+AB)
3.Colorless plastic bottle, and Z_1 (CP+ Z_1)

1999 Experiment C.II. (24 September-30 December)
1.ECO-TRAP, and Ammonium bicarbonate (ET+AB)
2.ECO-TRAP, and Ammonium bicarbonate and TML (EC+AB+TML)[∝]
3.ECO-TRAP, and Ammonium bicarbonate, TML (out of the trap) (EC+AB-TML)[*]

In experiment A, eleven combinations were tested, involving seven trap types (two McPhail type, glass-plastic, paper folded, colorless plastic bottle, dry trap, ECO-TRAP) and five different attractants (Dacus bait 100, Entomela, ammonium bicarbonate, Z_1, Trimedlure).

In experiment B.I., six combinations were tested: glass-plastic with Entomela, ECO-TRAP with ammonium bicarbonate, colorless plastic bottle with Z_1, dry trap with 2gr and 1gr. of Trimedlure and ECO-TRAP with a combination of ammonium bicarbonate and 1gr Trimedlure.

In experiment B.II., three trap types were tested: glass-plastic, ECO-TRAP and colorless plastic bottle with the following attractants: Entomela, ammonium bicarbonate and Z_1. The aim was to check their efficiency in the absence of Trimedlure, excluding any interaction between attractants and Trimedlure (which is a long range attractant).

In experiment C.I., three trap types were tested: glass-plastic trap with Entomela, ECO-TRAP with ammonium bicarbonate and colorless plastic bottle with Z_1.

In experiment C.II., trap efficiency was tested when food attractants were combined with Trimedlure in the same or in a separate trap. For this reason ECO-TRAP was compared with the following attractants: ammonium bicarbonate (as a blank), ammonium bicarbonate + Trimedlure in the same trap and ammonium bicarbonate and Trimedlure separately, 1m apart, in the same tree. Meteorological data for the three years were obtained from the Marathon Meteorological Station, of the National Meteorological Service.

Results

The results of experiment A are presented in Figure 1. The colorless plastic flask dry type trap baited with Trimedlure captured the highest number of males. There were no statistically significant differences in male captures amongst the rest of the cases. Z1 in the colorless plastic bottle attracted significantly more female insects than the Dacus bait 100 in the same type of trap. It also performed better in capturing more female insects than all the other cases, regardless of trap type or attractant.

Amongst the other cases, important differences were not observed in the number of captured female insects, with the exception of the glass-plastic trap with Dacus bait 100, which performed better than the McPhail type traps with the Dacus bait 100 attractant and the paper traps with attractants such as Entomela and ammonium bicarbonate.

[∝] Both attractants on the same trap
[*] Ammonium bicarbonate in the trap, dispenser 1m away the trap on the same tree

