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Back-yard medfly is a key factor in area-wide management in Southern Europe. Data from Attiki Greece, 38° northern latitude

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ABSTRACT

A twelve month Mediterranean fruit-fly, medfly, *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) record was kept in a small back-yard with 8 medfly host-fruit trees in a neighborhood about 7 km from the center of Athens, from November 2015 till November 2016. Similar small back-yards exist in the whole area. Large commercial host tree plantations exist at about 80 km west of Athens, while backyards with fruit trees exist in villages or small towns in-between. McPhail yellow bottom traps (one per tree) with Biolure (3 separate dispensers of ammonium acetate, trimethylamine, and putrescine) and a water solution of 1.5% sodium tetraborate and a few drops of kitchen detergent were used. Traps were examined approximately every week and water solution renewed. The Biolure dispensers were renewed every 3-4 months. On the average (medflies per tree-trap per day) 1.4 flies were trapped in November, less than 1 were trapped between December and early May, except mid-April when 1.7 flies were trapped. From June till October high records were detected. In June-July records up to over 52.7 flies were observed (highest population peak in the year), while in September-October records up to 34.3 flies were observed (second highest population peak in the year). The sex ratio of trapped flies was almost always in favor of females, usually between 60-100%. An increase of medfly catches was always detected following Biolure dispensers renewal. In case Area-wide SIT applications are considered, the reproductive behavior of released flies in these special environments must be well investigated.

KEY WORDS: Back-yard population, *Ceratitis capitata,* Greece, medfly.

Introduction

Area-wide (AW) Integrated Pest Management (IPM) is an intelligent, complex and laborious to implement operation which relies on advanced knowledge of insect pests and control technologies and increased managerial efficiency (Klassen 2007). Nevertheless, the combined AW-IPM is increasingly suggested especially for mobile insect pests where management at large scale is more effective as compared to un-coordinated field by field control (Hendrichs et al. 2007). Area-wide management of insect pests is a sound strategy both in terms of crop damage reduction (no continuous re-infestation) and application cost (synchronized uniform application over an extended area). Crop protection results are achieved faster and last longer. Except for the prerequisite of an effective control methodology of low cost, comparable or lower to insecticides, the second most important prerequisite is effective isolation of the treated area to avoid re-infestation. If possible, effective physical barriers, e.g. sea, host-tree free mountains or land, are most wanted. In certain cases, isolation could be

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possibly achieved by treatment of barrier zones. In the case of the cosmopolitan multi-host Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae), unless physical barriers exist, isolation of treated area is an extremely difficult task. This is due mainly to the numerous host-tree back-yards extending from cities and villages to major commercial plantations forming thus an uninterrupted continuum of hosts. This continuity from back-yards to big host-fruit-tree plantations is a common standard landscape pattern in southern Mediterranean Europe. In the present study the medfly adult population, as monitored by McPhail Biolure baited traps, is studied throughout the year in a typical suburban back-yard with medfly host-fruit trees just outside Athens, Greece.

Materials and Methods

In Greece, north latitude from 34°48′ to 41°45′, the major commercial medfly host fruit-tree plantations are often found near cities or villages which have numerous host-tree backyards (Fig. 1). The same applies over the whole of Southern Mediterranean Europe. Often, there is a continuum from back-yards to major commercial plantations. Back-yards usually contain several different medfly host trees, which means continuous medfly population growth throughout the year, as compared to commercial plantations composed of only one host-tree species or cultivar. No insecticidal treatments are usually applied in back-yards due to the immediate household proximity. The experimental back-yard used (Figs. 1 and 2) is located in Papagos municipality, 7 km north-east of the center of Athens, north latitude 38°. It contains 8 medfly host trees, 1 pine tree and ornamental plants. The host trees are: 3 orange (of which the two are navel oranges and the other an old cultivar of late maturation with many seeds in the fruit), 2 lemon, 2 mandarin (one with seeds and the other a seedless cultivar) and a fig tree. Similar host trees are found in the neighboring back-yards as well as apricot, loquat and pomegranate host trees. Plantation distances are usually very short between trees or between trees and buildings, with tree canopies often intermixing.

FIG. 1. Typical suburban area in southern Mediterranean Europe. The suburb shown, Papagos, is located 7 km from the center of Athens, capital city of Greece. The small experimental back-yard contains 8 medfly-host fruit trees in total.

FIG. 2. Partial view of the experimental and neighboring back-yards. Fig, loquat, mandarin, lemon and orange fruit trees, planted at short distances, can be seen.

