Monitoring Fruit Fly, *Ceratitis capitata* and Other Non-Target Insects in a Citrus Orchard in Tartous, Syria

S. Faskha
Tartous Research Center, General Commission of Agricultural Research, Damascus, Syria.
Email address of corresponding author: Shadifaskha5@gmail.com

Abstract

Faskha, S. 2026. Monitoring Fruit Fly, *Ceratitis capitata* and Other Non-Target Insects in a Citrus Orchard in Tartous, Syria. Arab Journal of Plant Protection, 44(3):304-309. https://doi.org/10.22268/AJPP-001404

The capture of Mediterranean fruit fly, *Ceratitis capitata* (Wied.) (Diptera: Tephritidae), and non-target insects to 4 different attractants was studied in a citrus orchard in Syria, using McPhail traps. The field experiment was conducted at Majdaloun El-Baher region in Tartous Governorate, from August until December 2013. The four tested substances included the sex pheromone trimedlure (TML) and three food attractants: Esca Proteica® (protein hydrolysate), ammonium biphosphate and NuLure. Results obtained showed that trimedlure (TML) was significantly more attractive to *C. capitata* males than protein hydrolysate, ammoniumbiphosphate and NuLure traps. Meanwhile, ammoniumbiphosphate lure was the most effective attractant for females. On the other hand, seven non-target insect orders were captured in the traps, with Diptera and Hymenoptera captures being highest for Nulure, followed by protein hydrolysate. Very few predators, parasitoids and pollinators were attracted to trimedlure and ammoniumbiphosphate lures. However, the results obtained suggested that TML and ammoniumbiphosphate could provide a suitable monitoring tool for the Mediterranean fruit fly.

Keywords: *Ceratitis capitata*, attractants, non-target insects, pheromones, citrus, Syria.

Introduction

The Mediterranean fruit fly (medfly or MFF), *Ceratitiscapitata* (Wied.), is one of the most serious pests worldwide, infesting fruits of over 300 plant species (Liquido *et al*., 1991). The damage to crops caused by medfly result from (1) oviposition in fruit, (2) feeding by the larvae and (3) decomposition of plant tissue by invading secondary microorganism (Thomas *et al.,* 2001). Under Syrian field conditions, this pest has nine generations per year, flying from one host species to another (Ahmad & Mofleh, 2003). Trapping systems or trap-lure combinations is one of the main approaches topics of biotechnical pest control (Zümreoğlu, 1990). For almost 50 years, trimedlure (TML) developed from an intensive US Department of Agriculture screening and testing program has been widely used as the "standard" synthetic male medfly attractant (Beroza *et al.,* 1961). Mass trapping was used over large areas in the Mediterranean region to control medfly (Delrio, 1989). After testing many bait spray formulations in the 1960s, Protein Insect Bait-7 (a combination of corn protein hydrolysate and corn steep liquor) or a similar product (i.e., Nu-Lure Insect Bait) were selected (Roessler, 1989). The McPhail trap has been the method of choice for trapping tephritid adults (Heath *et al.,* 1995). Later on, an effective female-targeted trapping system consisting of a McPhail trap baited with three food-based, synergistically acting attractants (ammonium acetate, putrescine and trimethylamine) was developed (Katsoyannos *et al.,* 1999; Martinez *et al.,* 2007).

This synthetic food lure was more specific than the liquid protein baits, able to detect female Medflies at a lower level. Female attractive baits are needed in any application system against this pest for monitoring and direct control (Mazor *et al*., 2002). However, attractants of female Medfly were marketed under different trade names (Biolure, Biolure Medfly 100, TMA, SEDQ and Tri-pack) (Navarro-Llopis *et al.,* 2008), where ammonia components formed the base of commercially available lures to attract fruit fly females (Thomas *et al.,* 2008). In Syria, several attractants for *C. capitata* included wet traps (sex pheromone + protein hydrolysate) and Jackson traps baited with trimedlure were previously tested (Mofleh & Ahmad, 2006).