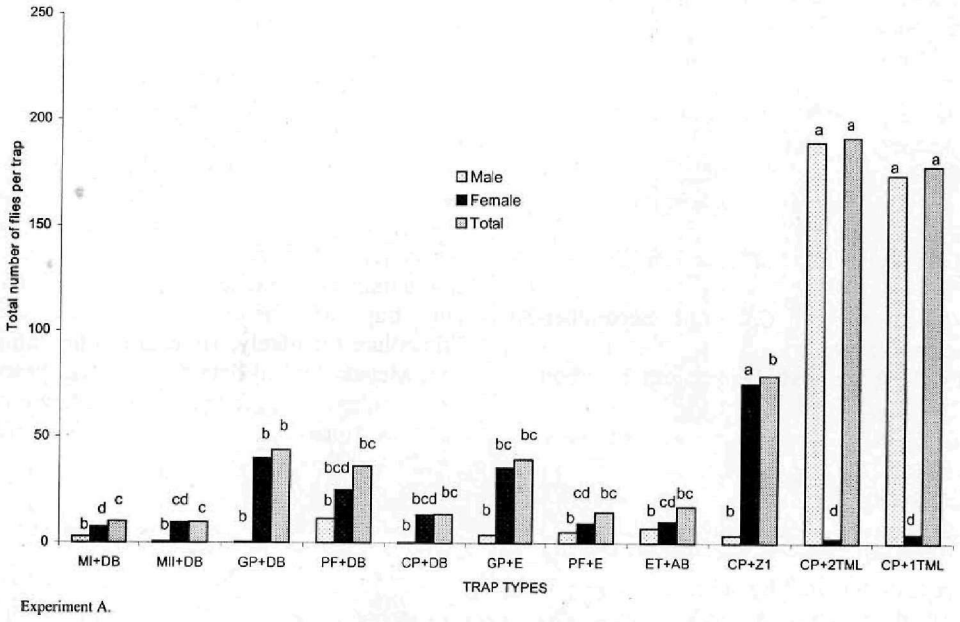
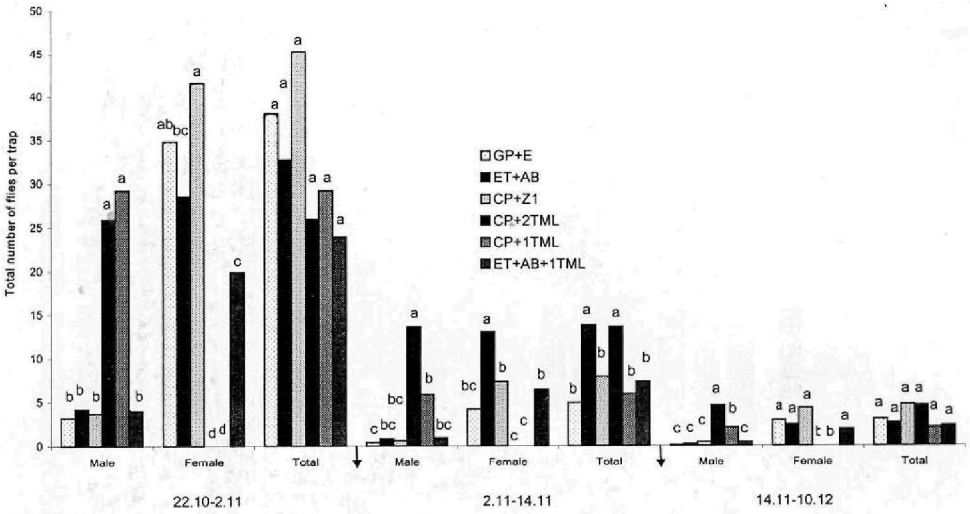


Fig. 1. Total numbers of captured adults of the Mediterranean fruit fly in different trap types and attractants from 1 September to 15 November 1997. Mean number of 9 replicates. Means, for each sex, with same letters are not significantly different, according to Duncan's multiple range test, (P>0.05).

The results of experiment B.I. are presented in Figure 2a. The choice of traps and attractants tested (glass-plastic with entomela, ECO-TRAP with ammonium bicarbonate, plastic bottle with Z1, Plastic flask with Trimedlure) were determined on the basis of their effectiveness in experiment A. The choice of trap type and attractants were combinations of those that exhibited the same effectiveness, and was based on the selective action of the attractant. So, between the two attractants Dacus bait 100 and Entomela in the glass-plastic trap and Dacus bait 100 in the paper folded trap which showed similar effectiveness, the Entomela was chosen due to the selectivity of attracting a significantly smaller number of beneficial insects, mainly Hymenoptera, against the attractants of protein nature (Broumas, unpublished results). Captures of male insects with Trimedlure alone were significantly higher in comparison with the other attractants, independent of the trap type used.

