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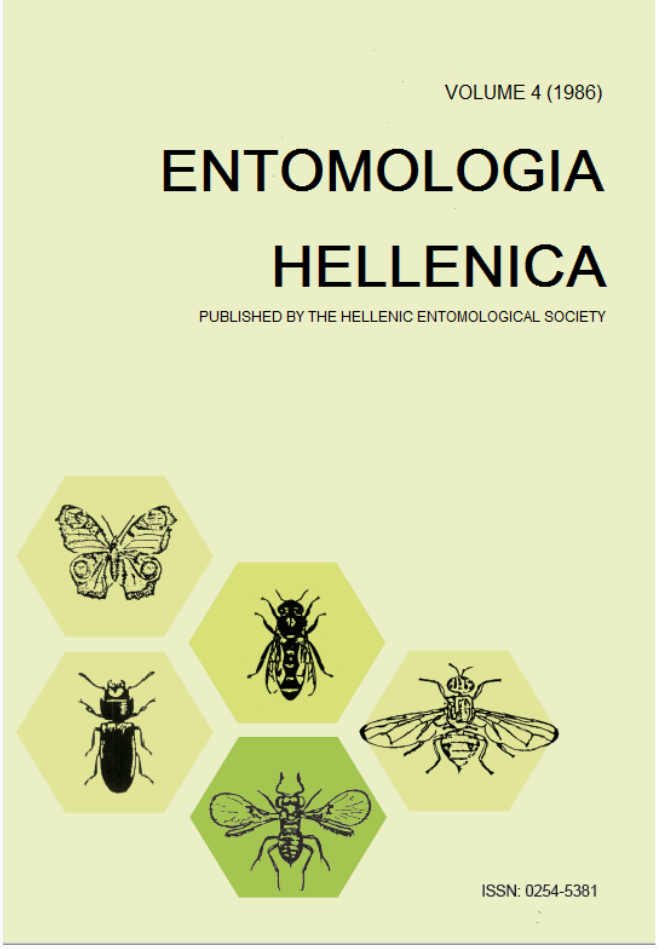

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G.E. Haniotakis

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Effect of Size, Color and Height of Pheromone Baited Sticky Traps on Captures of *Dacus oleae* Flies[1]

G. E. HANIOTAKIS

Institute of Biology, N.R.C. «Demokritos»
P.O. Box 60228, 15310 Aghia Paraskevi, Greece

ABSTRACT

The size of sticky pheromone traps has no effect on *Dacus oleae* catches when insect population densities are low. At high population densities trap catches increase with surface area. There were no differences in the numbers of *D. oleae* caught on yellow and white pheromone traps in periods of high pheromone effectiveness, which coincide with periods of high insect reproductive activity. During periods of reduced pheromone effectiveness, due either to low temperatures at the time of pheromone activity (dusk) or reduced insect reproductive activity, traps of yellow hues tend to capture more insects than traps of white color. The height at which pheromone traps are located inside the tree canopy has no effect on catches of *D. oleae*.

Introduction

Trap size and color can make a significant contribution to the total manufacturing cost of *Dacus oleae* (Gmelin) (Diptera, Tephritidae) pheromone traps, while the height at which the traps are located in the trees has a consiberable effect on convenience and operational cost. Thus, the effects of these factors on trap captures need to be established in order to facilitate the design and use of effective traps at low cost for this pest.

With regard to trap design, it is known that of the trap types tested, a vertical rectangle is the most effective (Haniotakis 1979, Haniotakis et al. 1982, Jones et al. 1983), but its optimal size has not been established. With regard to the color, it is known that *D. oleae* flies are attracted to yellowish hues with the combined properties of maximum light reflectance between 520-580 nm and little reflectance below 520 nm (Prokopy et al. 1975). However, comparative studies on the way in which colour influences the effectiveness of pheromone traps have not yet been reported. With regard to the effects of trap height on the numbers of insects caught, there seem to be contradictory results (Haniotakis et al. 1982, Quaglia et al. 1983, Jones et al. 1983) which need clarification. The purpose of this work was to establish the most effective size and color of pheromone baited sticky traps and the most suitable height for them to be deployed in the tree canopy to maximise catches of *D. oleae* at minimum cost.

