

ALESSANDRO BRATTI*, CARLO MALAVOLTA*, STEFANO MAINI*,
EDISON PASQUALINI*, AMEDEO CAPIZZI**

* Istituto di Entomologia «Guido Grandi» dell'Università degli Studi di Bologna

** Istituto «Guido Donegani» di Novara

Comparative Trials of Sex Attractant and Dispenser Types for *Cossus cossus* L. (Lepidoptera: Cossidae)

(Research funded by the Emilia-Romagna government)

INTRODUCTION

The problems and failures in the chemical control of *Cossus cossus* L. have led several researchers in Italy (Pasqualini *et al.*, 1981, 1982, in press) to experiment the mass trapping of males with sex attractants.

The numerous trials conducted over the last five years have yielded valuable practical results. For example, Pasqualini *et al.* (1985) had 35% lower captures from 1982-84 with 15 traps/ha baited with a rubber dispenser containing 0.8 mg of dodecenyl-acetate (Z5-12:Ac) and 0.2 mg of decenyl-acetate (Z3-10:Ac). From 1983-85, the same researchers recorded a 50% drop by employing 30 traps/ha with the same bait but changing the dispensers every 15 days. These data, however, need further corroboration. The pest population during the trial periods could have been in decline, given the fact that data on the population levels of the European goath moth (EGM) are lacking. It should also be kept in mind that the sex attractant for this species has been available for only a few years (Capizzi *et al.*, 1983).

Numerous parameters need to be determined so that mass trapping can be applied on a large scale. This study was designed to determine the optimal amount of Z5-12:Ac and Z3-10:Ac⁽¹⁾ as well as test new dispenser types. The final objective is to develop dispensers with the capacity to release attractant throughout the period of moth emergence and diminish the frequency of, or at best eliminate altogether, bait changes.

(¹) While Capizzi *et al.*, (1983) did not find this substance in the female abdominal tips, they did observe via electroantennography how greatly it affected males.

MATERIALS AND METHODS

The experiment was carried out from late May to early September 1985 in two trials. The first compared:

- a. Dispenser types.
- b. Sex attractant amounts.
- c. Dispenser replacement intervals.

The second tested only one dispenser type:

- a. Increasing amounts of Z3-10:Ac with the same amount of the main component Z5-12:Ac.
- b. Dispenser replacement intervals.

A randomized-block design with four replications was used in each trial. Modified Mastraps[®] (3 cm min. diam.) with a 1-litre polyethylene collector bag were employed throughout the experiment. The traps were checked and their field location in each block changed every 15 days.

TRIAL I: AMOUNTS, PERSISTENCE, DISPENSERS

The four blocks⁽²⁾, set up in two farms in the Province of Ferrara, covered an area of about 6 hectares of apple orchards. The trees ranged in age from 15 to 30 years, all trained as open vase, with a 6×4 m spacing. The main cultivars were Stark, Delicious, Stayman, Rome Beauty.

a. Dispensers

Three types were compared (Fig. 1):

Standard (S). It is a rubber septum 1×1×1 cm in size and impregnated with the attractant blend. Although it has shown good results in previous tests, it has the drawback of releasing the more volatile Z3-10:Ac too quickly, thereby altering the mixture so that its effectiveness lasts but a short time.

Bimatrix (B). It is formed of two standard dispensers, both impregnated with Z5-12:Ac only, linked together by a small plastic sleeve (polyamide resin) containing a compact rubber septum impregnated with Z3-10:Ac. Given its more extensive area, this dispenser permits a greater diffusion of Z5-12:Ac while slowing that of Z3-10:Ac, which is forced to pass from the rubber cylinder into the Z5-12:Ac dispensers before being released into the air.

Polyethylene fibrils (P). A layer of polyethylene felt fibre (Ferlosa[®]) coating on both facings was covered by impermeable aluminum so that release can occur only through the open edges. The structure and working mode of this dispenser were described by Capizzi *et al.* (1986).

⁽²⁾ Four blocks might not have been enough (marked differences were not statistically significant) but practical difficulties made it impossible to increase their number.