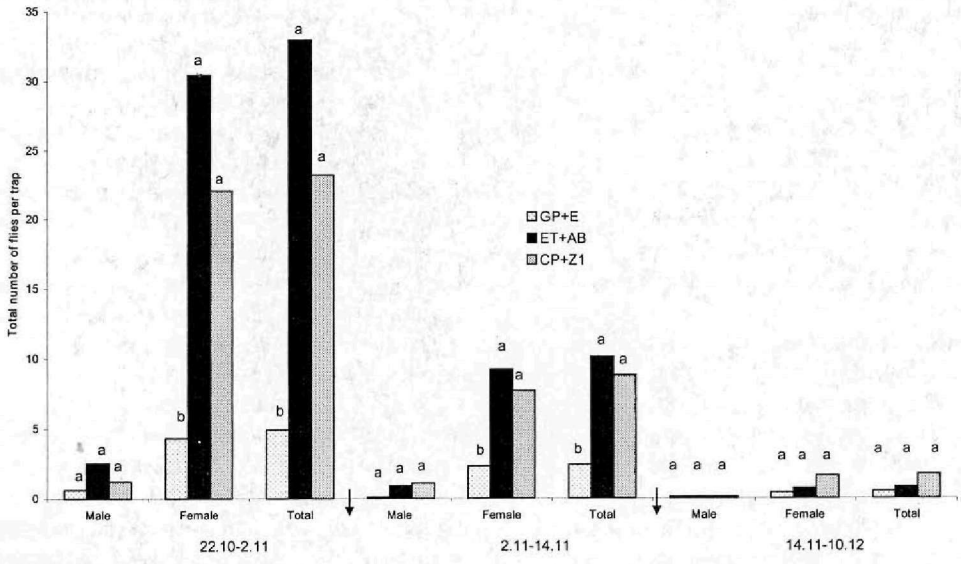
The results of experiment B.II are presented in Figure 2b. The captures of male insects varied at low population levels, without any significant differences between the three cases. The capture of female insects in the ECO-TRAP with ammonium bicarbonate and the colorless plastic bottle with Z1 were significantly higher than those in the glass-plastic trap with Entomela.

From the results of experiment C.I, Figures 3a and 3b, it is concluded that the plastic flask with attractant Z1 captured a larger total number of insects than the other two types of trap, on the basis of all measurements taken during the whole experiment (24.9-30.12.1999), without however, the above differences always being statistically significant during different periods.



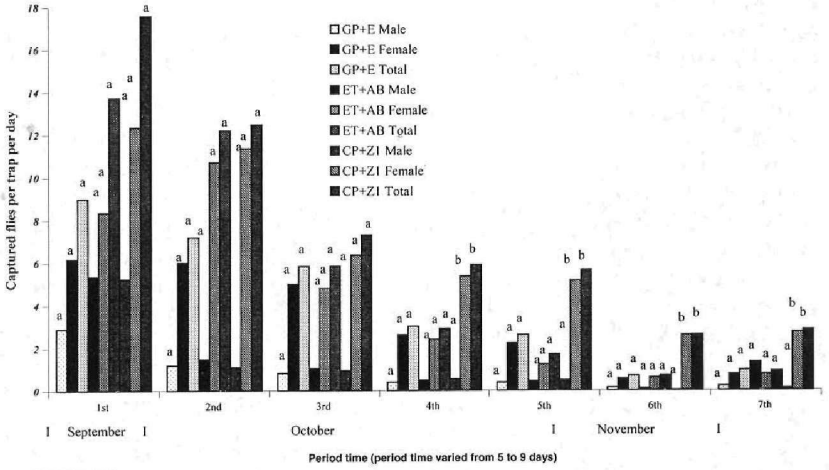
Experiment B.I

Fig. 2a. The number of captured adults of the Mediterranean fruit fly in different types of traps, during different periods from 22 of October until 10 December of 1998. Mean number of 10 replicates. Means, for each sex, with same letters are not significantly different, according to Duncan's multiple range test, (P>0.05).



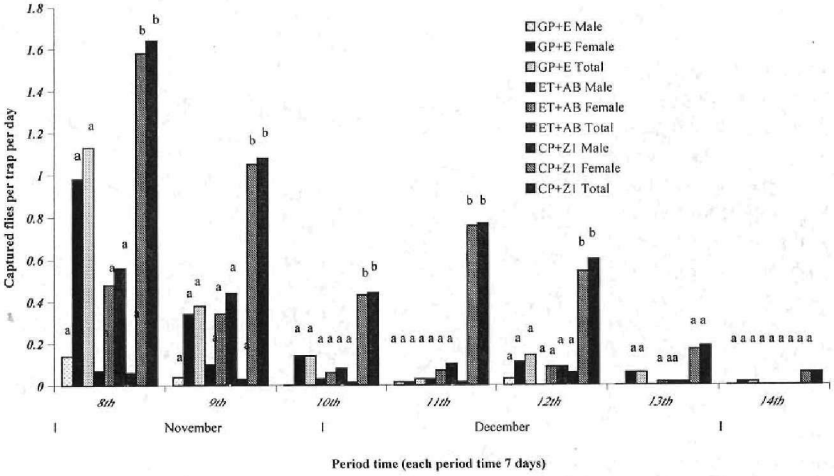
Experiment B.II

Fig. 2b. The number of captured adults of the Mediterranean fruit fly in different types of traps, during different periods from 22 of October until 10 December of 1998. Mean number of 10 replicates. Means, for each sex, with same letters are not significantly different, according to Duncan's multiple range test, (P>0.05).