Materials and Methods

a. Effect of trap size

Tests were conducted in an orchard at Ini, Heraklion, Crete, from July 20 to October 16, 1981. Yellow sticky poster board rectangles of three dimensions (7X10, 10X14 and 14X20 cm) were tested under a randomized complete block design. Traps were baited with polyethelene vial dispensers loaded with 50 mg of the complete sex attractant pheromone mixture of *D. oleae* (Mazomenos and Haniotakis 1985). Traps were checked once per week. Air temperature averages for each week were calculated from daily temperature values recorded 2 hours prior to sunset. For each week, estimated prevailing wind direction and velocity and rainfall were also noted. The traps were replaced once on August 28.

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b. Effect of trap color

Two tests were conducted as follows:

Test No. 1 - Sticky pheromone traps of the following three colors were compared during 1981 in an olive orchard at the village of Mochos, Crete: yellow, of the hue which attracts *D. oleae* flies, white, and a dark yellow which did not have the properties required for *D. oleae* attraction. Attractant yellow and white color traps were poster board rectangles (14X20 cm) and the dark yellow traps were made of presspan with the same dimensions. Pheromone dispensers were of the same type as those used in the previous experiments. Attractant yellow traps were compared to white ones from March 1 until Dec. 26, 1981, except during the month of August, when the white traps (but not dispensers) were replaced by dark yellow traps. Traps of all three colors were compared from Sept. 1 until Dec. 26. One trap of each color was placed at each of 17 sites in the orchard. Different trees at least 30 m apart were used for the individual traps to avoid interference among pheromone dispensers (Delrio et al. 1983). Traps were checked every 5 days. Pheromone dispensers were renewed on July 11 and Sept. 1. Sticky traps were renewed when needed.

Test No. 2 - In this test conducted at Ini, Heraklion, Crete, pheromone traps of attractant yellow and dark yellow were compared from July 10 to October 16, 1981. Dark yellow traps without pheromone dispensers were also included to test the attractiveness of this hue of yellow color to *D. oleae*, as this color had not previously been tested.

c. Effect of trap height

Tests were conducted in two different areas with different insect population densities, one at Liliano, Heraklion, Crete (Test No. 1) from June 24 until August 31, 1981, and another at Skalani, Heraklion, Crete (Test No. 2) from Sept. 4 to Nov. 2, 1981. Attractant yellow sticky pheromone traps were placed at three levels (lower, middle and upper sections of the olive canopy) along the vertical axis through the center of the trees. Traps at each level were placed at 10 sites and the trees used were at least 30 m apart with only one trap per site. Traps were checked every 5 days.

Results and Discussion

a. Effect of trap size

Table 1 shows the numbers of male and female *D. oleae* flies, captured on different size traps. Although there was a definite trend between trap size and numbers of flies caught, for both sexes, the differences were significant only between the larger size trap (14X20 cm) and the other two smaller sizes (7X10 and 10X14 cm) when the results for the whole season were pooled. Considering weekly trap captures, however, it is clear that trap size had a significant effect on captures, especially of males, when *D. oleae* populations were high. As expected in such cases, catches increase with trap surface as small size traps have a limited insect holding capacity. Mean numbers of *D. oleae* male flies caught per 100 square cm of trap surface calculated from the data of Table 1 for the entire test period were 34.3, 19.7 and 13.2, respectively, for small, medium and large size traps. The first mean (34.3) is significantly different from the other two (19.7 and 13.2) which are not significantly different (Duncan's multiple range test, $p=0.05$).

b. Effect of trap color

Test No. 1 - Fig. 1 shows mean numbers of male *D. oleae* flies caught on pheromone traps of different colors throughout the test period. Table 2 shows mean numbers of both sexes caught on pheromone traps of different colors in different time periods during which differences in environmental temperatures and rates of insect reproduction produced differences in the captures of traps with different colors.

During periods of reduced pheromone effectiveness (March 1 to Aug.31 and Oct. 12 to Dec. 26), white colored pheromone traps are inferior to those of yellow hue. During the period of high pheromone effectiveness, which coincides with the period of high insect reproductive rate and high population density (Sept. 1 to Oct. 11), no differences in trap catches due to color differences were observed. The following factors are thought to play a role in producing these results: combination of sex pheromones and yellow on the same trap has an additive effect on *D. oleae* captures (Haniotakis and Skyrianos 1981). Females respond to a specific component of the pheromone which functions as arrestant and aphrodisiac (Haniotakis et al. 1986). Males respond to pheromone at dusk only (Haniotakis 1974) while they respond to yellow color all day long. In the spring and late autumn when late afternoon temperatures fall to levels which restrict insect flight activity (below 14°C), but the temperature is still high during daytime, male response to pheromones is reduced while response to yellow is not affected. This difference in male response is reflected in the total trap captures. During high pheromone effectiveness, i.e. periods of high reproductive activity and high

TABLE 1. Numbers of *D. oleae* flies caught per trap per week on traps of different sizes. Means of 10 replicates. Ini, Crete, 1981.