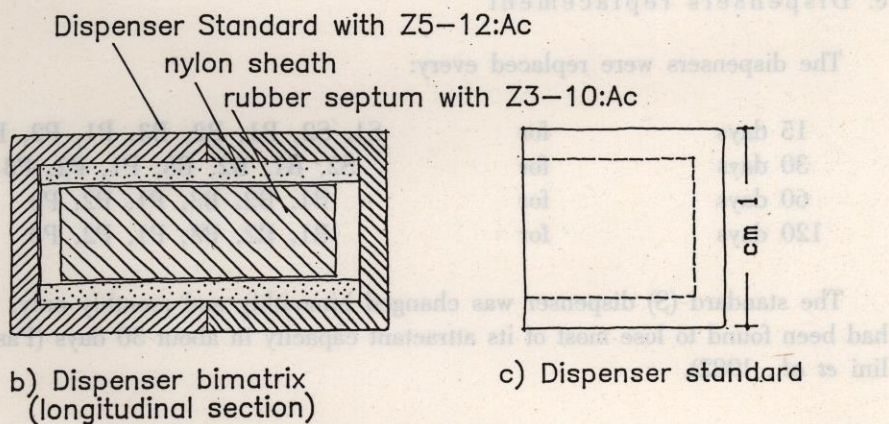
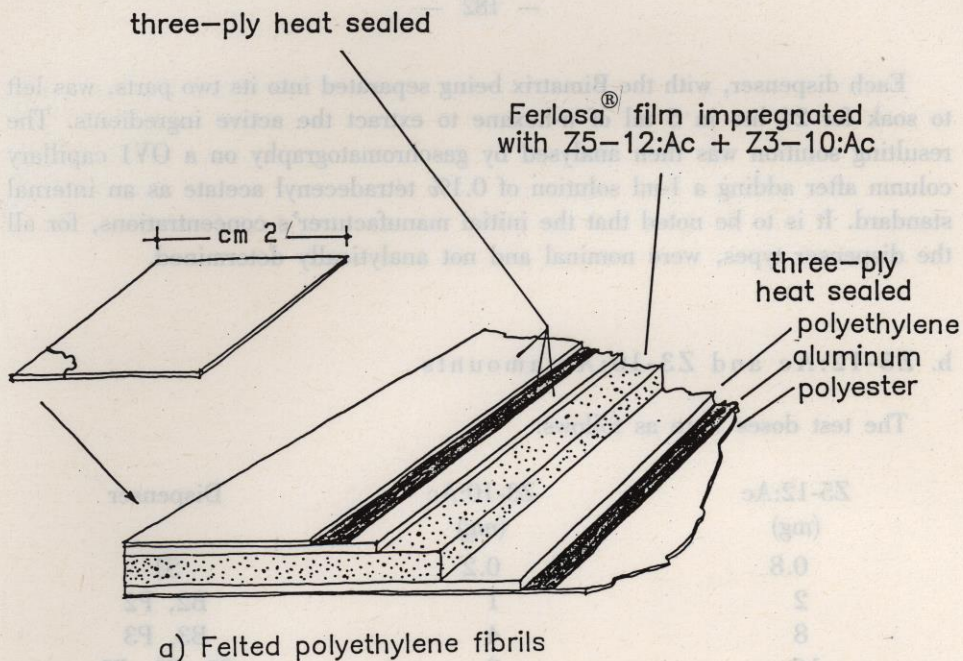


Fig. 1 - The three dispenser types compared in the experiment.

The way in which the dispensers released the sex attractant was studied in the laboratory. Each dispenser type was set along the central axis of a glass tube (\varnothing 12 cm) and kept at 25° C with a constant air flow of 1.5 m/sec.

To enhance comparison of the release rate in this experiment, a single amount (2 mg of Z5-12:Ac and 1 mg of Z3-10:Ac) was employed for all dispensers, which were then removed on different dates to determine their residual attractant content.

Each dispenser, with the Bimatrix being separated into its two parts, was left to soak for 24 hrs in 5 ml of n-hexane to extract the active ingredients. The resulting solution was then analysed by gaschromatography on a OV1 capillary column after adding a 1-ml solution of 0.1% tetradecenyl acetate as an internal standard. It is to be noted that the initial manufacturer's concentrations, for all the dispenser types, were nominal and not analytically determined.

b. Z5-12:Ac and Z3-10:Ac amounts

The test doses were as follows:

Z5-12:Ac (mg)	Z3-10:Ac (mg)	Dispenser
0.8	0.2	S1
2	1	B2, P2
8	4	B3, P3
16	8	S2, B1, P1

c. Dispensers replacement

The dispensers were replaced every:

15 days	for	S1, S2, B1, B2, B3, P1, P2, P3
30 days	for	S2, B1, B2, B3, P1, P2, P3
60 days	for	B1, B2, B3, P1, P2, P3
120 days	for	B1, B2, B3, P1, P2, P3

The standard (S) dispenser was changed bimonthly and monthly only, as it had been found to lose most of its attractant capacity in about 30 days (Pasqualini *et al.*, 1982).