The proteinaceous liquid was attractive to many insects besides the targeted fruit flies. Non-target attraction to liquid and sticky protein bait traps has been reported in literature for decades (Katsoyannos *et al*., 1999; Martinez *et al.,* 2007). Although most non-targets were saprophagous Diptera, substantial numbers of beneficial Tachinidae (Thomas, 2003) and honeydew-feeding Chrysopidae (Neuroptera) (Neuenschwander *et al.,* 1981) were also captured. However, the dispute as to the non-target impacts of such lures on beneficial and native insects was reported by Thomas (2003) and Leblanc *et al*. (2010a).

Female-targeted and male-targeted lures could be included as a component of an integrated pest management program (IPM) in Mediterranean countries, using the mass trapping technique (Navarro-Llopis *et al.,* 2008). Since the 90s, the IPM program has been used against citrus pests in Syria. Accordingly, the main objective of this study is to compare captures of *C. capitata* adults and non-target insects in McPhail traps in a citrus orchard, and their compatibility with biological control as the main component of the IPM program.

https://doi.org/10.22268/AJPP-001404
© 2026 Arab Society for Plant Protection الجمعية العربية لوقاية النبات

Materials and Methods

The present study was carried out at Majdaloun El-baher region in Tartous Governorate. A citrus orchard was chosen to carry out field experiments. This orchard included mixed citrus varieties (Navel and Jaffa orange, Clementine and Satsuma mandarin). In this orchard no chemical control measures were applied for several years, and the citrus trees were 15- 20 years old. The routine horticultural practices were applied.

The four tested substances included the sex pheromone trimedlure (TML) and three food attractants: Esca Proteica® (protein hydrolysate), ammonium biphosphate and NuLure (corn protein hydrolysate and corn steep liquor Miller Chemicals and Fertilizer, Hanover, PA). All attractants were tested in yellow plastic McPhail traps bait**,** where trimedlure **(**2 ml trimedlure/cigarette filter**)** hanged at the top of the trap, containing water and drops of soap to reduce the surface tension. The synthetic food baits (1% protein hydrolysate according to recommendations of the Ministry of Agriculture, 1% ammonium biphosphate and 2%NuLure) were prepared in water**,** and 250 ml of the liquid solution was used in each trap. The traps were hanged from 1.5 to 2m above ground level, orientated to the southeast**.** Traps were arranged in a randomized block design, with ten rows (blocks) of sixteen traps, with traps hanged in every third tree and every third row in the orchard. In each block, there were four traps (one for each treatment) according to Leblanc *et al*. (2010b). The numbers of *C. capitata* males and females and other insects captured per each trap were counted every 7-8 days with the replacement of the pheromone and the liquid solution. All of the traps were serviced by pouring their contents through a mesh strainer to separate the insects from the liquid. The insects strained from each trap were transferred to a separate jar of alcohol and labeled. All of the insects captured in the traps were subsequently identified to family, or in some cases, genus and species. The experiment extended from mid-August up to the mid-December 2013.

The effectiveness of the tested attractants against this insect was analyzed by ANOVA and chi-square test (X^2) according to the SPSS statistical analysis program. Means were separated by Tukey's honestly significant difference (HSD) ($p \leq 0.05$).

Results and Discussion

Capture of male Medfly

The results obtained related to the efficacy of some attractants of *C. capitata* males captured/trap was summarized in Table 1. TML treatment was significantly better than other tested treatments during the period of the experiment, with the exception of three readings: 7 and22 September and 6 October, where ammonium biphosphate differed significantly from protein hydrolysate and NuLure treatments with no significant differences observed between these treatments and the TML traps. On the other hand, the total mean captures per trap of males showed that there were significant differences among the tested baits (F= 49.15, df= 3, P= 0.0001 at a confidence level of 5%). TML was the most effective male-targeted lure for *C. capitata* (677.75 male/trap) followed by ammonium biphosphate, protein hydrolysate and NuLure (Total mean= 96.75, 9.5 and 5.75 male/trap, respectively). Generally, trimedlure appeared to be more active at high medfly population density.