Experiment C.I

Fig. 3a. Numbers of Ceratitis capitata adults captured in different traps during different time periods from September 24 to November 11, 1999. Means of 10 traps. Means, for each sex and time period, with same letters are not significantly different, according to Duncan's multiple range test, (P>0.05).



Experiment C.I

Fig. 3b. Numbers of Ceratitis capitata adults captured in different traps during different time periods from November 11 to December 24, 1999. Means of 10 traps. Means, for each sex and time period,with same letters are not significantly different, Duncan's multiple range test, P>0.05.

The differences appear to be significant in the middle of October and later, due to the large number of captured female insects. Between the glass-plastic trap with Entomela and ECO-TRAP trap with ammonia, the latter attracted a large number of both sexes during the period 24.9-7.10, without, however, these differences being statistically significant.

Finally, from experiment C.II, Figures 4a and 4b, it was found that the combination of the two attractants ammonium bicarbonate and Trimedlure in the same trap contributed only to increased captures of male insects.The placement of Trimedlure separately from the food attractant, at the same tree,at a distance of 1m does not appear to contribute significantly in increasing captures of female insects. However, if the captures of females are expressed as a percentage of the total captures, the trap with only ammonium bicarbonate has the highest percentage of female captures, followed by the combination of ammonium bicarbonate plus TML outside of the trap and the ammonium bicarbonate plus TML on the trap.

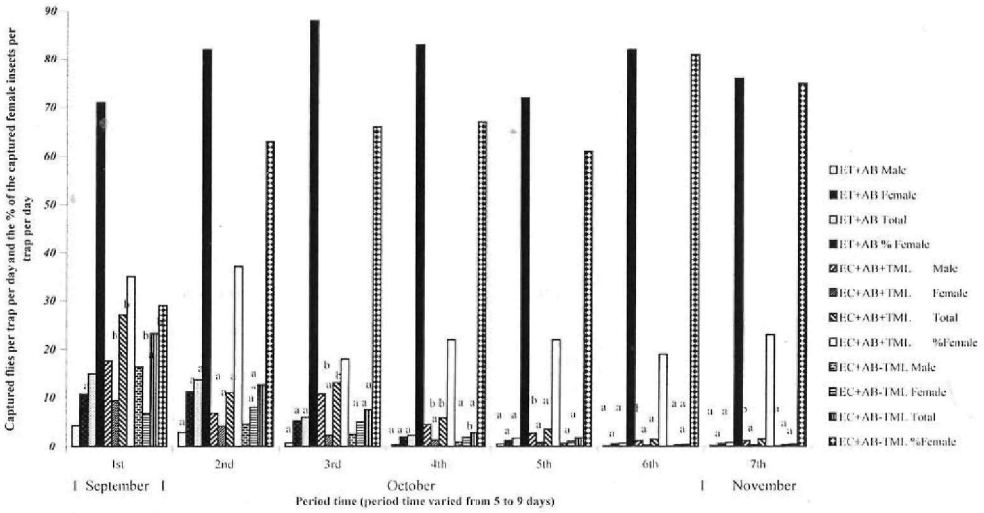
Discussion

Medfly response to food and/ or sex attractants is a complex process involving many factors and parameters, biological and /or environmental. Thus, variations in trap attractancy and effectiveness are observed between different years, or even between different months of the same year. Variables such as medfly population density, host(s) availability, natural food sources, as well as environmental temperature and humidity, (Figures 5a,5b and 5c) create a very specific, interacting bioenviromental complex. The three-year comparative field experiments presented in this paper, have clarified several questions regarding the effectiveness of the many different types of traps and attractants used for medfly population monitoring and control. They have also provided some indication as to which is the best trap and lure combination®.