TRIAL II: Z5-12:AC TO Z3-10:AC RATIO, PERSISTENCE

It was conducted at two sites near Ferrara. The four blocks covered a total of about 4 hectares of apple orchards planted at different densities with assorted cultivars, open-vase trained. Each 1-ha block contained 12 Mastraps[®]. Different amounts of Z3-10:Ac were tested with the same amount of Z5-10:Ac. The P dispenser was employed and changed every 15, 30 and 60 days. The amounts were:

Z5-12:Ac (mg)	Z3-10:Ac (mg)	Dispenser
8	2	P4
8	4	P3
8	8	P5
8	16	P6

In both trials the number of adults captured per trap was analysed statistically as follows:

- a) A factor analysis except for dispenser S.
- b) An analysis of variance comparing 15 days and monthly replacements. Duncan's test was used to compare the means ($\alpha = 0.05$).

RESULTS

A) TRIAL I

It is instructive to compare field results to the laboratory findings on release rate. Fig. 2 gives the analytical data for the release of Z5-12:Ac and Z3-10:Ac from the S, B and P dispensers. The curve indicates very different release rates, which are correlated with the dispensers' structural characteristics.

Greater insight can be gained by examining the variation in time of the ratio between the two components of the sex attractant (Table 1). Only the B dispenser kept the ratio unchanged, or varied it slightly.

The difference in volatility was only partly compensated by the P dispenser, which, however, showed a notable decrease in Z3-10:Ac. The S dispenser released the two attractant components at a rate directly proportional to their volatility, as is generally the case for single-structure rubber dispensers (Butler and Mc Donough, 1979, 1981; Heath *et al.*, 1986). In this case the ratio increased about 17-fold in the span of 100 hours.

Dispenser comparison

No significant differences were found between the two dispensers studied (B, P), although B trapped more males than P (4.17 ± 0.52 vs. 3.23 ± 0.78).

For B the quantities of Z5-12:Ac and Z3-10:Ac of (16+8) mg and (8+4) mg should be considered better than that for the (2+1) mg. The same holds for the P dispenser (Table 2).

The data in Table 3 clearly show that B remained effective even when never replaced. This is in evident contrast to the case of the P dispenser for which the mean number of captured males decreased with 60-day replacement and even more so for 120-day replacement.