McPhail yellow bottom traps were suspended on 12 November 2015 and were inspected weekly till 23 November 2016, except for the period December through March when due to the cold weather and absence of considerable numbers of adult flies, trap inspection was conducted less frequently. One trap was suspended per host tree. Traps were initially (November 2015) suspended in the 2 navel and the 2 mandarin trees, in mid-April traps were also suspended in the 2 lemon and the orange tree cultivar with seeds, while the trap in the fig tree was suspended in mid-June, i.e. about one month before the first figs mature. The yellow lower part of the trap was filled with ~250 ml tap-water and a few drops of kitchen detergent. From June till November 1.5 % borax (sodium tetraborate 10-hydrate) was added into the water to preserve trapped insects in good condition. On the inside of the upper transparent part of the trap the 3 separate Biolure dispensers were stuck: ammonium acetate, putrescine (1.4 diaminobutane), and trimethylamine (Heath et al. 1997). Putrescine is usually produced by the breakdown of aminoacids in living or dead organisms, while trimethylamine is a product of decomposition of plants and animals. Dispensers were renewed every 3-4 months. Biolure medfly attraction into McPhail yellow-bottom traps proved more powerful when compared with Trimedlure (a powerful male selective medfly parapheromone) and orange fruit volatiles (Reboulakis et al. 2002; for medfly attraction/trapping, detection, monitoring and control refer also to Economopoulos 2002). In the experimental back-yard, oranges and mandarins ripen from November till January-February when they are completely consumed, lemons from November till the end of spring when again they are completely consumed, while figs ripen from end-July till mid-September when all had been consumed or dropped to the ground. Apricots and loquats in neighboring back-yards ripen in May-June.

Results

In Figure 3, means of flies per tree-trap per day, for the whole back-yard and over the whole experimental year, are shown. When the trap catches in the different fruit trees were examined separately, major differences were observed due to the different fruit tree species/cultivars, fruit maturation status and fruit trees in the immediate vicinity of neighboring back-yards. Therefore, the medfly population in the experimental back-yard is examined as a whole and medfly population means per trap per day are presented. Almost zero to very few medflies were trapped from the end of December till mid-April. Thereafter, the numbers of flies trapped increased progressively to reach very high levels in June-July, an average of 52.7 medflies per tree-trap per day (week 18-25 June), i.e. the highest population peak for the particular back-yard over the whole year. Between the middle of July and the beginning of September the population fluctuated at rather low levels (8-20 flies per trap per day), to increase thereafter to the second yearly peak of 34.3 mf/t/d (week 13-20 Sept.). It is noted that both population peaks coincided with Biolure renewal, i.e. June 18 and September 6. No increase in medfly trap catches was observed following the renewal of Biolure in mid-February. The ratio of females/males was strongly in favor of females (over 80%) from mid-November till end-May and from the beginning of October till mid-November, i.e. periods of low population level and probably increased feeding related to reproduction. From April till November, temperatures were favorable for increased medfly flying activity, with highest temperatures at mid-day above 20°C. The highest temperatures of this particular year, up to 40°C, occurred in June.

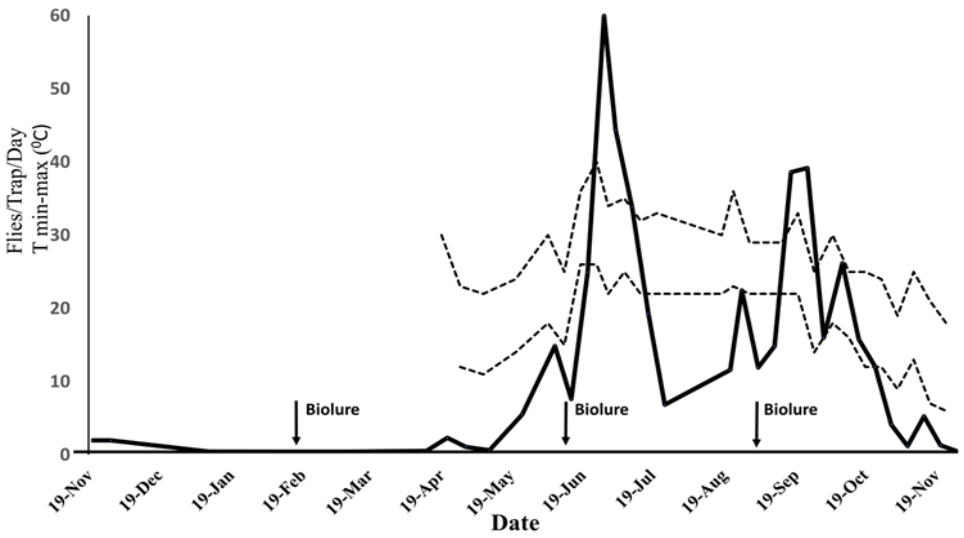

FIG. 3. Mean yearly medfly captures from November 12, 2015 till November 23, 2016. The fruit trees with trap were four (4) at the start of the experimental period (November 2015), seven (7) by mid-April and eight (8) after mid-June. The temperature range (dotted lines) and Biolure renewal dates (arrows) are also indicated.