	Trap size (cm)						
	7×10		10×14		14×20		
Date	Males	Females	Males	Females	Males	Females	Mean temp. (°C)
July 17	2.2a*	0.8b	3.0a	0.7b	2.0a	2.9a	30.4
July 24	0.5a	0.1a	0.8a	0.0a	0.3a	0.1a	28.0
July 31	2.9a	0.0a	4.6a	0.1a	2.2a	0.0a	28.3
Aug. 7	3.8a	0.0a	5.6a	0.1a	4.0a	0.3a	27.0
Aug. 14	3.9a	0.7a	2.7a	0.6a	2.0a	0.5a	29.1
Aug. 21	13.1a	0.3a	12.4a	0.3a	12.9a	0.8a	29.8
Aug. 28	26.2a	0.7b	26.1a	1.7ab	30.6a	2.5a	30.1
Sep. 4	33.8a	1.6a	38.5a	2.0a	46.2a	2.6a	27.1
Sep. 11	48.1b	1.3a	48.9b	1.6a	77.3a	2.0a	24.9
Sep. 18**	9.2a	0.3b	11.2a	0.5ab	17.1a	1.2a	–
Sep. 25	29.1a	0.9a	28.8a	0.9a	38.5a	1.3a	–
Oct. 2	74.4b	4.0ab	87.1ab	3.4b	103.9a	6.3a	26.8
Oct. 9	47.7a	1.2b	57.1a	2.6ab	92.9a	4.3a	24.1
Oct. 16	44.2b	0.5b	59.9b	1.7a	88.2a	1.9a	25.0
Means	24.0a	0.9b	27.6b	1.2b	37.0a	1.9a	

* For each sex, means followed by same letter in the row are not significantly different, Duncan's Multiple Range Test, after significant F-values with two way analysis of variance, p=0.05.

** Bait spray was applied in the experimental orchard.

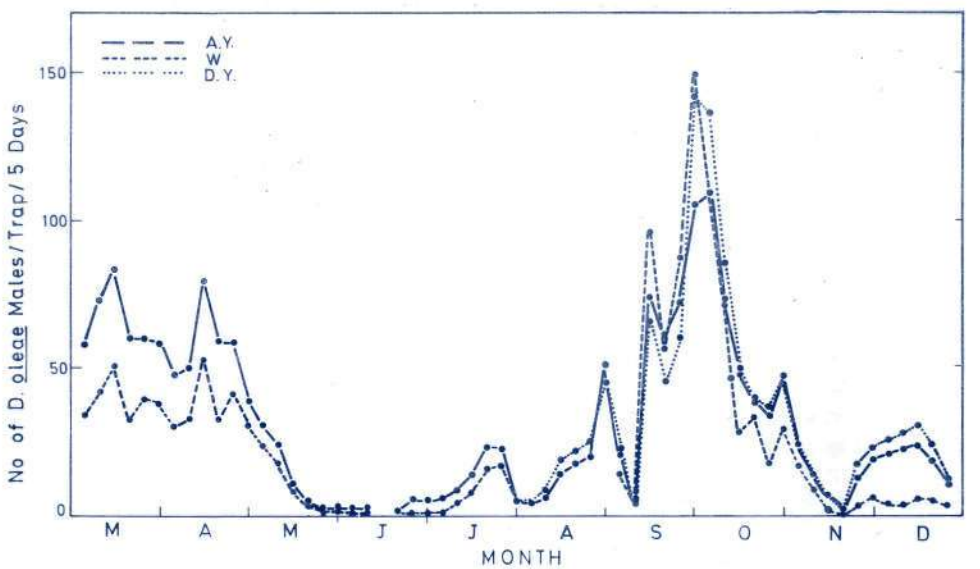

FIG. 1. Numbers of *D. oleae* male flies caught on pheromone traps of attracting yellow (A.Y.), white (W) and dark yellow (D.Y.) color. Means of 17 replicates, Mochos, Crete, 1981.