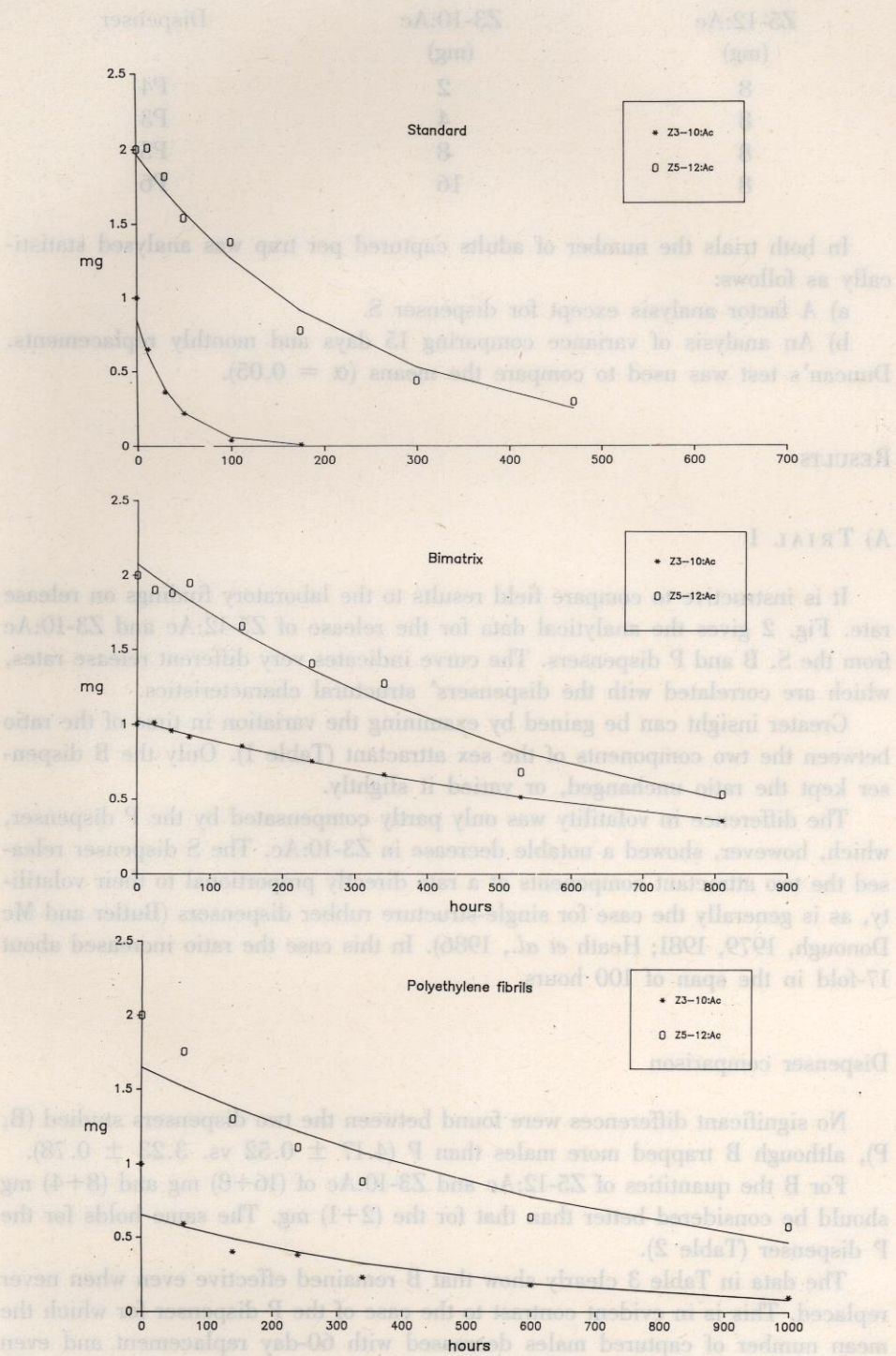


Fig. 2 - Release in time of Z5-12:Ac and Z3-10:Ac for the three dispenser types.

Table 1 - Variations in time of the Z5-12:Ac/Z3-10:Ac ratio by dispenser type.

Dispenser	Time (h)	Z5-12:Ac/Z3-10:Ac Ratio
Standard (S)	0	2.00
	12	3.10
	30	5.05
	50	7.00
	100	34.50
	175	58.00
Bimatrix (B)	0	2.00
	24	1.88
	48	1.96
	72	2.12
	144	1.93
	240	1.86
	340	1.91
	810	1.50
Polyethylene fibrils (P)	0	2.00
	65	2.97
	140	3.25
	240	2.92
	340	3.82
	600	3.56
	1000	5.80

Table 2 - Comparison of sex attractant components amounts for dispenser B and P.

Dispenser	Sex attractant Z5-12:Ac + Z3-10:Ac (mg)	Mean number of males captured per trap
Bimatrix (B)	(2 + 1)	2.19 ± 0.06 a
	(8 + 4)	4.56 ± 0.77 b
	(16 + 8)	5.75 ± 0.37 b
Polyethylene fibrils (P)	(2 + 1)	0.94 ± 0.28 a
	(8 + 4)	3.44 ± 1.54 b
	(16 + 8)	5.31 ± 1.13 b

Table 3 - Comparison of B and P dispenser replacement interval.

Dispenser	Replacement Interval (days)	Mean number of males captured per trap
Bimatrix (B)	15	4.25 ± 1.33 a
	30	4.08 ± 0.96 a
	60	4.92 ± 1.36 a
	120	3.42 ± 0.87 a
Polyethylene fibrils (P)	15	5.00 ± 1.75 a
	30	4.17 ± 2.19 a
	60	1.83 ± 0.96 b
	120	1.75 ± 0.80 b

Comparison of components quantities

There was a significant difference among the three amounts of the Z5-12:Ac and Z3-10:Ac. In particular, the mean number of captured males increased as did the concentrations: 1.56 ± 0.27 for (2+1) mg, 4.00 ± 0.82 for (8+4) mg and 4.90 ± 0.65 for (16+8) mg (Fig. 3).