The plastic bottle with attractant Z1 performed best in absolute numbers from the point of view of capturing female insects during the period of high population density (22.10-2.11). However, the performance of this trap was not statistically different from the glass-plastic trap with Entomela, which was also effective without being different from the ECO-TRAP containing as attractant ammonium bicarbonate. During the period of low population density (2.11-14.11) it was generally observed that there was a tendency for a high number of captures in the ECO-TRAP with ammonium bicarbonate (attractant in dry form) compared to traps with liquid attractants. One explanation may be that high humidity favors the evolution of ammonia from the ECO-TRAP whereas the evaporation from liquid traps was not that high under these conditions. During the rest of the period (14.11-10.12) the insect population was too low to consider any statistically significant differences.

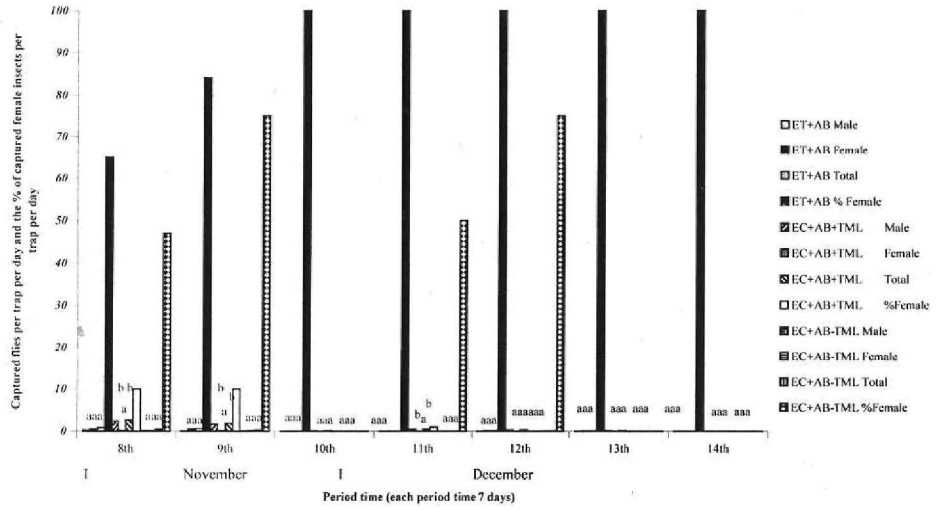
The combination of the two attractants in the ECO-TRAP (Trimedlure and ammonium bicarbonate) does not seem to contribute to increased captures when compared with the same trap with only ammonium bicarbonate as attractant, which however, attracted a greater number of female insects. More specifically, in experiment A the sex specific attractancy exhibited between food attractants for females, and the sex attractant (TML) for males, is attributed to natural female attractancy to protein sources in order to get the protein needed for oogenesis, while, male attractancy to TML is reflecting males searching activity to locate potential female mates. Taking into account total

® Biolure should be included, but, unfortunately at the time experiments were conducted it was not available in the Greek market.



Experiment C.II

Fig. 4a. Mediterranean fruit fly adults captured in different traps and attractants in different time periods from 24 September to 11 November 1999. Means of 5 replicates. Means of numbers of flies and percentages, followed by the same letter are not statistically significant according to Duncan's multiple test (P=0.05).



Experiment C.II

Fig. 4b Mediterranean fruit fly adults captured in different traps and attractants in different time periods from 11 November to 30 December 1999. Means of 5 replicates. Means of numbers of flies and percentages, followed by the same letter are not statistically significant according to Duncan's multiple test (P=0.05).