TABLE 2. Numbers of *D. oleae* flies caught per trap per 5 days on pheromone traps of attractant yellow (A.Y.), white (W) and dark yellow (D.Y.) color during different time periods. Means of 17 replicates, Mochos, Crete, 1981.

	A.Y.		W		D.Y.	
Time period (month/day)	Males	Females	Males	Females	Males	Females
3/1 - 7/26	31.9a*	3.8a	19.8b	0.9b	–	–
9/1 - 10/11	63.2a	1.7a	71.2a	1.8a	67.0a	1.6a
10/12 - 12/26	23.5a	1.2a	11.7b	0.2b	25.9a	1.2a

* For each sex, means followed by same letter in the row are not significantly different, Duncan's Multiple Range Test, after significant F-values with two-way analysis of variance, p=0.05.

evening temperatures, however, the contribution of the yellow color to the trap catches is negligible, and thus has little effect on total trap catches.

Differences in trap catches between white and attractant yellow colors from mid-May to mid-July can be attributed to reduced pheromone effectiveness due to the reduction in insect reproductive activity (Haniotakis et al. 1982). No significant differences were found

TABLE 3. Numbers of *D. oleae* flies caught per trap per 5 days in pheromone traps of attractant yellow (A.Y.), dark yellow (D.Y.) and dark yellow without pheromone (D.Y.-Ph) from July 10 to Oct. 16. Means of 10 replicates, Ini, Crete, 1981.

	Trap color					
	A.Y.		D.Y.		D.Y. - Ph	
Date	Males	Females	Males	Females	Males	Females
July 17	2.0	2.9	3.6	1.6	1.8	1.2
July 24	0.3	0.1	0.6	0.1	0.0	0.1
July 31	2.2	0.0	2.3	0.1	0.0	0.0
Aug. 7	4.0	0.3	4.1	0.1	0.0	0.1
Aug. 14	2.0	0.5	1.8	0.2	0.0	0.1
Aug. 21	12.9	0.8	13.7	0.3	0.0	0.2
Aug. 28	30.6	2.5	24.0	1.7	0.5	0.2
Sep. 4	46.2	2.6	54.1	1.3	1.0	1.0
Sep. 11*	77.3	2.0	86.3	1.0	3.3	1.0
Sep. 18	17.1	1.2	18.5	1.2	1.3	0.2
Sep. 25	38.5	1.3	49.5	1.1	1.4	0.7
Oct. 2	103.9	6.3	119.0	3.5	7.5	4.0
Oct. 9	92.9	4.3	73.0	2.5	5.5	3.4
Oct. 16	88.2	1.9	76.7	1.2	0.5	0.9
Means	37.0a**	1.9a	37.7a	1.1b	1.6b	0.9b

* Bait spray was applied from the air.

** For each, sex, means followed by same letter in the row are not significantly different. Duncan's Multiple Range Test, after significant F-values with two-way analysis of variance, p=0.05.

between the two yellow hues except for a trend toward higher catches in dark yellow traps during late fall and early winter, for which no explanation can be offered. It is known, however, that although the attractant yellow is preferred by *D. oleae* flies, other hues of yellow also have various degrees of attraction (Prokopy et al. 1975).

Test No. 2 - Table 3 shows the numbers of *D. oleae* flies caught on pheromone traps of attractant yellow and dark yellow color as well as on traps of dark yellow without pheromones. The results of this test were in general similar to the results of Test No. 1 in regard to the effect of yellow hues on pheromone trap effectiveness. The only difference was that attrac-

TABLE 4. Numbers of *D. oleae* flies caught per trap per 5 days on pheromone traps placed at low, middle, and upper sections of the olive tree. Means of 10 replicates. Test No. 1 - orchard with low to medium insect population densities (Liliano), Test No. 2 - orchard with high densities (Skalani), Crete, 1981.