Figure 4 is a representative photo showing the captures of the trap suspended in the bigger of the two navel orange trees, located SE of back-yard, during the week 5-12 October 2016. In total, 220 medfly females, 24 males and 2 houseflies were captured. It is noted that a much higher number of medflies were caught in the same trap during 13-20 September (388 females and 74 males) and during 27 September to 5 October (356 females and 92 males). In the much higher peak of trapped medflies of June-July, 648 total medflies were caught in the same trap during 18-25 June, and 592 total medflies were caught during 30 June to 7 July. In the photo of Fig. 4, the extreme species selectivity of Biolure can be observed, i.e. only medflies can be seen in the yellow trap bottom plus 2 houseflies.

FIG. 4. Medflies captured in the trap suspended in a rather big navel orange tree within one week, October 5-12, 2016: in total 220 female and 24 male medflies. Only 2 houseflies and no other non-target insect species were detected in the trap in the specific period.

Discussion

The above results suggest that in the Attiki province of Greece, 37.59ºN, 23.43ºE, the medfly adult population first appeared in substantial numbers in the traps in the second half of April. It increased to yearly peak levels at the end of June-beginning of July, decreased in July-August and increased again thereafter reaching a second population peak in September-October. The population peak in the fall was considerably lower than that of the summer. In the multi-host back-yard of this study, the medfly population increased to over 52.7 flies per tree-trap per day in the summer months of June-July. In the second population peak observed in the fall, the population increased to over 34.3 flies per tree-trap per day (Fig. 3). These trapping records show an enormous potential for

population build-up and spread. Furthermore, in the numerous contiguous back-yards many fruits often remain unharvested, and this further exacerbates the problem of population increase and spread in late season. This has been reported in another fly, *Drosophila suzuki* Matsumura (Diptera: Drosophilidae). In this fly, off-season un-harvested or dropped host fruits were reported to be important late season reproductive resources (Bal et al. 2017). In a 4-year study, using another highly selective medfly trap (i.e. the trimedlure-baited male selective Jackson trap) and different host trees (apricot, cherry, peach, apple, pear and fig) at 40.3º northern latitude of Greece (Thessaloniki, Central Macedonia), there was only one yearly population peak in fall, while adult males were first trapped in July-August. Except in one of the four years of the study, the number of flies per trap per day never exceeded 22 (Papadopoulos et al. 2001). Trimedlure is also known to be a potent medfly lure, attracting males from a considerable distance. In Crete, Heraklion area (35.5º northern latitude), the medfly was found to reproduce and grow even during the cooler part of the year but at reduced rates and a longer developmental duration was observed for the larval and pupal stages (Mavrikakis et al. 2000). Trimedlure Jackson traps and food lure McPhail traps were used in this study. As the present study confirmed, the Biolure is an attractant that is species-selective for the medfly (Fig. 4) and especially for the females (Epsky et al. 1999). Very high female/male ratios were observed in the Biolure traps in winter and spring when the population started increasing. This could be related to increased female need for feeding due to high metabolic activity connected with the initiation of ovarian development and egg maturation. Although Biolure is known to last long under field conditions, the immediate increase in trap captures in the second half of June and first half of September could be connected, among other factors, to the renewal of Biolure and the greater efficiency of the fresh dispensers.

The present results clearly indicate that enormous medfly populations can breed in the many back-yards of suburban and rural settings of Mediterranean Europe, which contain many different medfly host trees. Unless these numerous medfly-breeding hot spots are taken care of, no area-wide medfly management initiative could be undertaken. In addition, our findings corroborate other recent studies that highlight the significance of urban environments for the gradual establishment of incipient populations of insects, some of which might stay undetected for years (Papadopoulos et al. 2013, Lux 2018). In at least some of these countries, given the opposition of back-yard owners to any control practices, especially with insecticides, no legislation exists permitting forced drastic control or eradication of the fly. In case SIT is considered to control/eradicate the fly, the field behavior of released flies in the back-yard complex environment (buildings, continuous night lights etc.) must be well investigated before the actual releases take place.