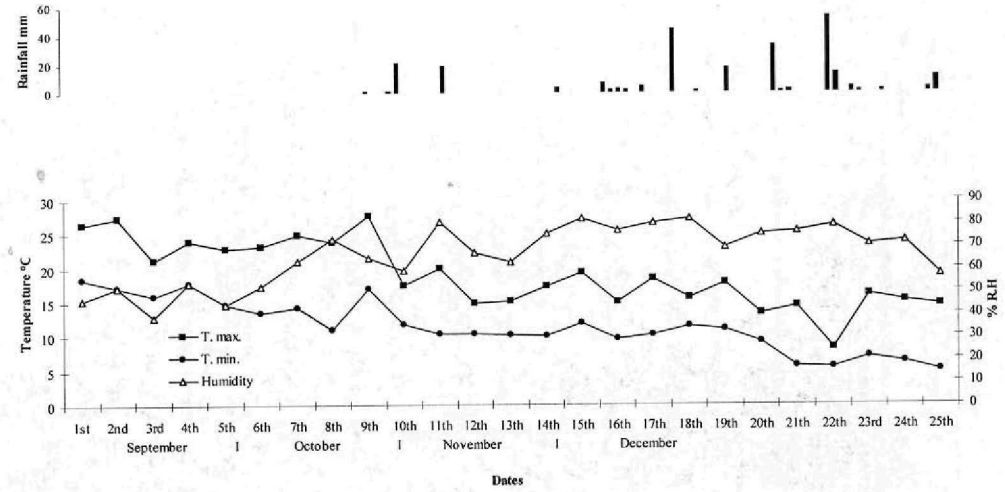


Fig. 5a. Meteorological Data of the Year 1997, indicating mean values for Temperature maximum (T.max.), Temperature minimum (T. min.), % R.H. and Rainfall. Each point represents five days means.

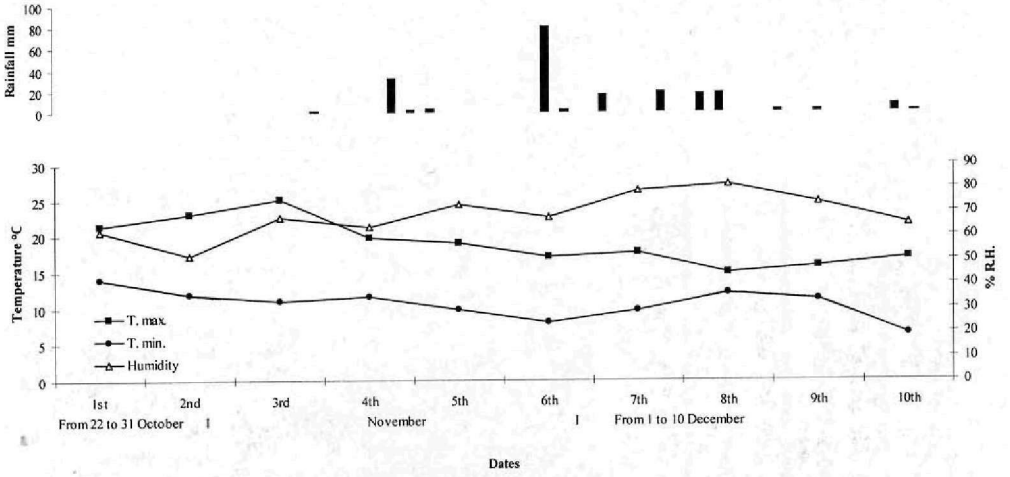


Fig. 5b. Meteorological Data of the Year 1998, indicating mean values for Temperature maximum (T. max.), Temperature minimum (T. min.), % R.H and Rainfall. Each point represents five days means.

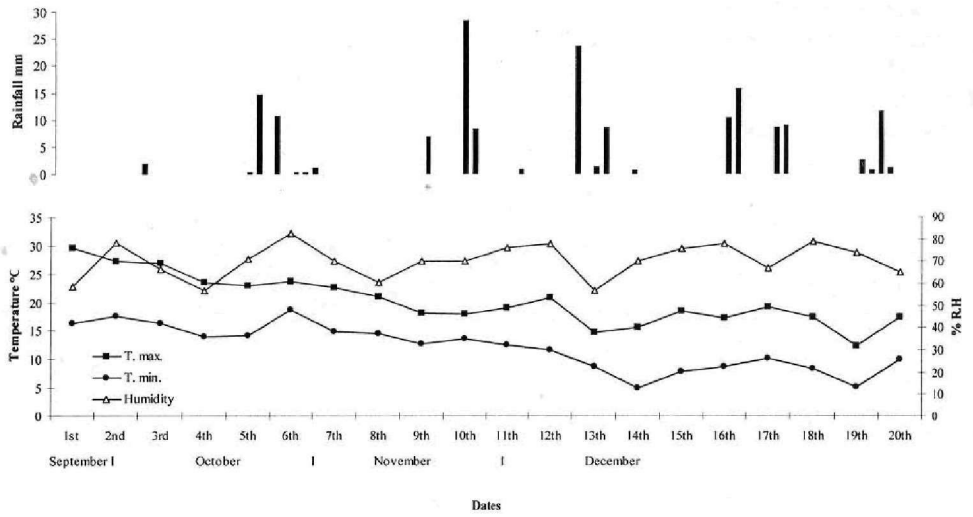


Fig. 5c. Meteorological Data of the Year 1999, indicating mean values for Temperature maximum (T. max.), Temperature minimum (T. min.), % R.H. and Rainfall. Each point represents five days means.