Comparison between the total numbers of males captured showed that the most efficient in capturing medfly males was the TML treatment (2711 male), followed by ammonium biphosphate**,** protein hydrolysate and NuLure (387, 38 and 23 male, respectively) (Table 1).

Capture of female Medfly

Results of Statistical analysis of the results obtained indicated that ammonium biphosphate was significantly better than other tested attractants from the last week in September until mid-November (Table 1)**.** However, at high population density of *C. capitata,* the differences between ammonium biphosphate, protein hydrolysate and NuLure were significant**.** Generally**,** trimedlure was significantly less attractive to females than other attractants. The total mean capture per trap of females showed that there were significant differences among the tested attractants (F= 5.36, df= 3, P= 0.014 at 5%), and ammonium biphosphate was the most attractive lure for female medfly(with a mean= 396.75 female/trap), followed by protein hydrolysate (112 female/trap). However, there were insignificant differences between Nulure and trimedlure treatments (93 and 40.25 female/trap, respectively).

As shown in Table 2**,** it was obvious that the total number off males captured by ammonium biphosphate traps was the highest (1587) compared with 448, 372 and 161 for protein hydrolysate, NuLure and TML, respectively. Moreover, the higher percentage off males in the total capture was in Nulure traps (94% of the total captures**)**, followed by protein hydrolysate, ammonium biphosphate and trimedlure traps (92.18, 80.39 and 5.6%, respectively). The TML treatment was up to 7.3, 5.9 and 1.45 times more attractive to *C. capitata* adults than Nulure, protein hydrolysate and ammonium biphosphate treatments, respectively**.**

Results reported in this study were in agreement with what has been reported earlier (Mofleh & Ahmad, 2006; Vargas *et al.,* 2002) suggesting that protein baits were more attractive to females than to males. Epsky *et al*. (1999) and Katsoyannos *et al*. (1999) showed that the three-component food-based synthetic attractant (ammonium acetate, putrescine and trimethylamine) was superior to protein hydrolysate lures, and they captured more females than the NuLure/borax-baited traps. However, Broughton & De Lima (2002) reported that females comprised 34 -95% of the total flies captured in female-targeted traps. This may explain results obtained in this study where the females total capture by TML+ water traps was only 5.6%. In addition, Epsky *et al.* (1999) indicated that females accounted for 43- 90% of the total capture in the food-baits, whereas 0.0-4.4% of the flies were captured by trimedlure-baits.

Table 1. Mean number of *C. capitata* male's and female's captures per trap in McPhail traps in a citrus orchard at Tartous Governorate, during the2013 season.