The only significant finding, with regard to the bait replacement interval at each amount, was for the (8+4) mg, where a difference was found between 15-day replacement and no replacement (shown as 120-day replacement, Table 4).

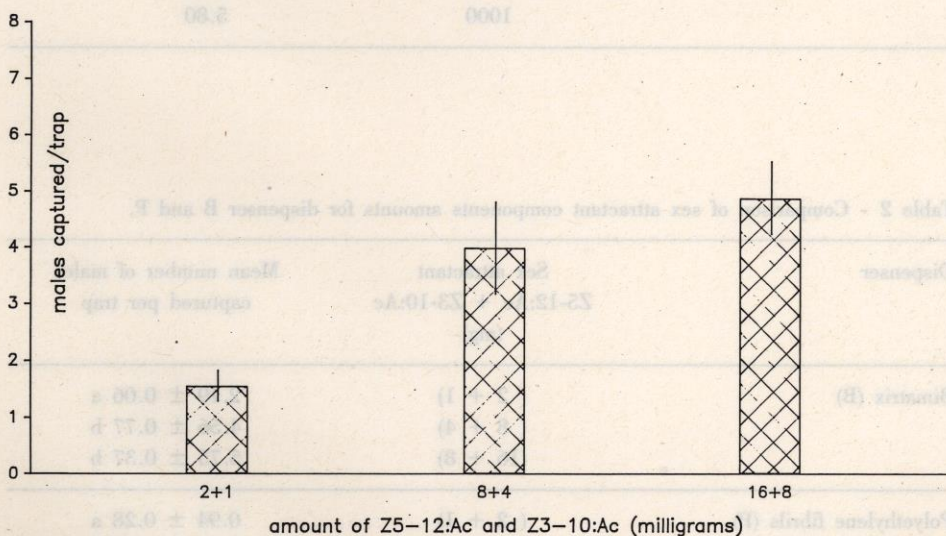


Fig. 3 - Mean number of *Cossus cossus* L. males captured with Z5-12:Ac and Z3-10:Ac from late May to early September, 1985.

Table 4 - Comparison of dispenser-replacement interval at the same component quantities of attractant.

Sex attractant Z5-12:Ac + Z3-10:Ac (mg)	Replacement Interval (days)	Mean number of males captured per trap
2 + 1	15	2.00 ± 0.25 a
	30	1.50 ± 0.75 a
	60	1.50 ± 0.75 a
	120	1.25 ± 0.75 a
8 + 4	15	5.75 ± 2.00 a
	30	4.00 ± 0.50 ab
	60	3.88 ± 2.90 ab
	120	2.38 ± 0.88 b
16 + 8	15	6.13 ± 0.62 a
	30	6.87 ± 1.38 a
	60	4.75 ± 1.00 a
	120	4.13 ± 0.87 a

Dispenser-replacement interval

Figure 4 shows that by decreasing the frequency of bait replacement, the number of males trapped decreased. However, these differences are not significant, except for the 15-day and the no-replacement intervals (4.63 ± 0.99 vs. 2.58 ± 0.65).