	No. of flies caught at					
	Low		Middle		Top	
	Males	Females	Males	Females	Males	Females
Date	Test No. 1 - Liliano					
July 1	3.5	15.0	3.0	9.5	3.4	12.5
July 6	9.3	5.2	8.0	6.7	11.2	5.8
July 10	15.5	11.0	12.1	10.5	14.9	12.8
July 15	8.3	4.5	5.3	2.4	6.7	3.7
July 20	1.2	0.3	1.2	0.3	1.3	0.3
July 25	1.8	0.7	1.7	0.5	1.7	0.7
Aug. 1	5.1	0.4	4.6	0.2	6.1	0.7
Aug. 5	6.4	0.9	7.0	1.0	5.5	0.7
Aug. 10	6.9	0.9	7.8	1.2	7.9	1.8
Aug. 15	18.0	4.6	16.3	4.9	13.8	4.0
Aug. 20	30.4	8.1	26.5	6.3	27.1	7.3
Aug. 25	39.8	10.6	33.7	8.3	37.8	9.5
Aug. 31	54.4	16.8	47.9	14.6	51.7	15.2
Means	15.4*	6.1	13.5	5.1	14.6	5.8
	Test No. 2 - Skalani					
Oct. 1	440.9	36.4	332.8	33.7	414.7	39.3
Oct. 6	484.1	41.7	356.3	28.3	487.9	41.6
Oct. 12	516.7	37.9	367.8	27.4	504.3	38.5
Oct. 16	174.6	21.8	298.2	25.8	223.8	27.0
Oct. 21	140.7	24.9	125.6	21.7	132.6	23.2
Oct. 26	53.6	12.2	43.4	9.5	52.7	13.1
Nov. 2	96.1	18.9	85.3	18.8	94.9	20.0
Means	272.4*	27.7	229.9	23.6	273.0	29.0

* Analysis of variance of $\log(\times+1)$ transformed trap catches for each sex throughout the experimental period revealed no significant differences at $p=0.05$.

tant yellow traps caught significantly more females than traps of the dark yellow hue. This difference, however, may be due to differences in the test periods. The response of *D. oleae* flies to the hue of the dark yellow tested here was negligible.

Considering that the olive growing season (when pheromone traps are normally used) extends from late June until late October, it is doubtful if the use of yellow colored traps is necessary to achieve maximum overall trap efficiency. In any case, use of attractant yellow traps for mass trapping purposes is not recommended, because they are destructive to the beneficial insects of the olive orchards (Neuenschwander 1982).

c. Effect of height

Table 4 shows the results of the two experiments in which the effect of height on trap catches was tested in orchards of low to medium and high population densities. These indicate that trap height within the tree has no effect on total catches of either sex. Traps therefore can be placed inside the tree canopy within reach from the ground for practical use, which is both convenient and economic. This is in contrast to chromotropic traps, in which catches are affected by height, with maximum catches occurring at a medium canopy position (Cirio et al. 1979). This difference is understandable if one keeps in mind that pheromones are powerful long-range olfactory attractants, while visual attractants are relatively weak and active over a short range and thus need to be placed in sites where most insect activity occurs to maximise catches.

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KEY WORDS: *Dacus oleae*, olive fruit fly, trapping, sticky traps, pheromone traps, sex attractants

Επίδραση του Μεγέθους, Χρώματος και Ύψους Ανάρτησης της Παγίδας Φερομόνης με Κόλλα στις Συλλήψεις του Δάκου της Ελιάς

Γ. Ε. ΧΑΝΙΩΤΑΚΗΣ

Ινστιτούτο Βιολογίας, Ε.Κ.Ε.Φ.Ε. «Δημόκριτος», Τ.Θ. 60228, 15310 Αγία Παρασκευή, Αττική

ΠΕΡΙΛΗΨΗ

Το μέγεθος της παγίδας φερομόνης με κόλλα δεν έχει επίδραση στις συλλήψεις δάκου όταν η πυκνότητα του πληθυσμού του εντόμου είναι χαμηλή. Σε περιπτώσεις όμως υψηλών δακοπληθυσμών ο αριθμός των συλλαμβανομένων εντόμων αυξάνεται με την αύξηση της επιφάνειας της παγίδας. Το χρώμα της παγίδας φερομόνης δεν έχει επίδραση στις συλλήψεις δάκων σε περιόδους υψηλής δραστικότητας της φερομόνης, που συμπίπτουν με τις περιόδους υψηλής αναπαραγωγικής δραστηριότητας του εντόμου. Σε περιόδους μειωμένης δραστικότητας της φερομόνης, είτε λόγω χαμηλών θερμοκρασιών κατά τις ώρες δράσεως των παγίδων (σούρουπο), είτε λόγω μειωμένης αναπαραγωγικής δραστηριότητας του εντόμου, οι παγίδες κιτρίνου χρώματος συλλαμβάνουν περισσότερα έντομα από τις παγίδες λευκού χρώματος. Το ύψος της παγίδας φερομόνης εντός του φυλλώματος του δέντρου δεν έχει επίδραση στις συλλήψεις.