	Mean number of captured male and female/trap																Total
Treatment	**23/8**	**31/8**	**7/9**	**15/9**	**22/9**	**29/9**	**6/10**	**13/10**	**20/10**	**28/10**	**5/11**	**13/11**	**21/11**	**29/11**	**7/12**	**15/12**	**mean**
***C. capitata* male**																	
Protein hydrolysate	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 a	0.00 b	0.25 b	0.00 b	5.50 b	0.50 b	2.00 b	0.75 b	0.25 b	0.00 b	0.25 b	9.5 b
Ammonium biphosphate	1.75 b	3.50 b	5.25 a	1.25 b	1.75 ab	5.50 a	6.5 ab	5.75 b	2.75 b	20.25 b	9.75 b	15.00 b	1.50 b	5.0 b	4.00 b	7.25 b	96.75 b
Nulure	0.25b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 a	0.00 b	0.00 b	0.00 b	3.75 b	0.00 b	0.00 b	0.50 b	0.0 b	0.25 b	1.00 b	5.75 b
TML	14.50 a	15.00 a	3.50 ab	7.50 a	8.50 a	6.25 a	11.75 a	43 a	44.75 a	109.75 a	73.75 a	127.75 a	59.75 a	78.25 a	42.75 a	31.00 a	677.75 a
F	12.08	8.96	5.93	12.44	4.85	3.4	4.22	30.45	47.27	13.35	15.99	43.47	90.41	8.217	10.98	7.23	49.15
Significance	0.001	0.002	0.01	0.001	0.02	0.053	0.03	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.003	0.001	0.005	0.0001
***C. capitata* female**																	
Protein hydrolysate	1.25 a	0.50 b	0.00 a	0.00 a	0.75 a	0.25 b	0.25 b	1.75 b	4.50 a	34.75 b	16.50 ab	19.50 ab	6.25 a	11.00 a	5.25 b	9.50 ab	112.00 ab
Ammonium biphosphate	1.50 a	5.00 a	1.00 a	1.25 a	2.50 a	4.75 a	11.75 a	16.50 a	9.00 a	106.5 a	48.75 a	53.00 a	8.50 a	33.75 a	43.75 a	49.25 a	396.75 a
Nulure	1.00 a	0.75 b	0.00 a	0.00 a	0.00 a	0.00 b	1.50 b	2.50 b	1.00 b	31.75 b	3.50 b	11.00 ab	1.25 a	13.50 a	14.50 b	10.75 ab	93.00 b
TML	0.00 b	0.75 b	0.0 0 a	0.00 a	0.50 a	0.75 b	0.00 b	0.00 b	0.25 b	10.25 b	3.00 b	9.25 b	1.25 a	4.50 a	6.00 b	3.75 b	40.25 b
F	2.13	5.08	2.00	1.74	1.16	6.97	2.86	9.57	2.8	7.23	4.52	3.92	0.67	1.51	3.82	4.29	5.36
Significance	0.15	0.17	0.168	0.21	0.36	0.006	0.08	0.002	0.08	0.005	0.024	0.37	0.59	0.26	0.039	0.028	0.014

Means followed by the same letters in the same column are not significantly different at P=0.05.

Table 2. Total numbers of males and females captured in McPhail traps, in a citrus orchard at Tartous Governorate, during 2013season.

Treatment	Total males	Total females	Total (male+female)	% female
Protein hydrolysate	38	448	486	92.18
Ammonium biphosphate	387	1587	1974	80.39
Nulure	23	372	395	94.18
Trimedlure	2711	161	2872	5.60
Chi-Square (X^2)	6339.27	1923.55	3029.61	-
Probability	0.0001	0.0001	0.0001	-

Capture of non-target insects

A total of 9354non-target insects, representing 7 orders of arthropods, were captured in the traps. These included 8967 insects of Diptera (families: Drosophilidae, Muscidae, Sarcophagidae, Tachinidae, Tephritidae, Calliphoridae and Syrphidae), 289 of Hymenoptera (Vespidae, Apidae, Chalcidoids and Formicidae), 41 of Lepidoptera (Noctuidae, Gracilariidae and others), 37 of Neuropterea (Chrysopidae and Myrmeleonidae), 10 of Coleoptera (Coccinellidae and Staphylinidae), 6 of Araneae (Araneidae) and 4 of Dermaptera (Forficulidae) (Table 3). It was obvious that the protein hydrolysate traps caught more dipteran insects over the other lures with significant differences (x^2= 6711.6, df= 3, *P*= 0.0001 at 5%). On the other hand, the Nulure traps were significantly more attractive to hymenoptera insects than the protein hydrolysate (x^2= 87.5, df= 3, *P*= 0.0001). Significantly more neuropteran insects were captured by the protein hydrolysate traps than the other lures (x^2= 10.89, df= 3, *P*= 0.012). On the other hand, the largest number of lepidopteran insects were caught by ammonium biphosphate traps (x^2= 10.2, df= 3, *P*= 0.017). Low numbers of non- target Coleoptera, Dermaptera and Araneae insects were attracted to the traps, but the differences were not significant (Table 4).

Beneficial insects, out of the 667 total non-target insects captured in traps, were predators or parasitoids. 379

individuals were captured in Nulure traps, 251 in protein hydrolysate traps, 32 in ammonium biphosphate traps and 5 in TML traps.