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Η μύγα της Μεσογείου σε κήπους είναι κλειδί στην ολοκληρωμένη διαχείριση των πληθυσμών της στη Νότια Ευρώπη. Δεδομένα από την Αττική, 38ο βόρειο πλάτος

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ΠΕΡΙΛΗΨΗ

Η ανάπτυξη αποτελεσματικού συστήματος ολοκληρωμένης καταπολέμησης σε μεγάλες εκτάσεις (Area-Wide Management) της κοσμοπολίτικης "μύγας της Μεσογείου", *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae), προϋποθέτει αποτελεσματικό χειρισμό των πληθυσμών του εντόμου σε πολυάριθμους μικρούς κήπους οπωροφόρων δέντρων σε αστικούς, προαστιακούς και μικρούς αγροτικούς οικισμούς. Αυτό είναι εξαιρετικά δύσκολο για πολλούς λόγους. Έτσι, μαζικές πληθυσμιακές εξάρσεις του εντόμου στις περιοχές αυτές επεκτείνονται σε γειτονικές εμπορικές φυτείες φρούτων, ξενιστών του εντόμου, κάνοντας εξαιρετικά δύσκολη έως αδύνατη την εφαρμογή αποτελεσματικής ολοκληρωμένης διαχείρισης του εντόμου σε μεγάλες εκτάσεις και χρονικές περιόδους. Σε μελέτη 12 μηνών του πληθυσμού της μύγας Μεσογείου σε μικρό κήπο οπωροφόρων δέντρων σε απόσταση 7 χιλιομέτρων από το κέντρο της Αθήνας χρησιμοποιήθηκαν πλαστικές παγίδες τύπου McPhail με κίτρινο το κάτω ήμισυ τμήμα τους. Στις παγίδες, μια ανά δέντρο, χρησιμοποιήθηκε το ελκυστικό Biolure: αυτοκόλλητες μεμβράνες βραδείας απελευθέρωσης οξικού αμμωνίου, τριμεθυλαμίνης και πουτρεσκίνης, στο επάνω εσωτερικό ήμισυ της παγίδας. Στο κάτω ήμισυ των παγίδων τοποθετήθηκε υγρό διάλυμα 250 κ.ε. νερού περίπου με 1,5% τετραβορικό νάτριο και 2-3 σταγόνες απορρυπαντικό κουζίνας. Το υγρό ανανεωνόταν περίπου κάθε εβδομάδα και τα έντομα καταγράφονταν, ενώ οι μεμβράνες Biolure αντικαθίσταντο κάθε 3-4 μήνες. Κατά μέσον όρο παγιδεύτηκαν 1,4 άτομα του εντόμου ανά δέντρο/παγίδα ανά ημέρα το Νοέμβριο και λιγότερα από 1 μεταξύ Δεκεμβρίου και Μαΐου, με εξαίρεση τα μέσα Απριλίου όταν παγιδεύτηκαν 1,7. Από τον Ιούνιο έως τον Οκτώβριο οι συλλήψεις ήταν πολύ υψηλές, έως 52,7 άτομα ανά ημέρα τον Ιούνιο-Ιούλιο ενώ μέχρι 34,3 άτομα ανά ημέρα το Σεπτέμβριο-Οκτώβριο. Η αναλογία φύλου ήταν συνήθως 60-100% θηλυκά. Οι συλλήψεις ήταν πάντα αυξημένες μετά την ανανέωση του Biolure. Με δεδομένα τον τεράστιο αριθμό μικρών κήπων με οπωροφόρα δέντρα γύρω ή πίσω από κατοικίες στην περιφέρεια πόλεων, τα προάστια και τους αγροτικούς οικισμούς της Μεσογείου, τη συνήθως μη καταπολέμηση κυρίως λόγω της άμεσης γειτνίασης δέντρων και οικιών, και τη συχνή ύπαρξη εκτεταμένων εμπορικών φυτειών οπωροφόρων δέντρων ξενιστών σε μικρή απόσταση, οδηγούμαστε στην αδυναμία εφαρμογής εκτεταμένης στρατηγικής ολοκληρωμένης αντιμετώπισης του εντόμου. Στην περίπτωση εφαρμογής καταπολέμησης με εξαπόλυση στείρων αρσενικών, μεθόδου μηδενικής περιβαλλοντικής μόλυνσης, θα πρέπει να μελετηθεί η συμπεριφορά των μαζικά εκτραφέντων στείρων αρσενικών στο αφύσικο περιβάλλον των μικρών κήπων με ενδιάμεσα κτήρια, συνεχή νυχτερινό φωτισμό λόγω φωτισμού δρόμων και οικιών, και άλλες συνθήκες που διαφέρουν τόσο από τις συνθήκες των εκτεταμένων φυτειών όσο και του εργοστασίου μαζικής εκτροφής του εντόμου.