numbers of both sexes is misleading since it is the female doing the real fruit damage. The theory developed out of this observation, i.e. to combine food and sex attractant(s) in one trap, or in separate traps placed at a distance, within the canopy of the same tree, is under investigation, without conclusive results, so far.

In experiment B.I., trap efficiency was influenced by both, fly population density and relative humidity of the air (R.H.). Thus, the trap CP+Z1 performed best, capturing the highest number of female flies during the high population density period (22.10-2.11) with high R.H..The next period (2.11-14.11) with low population density and high R.H. the trap CP+AB (dry ammonium bicarbonate) performed best indicating that the dry form of the attractant works better than liquid attractants, under high R.H., where attractant's evaporation is limited.

The combination of food and sex attractants in the same trap (ET+AB+TML), performed moderately, capturing in all the times more females, with total captures ranking fourth when compared with the other traps.

In experiment B.II the best performance was exhibited by traps ET+AB and CP+ Z1, consistently throughout the whole experimental period, irrespective of the population density. The phenomenal contradiction with the results of experiment B.I., regarding female captures in trap GP+E could be attributed to the absence from the experimental grove of any TML which is acting as a long range sex attractant. The results of experiments C.I and C.II showed the superiority of the food attractant Z1 in the plastic bottle of 1,5L volume, which lasted over the whole experimental period, offering the most efficient solution to Medfly trapping. Close to this trap are placed the traps GP+E and CP+1TML.

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Σύγκριση διαφόρων παγίδων και ελκυστικών ουσιών της μύγας της Μεσογείου *Ceratitis capitata* (Diptera: Tephritidae) σε πειράματα υπαίθρου το φθινόπωρο

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ΠΕΡΙΛΗΨΗ

Για την επιλογή της πλέον αποτελεσματικής παγίδας και ελκυστικού μεταξύ ορισμένων από τους τύπους παγίδων και ελκυστικών ουσιών που χρησιμοποιούνται σήμερα για την παρακολούθηση και καταπολέμηση της μύγας της Μεσογείου, *Ceratitis capitata*, (Wiedemann) (Diptera: Tephritidae), συγκρίθηκαν σε πορτοκαλεώνες επτά τύποι παγίδων (δύο τύπου McPhail, Υαλοπλαστική, χάρτινο-δίπτυχο, χάρτινος φάκελος-χαρτοπλαστική, διαφανής πλαστική φιάλη, παγίδα ξηρού τύπου), τέσσερα τροφικά ελκυστικά (Dacus bait 100, Entomela 12SL, όξινο ανθρακικό αμμώνιο και το με κωδικό Z1), ένα ελκυστικό φύλου (Trimedlure) και ένας συνδυασμός τροφικού και ελκυστικού φύλου (Όξινο ανθρακικό αμμώνιο+Trimedlure). Τα αποτελέσματα έδειξαν ότι μεταξύ των παγίδων τύπου McPhail δεν υπάρχουν σημαντικές διαφορές. Η παγίδα τύπου πλαστικής φιάλης απεδείχθη πολύ αποτελεσματική όταν πληρούται με το Z1 (πρωτεϊνικό τροφικό ελκυστικό). Από τα δοκιμασθέντα ελκυστικά , τα πλέον αποτελεσματικά ήταν το Z1 και το Entomela. Ο συνδυασμός ελκυστικών τροφής και φύλου δεν έδειξε σημαντική συνεργιστική δράση στην αποτελεσματικότητα της παγίδας. Τα αποτελέσματα επιτρέπουν μια καλύτερη επιλογή μεταξύ των παραπάνω τύπων παγίδων και ελκυστικών, για παρακολούθηση και καταπολέμηση της μύγας της Μεσογείου.