The family (Tachinidae) formed the largest component (47.4%) of the predator-parasite guild present in the traps. These were captured mostly by protein hydrolysate and Nuluretraps (161 and 138 individuals, respectively). Cecidomyiid and Syrphid flies are believed to be the most important citrus aphid predators among the dipterans**,** but they were not attracted to the traps in significant numbers.

Table 3. Number of non-target insects captured from each order by different lures, in a citrus orchard at Tartous Governorate, Syria, during 2013 season.

Order	Protein hydrolysate	Ammonium biphosphate	Nulure	TML	X^2	*P*
Diptera	4065	596	4274	32	6711.60	0.0001
Hymenoptera	65	0.0	224	0	87.50	0.0001
Lepidoptera	12	16	11	2	10.20	0.017
Neuroptera	17	8	9	3	10.89	0.012
Coleoptera	2	4	4	0	0.80	0.670
Araneae	2	1	2	1	0.67	0.880
Dermaptera	2	1	1	0	0.50	0.780
Total	**4,165**	**626**	**4,525**	**38**	**6,988.17**	**0.0001**

Table 4. Number of insect predators and parasitoids which belong to different families captured by different lures, in a citrus orchard at Tartous Governorate, Syria, during 2013 season.

Order/Family	Protein hydrolysate	Ammonium biphosphate	Nulure	TML	X^2	*P*
Diptera						
Tachinidae	161	16	138	1	256.40	0.0001
Syrphidae	2	1	3	0	1.00	0.61
Cecidomyiidae	3	1	3	0	1.14	0.56
Neuroptera						
Chrysopidae	16	8	7	3	10.50	0.015
Myrmeleonidae	1	0	2	0	0.33	0.56
Coleoptera						
Coccinellidae	1	4	1	0	3.00	0.22
Staphylinidae	1	0	2	0	0.33	0.56
Hymenoptera						
Vespidae	60	0	216	0	88.20	0.0001
Chalcidoids	2	0	4	0	0.67	0.4
Dermaptera						
Forficulidae	2	1	1	0	0.50	0.78
Araneae						
Araneidae	2	1	2	1	0.67	0.88
Total	**251**	**32**	**379**	**5**	**578.5**	**0.0001**

Lace-wing adults, *Chrysoper lacarnea* (Stephens) (Chrysopidae), were attracted to protein hydrolysate, ammonium biphosphate and Nulure traps. On the other hand, Wasp's adults (Vespidae) were found attracted only to protein hydrolysate and Nulure traps (60 and 216wasps, respectively). Moreover, the low numbers of beneficial insects representing six insect families (Myrmeleonidae: *Cuetavariegate* (Klug); Coccinellidae: *Oenopiaconglobata* (L.)*, Rodolia cardinalis* (Mulsant) and *Chilocorus bipustulatus* (L.); Staphylinidae:*Xantholinus* sp. ;Chalcidoids: *Trichogramma* sp. and *Calesnoacki* (Howard); Forficulidae:*Forficula Auricularia* (L.) and Araneidae (unknown species) were caught by lure traps and the differences were not significant. Pollinator honey bee, *Apis mellifera* L., was captured in the traps, though only in small numbers. Given the abundance of this insect, the traps cannot be considered a hazard to any significant degree.

Generally, Nulure and protein hydrolysate were 11.5 and 8.6 times more attractive to non-target insects than medfly adults, respectively. To the contrary, TML and ammonium biphosphate were 75.6 and 3 times more attractive to medfly adults than non-target insects,

respectively. Pezhman *et al.* (2011) found that the total capture rate of non-target insects in treatments were 2.3 times compared to medfly. *Minettia* sp. (Diptera: Lauxaniidae) was the dominant species among the non-target insects captured by some treatments. The obtained results obtained in this study were in harmony with those reported by Thomas (2003), who indicated that traps baited with synthetic lures (ammonium acetate and putrescine) captured as many Mexican fruit flies as the traditional torula yeast/borax slurry, but with far fewer non-target insects. Ninety percent of the non-target insects were dipterans, where the family Tachinidae formed the largest component (58%) of the predator-parasite guild present in the traps.

Leblanc *et al*. (2010b) indicated that non-target insects of the families Drosophilidae, Neriidae, Phoridae, Calliphoridae, Sarcophagidae, and Muscidae were more strongly attracted to BioLurethan to torula yeast, and both lures equally attracted Chloropidae insects. In addition, ammonium acetate was the main attractant for at least 13 species, including *C. capitata*, all the endemic drosophilids and calliphorids **(**Heath *et al.,* 2004; Leblanc *et al*., 2010a**)**. In the current study, drosophilids and sarcophagids ranked first and third in abundance among captured insects, respectively.

Regarding beneficial insects, in this study, Chrysoperla genus was predominant, while Thomas (2003) found that the three genera Chrysoperla, Ceraeochrysa, and Leucochrysa, were predominant, and are nectar feeders as adults. Larval stages of lace-wings are generalist predators. Furthermore, Neuenschwander *et al*. (1981) reported that lace-wings (family Chrysopidae), were attracted to McPhail traps.

Since the 90s of the past century, the biological control program for citrus insects has been applied in Syria, and included the control of whiteflies, scale insects & mealybugs, citrus aphids and citrus leafminer. Therefore, the conservation of natural enemies is a key component of any suitable IPM program for citrus pests. Thomas (2003) pointed out that although the non-target catch was sometimes referred to as "trash", many non-target insects were beneficials, including predators and parasites. So, the non-target risks associated with the use of lures must be considered carefully in sensitive island environments such as Hawaii, where a large diversity of endemic insects occurs, including 12 endangered species of Drosophilidae (U.S. Fish &Wildlife Service, 2007).

الملخص

فسخه، شادي. 2026. مراقبة ذبابة الفاكهة (*Ceratitis capitata*) والحشرات الأخرى غير المستهدفة في بساتين الحمضيات في سورية. مجلة وقاية النبات العربية، 44(3):304−309. https://doi.org/10.22268/AJPP-001404

درس صيد ذبابة الفاكهة (*Ceratitis capitata* Wied.) (Diptera: Tephritidae) والحشرات غير المستهدفة باستخدام أربع مواد جاذبة في بساتين الحمضيات في سورية، وذلك باستخدام مصائد ماكفيل. أجريت التجربة في بستان حمضيات في منطقة مجدلون البحر التابعة لمحافظة طرطوس، خلال الفترة من آب/أغسطس إلى كانون الأول/ديسمبر 2013. شملت المواد المختبرة: الفيرمون trimedlure(TML) وثلاثة مواد جاذبة غذائية: هيدروليزات البروتين (Protein hydrolysate)، بيفوسفات الأمونيوم (Ammoniumbiphosphate) ونيولور (NuLure). أظهرت النتائج المتحصل عليها أن الفيرمون TML كان أكثر جاذبية وبشكل معنوي لذكور *C. Capitata* من هيدروليزات البروتين وبيفوسفات الأمونيوم ونيولور. في حين كان بيفوسفات الأمونيوم هو أكثر مواد الجذب فعاليةً للإناث. من ناحية أخرى، تم اصطياد سبع رتب من الحشرات غير المستهدفة في المصائد، وكانت نسبة صيد رتبة ثنائية الأجنحة وغشائية الأجنحة هي الأعلى بالنسبة لمادة نيولور، تلتها مادة هيدروليزات البروتين. وقد انجذب عدد قليل جداً من الحشرات المفترسة والمتطفلات والملقحات إلى الفيرمون TML وبيفوسفات الأمونيوم. ومع ذلك، أشارت النتائج إلى أن كلاً من الفيرمون TML وبيفوسفات الأمونيوم يمكن أن توفر أداة مراقبة مناسبة لذبابة الفاكهة.

كلمات مفتاحية: ذبابة الفاكهة، مواد جاذبة، حشرات غير مستهدفة، حمضيات، سورية.

عناوين الباحثين: شادي فسخه، مركز بحوث طرطوس، الهيئة العامة للبحوث الزراعية، دمشق، سورية. البريد الإلكتروني للباحث المراسل: Shadifaskha5@gmail.com

References

Ahmed, M. and M. Mofleh. 2003. Population dynamics of the Mediterranean fruit fly, *Ceratitis capitata* (Wied.) (Diptera: Tephritidae), in the coastal region of Syria. Abstract Book, 8th Arab Congress of Plant Protection. B. Bayaa, K.M. Makkouk, S.G. Kumari and I. El-Ghariani (eds.). 12-16 October 2003, El-Beida, Libya.

Beroza, M., N. Green, S.I. Gertler, L.F. Steiner and D.H. Miyashita. 1961. Insect attractants: New attractants for the Mediterranean fruit fly. Journal of Agricultural and Food Chemistry, 9(5):361-365. https://doi.org/10.1021/jf60117a007

Broughton, S. and C.P.F. De Lima. 2002. Field evaluation of female attractants for monitoring *Ceratitis capitata* (Diptera: Tephritidae) under a range of climatic conditions and population levels in Western Australia. Journal of Economic Entomology, 95(2):507-512. https://doi.org/10.1603/0022-0493-95.2.507

Delrio, G. 1989. Mass trapping experiments to control the olive fruit fly in Sardinia. Pp. 419-425. *In*: Fruit Flies of Economic Importance 87: Proceedings of the CEC/IOBC International Symposium. R. Cavalloro (ed.), 7-10 April 1987, Rome, Italy.

Epsky, N.D., J. Hendrichs, B.I. Katsoyannos, L.A. Vásquez, J.P. Ros, A. Zümreoğlu, R. Pereira, A. Bakri, S.I. Seewooruthun and R.R. Heath. 1999. Field evaluation of female-targeted trapping systems

for *Ceratitis capitata* (Diptera: Tephritidae) in seven countries. Journal of Economic Entomology, 92(1):156-164. https://doi.org/10.1093/jee/92.1.156

Heath, R.R., N.D. Epsky, A. Guzman, B.D. Dueben, A. Manukian and W.L. Meyer. 1995. Development of a dry plastic insect trap with food-based synthetic attractant for the Mediterranean and Mexican fruit flies (Diptera: Tephritidae). Journal of Economic Entomology, 88(5):1307-1315. https://doi.org/10.1093/jee/88.5.1307

Heath, R.R., N.D. Epsky, D. Midgarden and B.I. Katsoyannos. 2004. Efficacy of 1,4-diaminobutane (putrescine) in a food-based synthetic attractant for capture of Mediterranean and Mexican fruit flies (Diptera: Tephritidae). Journal of Economic Entomology, 97(3):1126-1131. https://doi.org/10.1603/0022-0493(2004)097[1126:EODPIA]2.0.CO;2

Katsoyannos, B.I., R.R. Heath, N.T. Papadopoulos, N.D. Epsky and J. Hendrichs. 1999. Field evaluation of Mediterranean fruit fly (Diptera: Tephritidae) female selective attractants for use in monitoring programs. Journal of Economic Entomology, 92(3):583-589. https://doi.org/10.1093/jee/92.3.583

Leblanc, L., R.I. Vargas and D. Rubinoff. 2010a. Attraction of *Ceratitis capitata* (Diptera: Tephritidae) and endemic and introduced nontarget insects to BioLure bait and its individual components in Hawaii. Environmental Entomology, 39(3):989-998. https://doi.org/10.1603/EN09287

Leblanc, L., R.I. Vargas and D. Rubinoff. 2010b. Captures of pest fruit flies (Diptera: Tephritidae) and nontarget insects in BioLure and torula yeast traps in Hawaii. Environmental Entomology, 39(5):1626-1630. https://doi.org/10.1603/EN10090

Liquido, N.J., L.A. Shinoda and R.T. Cunningham. 1991. Host plants of Mediterranean fruit fly (Diptera: Tephritidae): An annotated world review. Miscellaneous Publications of the Entomological Society of America, 77:1-52.

Martinez, A.J., E.J. Salinas and P. Rendon. 2007. Capture of Anastrepha species (Diptera: Tephritidae) with Multilure traps and BioLure attractants in Guatemala. Florida Entomologist, 90(1):258-263. https://doi.org/10.1653/0015-4040(2007)90[258:COASDT]2.0.CO;2

Mazor, M., A. Peysakhis and G. Reuven. 2002. Release rate of ammonia: A key component in the attraction of female Mediterranean fruit fly to protein-based food lures. IOBC/WPRS Bulletin, 25:1-6.

Mofleh, M. and M. Ahmad. 2006. Comparison of the efficacy of different traps and attractants to control *Ceratitis capitata* in Syria. Abstract Book, Ninth Arab Congress of Plant Protection. Kumari, S.G., K.M. Makkouk, S. AlShaabi and A. AlAhmed (eds.). 19-23 November 2006, Damascus, Syria.

Navarro-Llopis, V., F. Alfaro, J. Domínguez, J. Sanchis and J. Primo. 2008. Evaluation of traps and lures for mass trapping of Mediterranean fruit fly in citrus groves. Journal of Economic Entomology, 101(1):126-131. https://doi.org/10.1603/0022-0493(2008)101[126:EOTALF]2.0.CO;2

Neuenschwander, P., M. Canard and S. Michelakis. 1981. The attractivity of protein hydrolysate-baited McPhail traps to different chrysopid and hemerobiid species (Neuroptera) in a Cretan olive orchard. Annales de la Société Entomologique de France, 17(2):213-220.

Pezhman, H., H. Ostovan, K. Kamali and V. Rezaei. 2011. Evaluation of various traps and attractants for trapping the Mediterranean fruit fly, *Ceratitis capitata* (Diptera: Tephritidae), in a mixed-fruit orchard in Shiraz, Fars Province. Applied Entomology and Phytopathology, 78(2):217-236.

Roessler, Y. 1989. Insecticidal bait and cover sprays. Pp. 329-336. *In*: Fruit Flies: Their Biology, Natural Enemies and Control. Volume 3B. A.S. Robinson and G. Hooper (eds.). Elsevier, Amsterdam, The Netherlands.

Thomas, D.B. 2003. Nontarget insects captured in fruit fly (Diptera: Tephritidae) surveillance traps. Journal of Economic Entomology, 96(6):1732-1737. https://doi.org/10.1603/0022-0493-96.6.1732

Thomas, D.B., N.D. Epsky, C.A. Serra, D.G. Hall, P.E. Kendra and R.R. Heath. 2008. Ammonia formulations and capture of Anastrepha fruit flies (Diptera: Tephritidae). Journal of Entomological Science, 43(1):76-85. https://doi.org/10.18474/0749-8004-43.1.76

Thomas, M.C., J.B. Heppner, R.E. Woodruff, H.V. Weems and G.J. Steck. 2001. Mediterranean Fruit Fly, *Ceratitis capitata* (Wiedemann) (Insecta: Diptera: Tephritidae). Publication No. EENY-214. Florida Department of Agriculture and Consumer Services, Division of Plant Industry, and University of Florida, Gainesville, FL, USA.

U.S. Fish and Wildlife Service. 2007. Endangered and threatened wildlife and plants: Revised proposed designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands; proposed rule. Federal Register, 72:67427-67522.

Vargas, R.I., N.W. Miller and R.J. Prokopy. 2002. Attraction and feeding responses of Mediterranean fruit fly and a natural enemy to protein baits laced with two novel toxins, phloxine B and spinosad. Entomologia Experimentalis et Applicata, 102(3):273-282. https://doi.org/10.1046/j.1570-7458.2002.00948.x

Zümreoğlu, A. 1990. Standardization of Medfly (*Ceratitis capitata* Wied.) trapping for use in sterile insect technique programmes: Two-year investigations on the efficiency of various Medfly trapping systems in western Turkey. Türkiye Entomoloji Dergisi, 14(3):155-166.

Received: December 1, 2024; Accepted: January 15, 2025

تاريخ الاستلام: 2024/12/1؛ تاريخ الموافقة على النشر: 2025/1/15