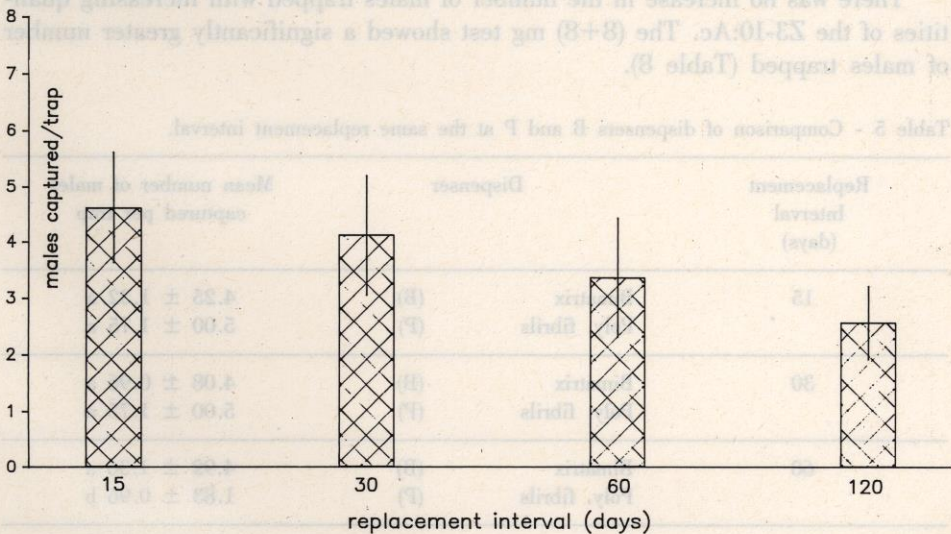


Fig. 4 - Mean number of *Cossus cossus* L. males captured with Z5-12:Ac and Z3-10:Ac as per dispenser replacement intervals from late May to early September, 1985.

A comparison of the attractant power of dispensers B and P at equal field life reveals that there are no significant differences for 15-day and monthly replacements but that dispenser B was more effective than P with 60 and 120-day replacements (Tab. 5).

The data in Table 6 report the performance of the different component amounts at the same replacement frequency. They show that at the more frequent replacements (15 and 30 days) the (2+1) mg amount attracted less than the other two. At the 60-day replacement and «no replacement» intervals the results are not so clear-cut, although the (16+8) mg amount attracted more males.

Comparison of dispensers S, B, P with different components amounts at the same replacement interval

a) 15-day replacement

The number of captured males tended to increase with increasing amounts of sex attractant, ranging from about two males for P (2+1) mg, S (0.8+0.2) mg and B (2+1) mg up to six for S (16+8) mg and about eight for P (8+4) mg.

b) 30-day replacement

The above pattern holds here, too, and is even more pronounced (Table 7).

B) TRIAL II

Increasing amount of Z3-10:Ac at the same quantity of Z5-12:Ac in dispenser P

There was no increase in the number of males trapped with increasing quantities of the Z3-10:Ac. The (8+8) mg test showed a significantly greater number of males trapped (Table 8).

Table 5 - Comparison of dispensers B and P at the same replacement interval.

Replacement Interval (days)	Dispenser		Mean number of males captured per trap
15	Bimatrix	(B)	4.25 ± 1.32 a
	Poly. fibrils	(P)	5.00 ± 1.75 a
30	Bimatrix	(B)	4.08 ± 0.96 a
	Poly. fibrils	(P)	5.00 ± 1.75 a
60	Bimatrix	(B)	4.92 ± 1.36 a
	Poly. fibrils	(P)	1.83 ± 0.96 b
120	Bimatrix	(B)	3.42 ± 0.87 a
	Poly. fibrils	(P)	1.75 ± 0.80 a

Table 6 - Comparison of attractant components amounts at the same replacement interval.

Replacement Interval (days)	Sex attractant Z5-12:Ac + Z3-10:Ac (mg)	Mean number of males captured per trap
15	2 + 1	2.00 ± 0.25 a
	8 + 4	5.75 ± 2.00 b
	16 + 8	6.13 ± 0.62 b
30	2 + 1	1.50 ± 0.75 a
	8 + 4	4.00 ± 0.50 b
	16 + 8	6.87 ± 1.37 b
60	2 + 1	1.50 ± 0.75 a
	8 + 4	3.88 ± 2.19 ab
	16 + 8	4.75 ± 1.00 b
120	2 + 1	1.25 ± 0.75 a
	8 + 4	2.38 ± 0.87 a
	16 + 8	4.13 ± 0.87 a

Table 7 - Comparison of dispensers S, B, P at monthly replacement.

Dispenser	Sex attractant Z5-12:Ac + Z3-10:Ac (mg)	Mean number of males captured per trap
Poly. fibrils (P)	2 + 1	0.75 ± 0.25 a
Bimatrix (B)	2 + 1	2.25 ± 0.25 a
Poly. fibrils (P)	8 + 4	3.50 ± 2.22 a
Bimatrix (B)	8 + 4	4.50 ± 0.29 ab
Standard (S)	16 + 8	5.25 ± 1.11 ab
Bimatrix (B)	16 + 8	5.50 ± 1.44 ab
Poly. fibrils (P)	16 + 8	8.25 ± 3.04 b

Table 8 - Comparison of Z5-12:Ac to Z3-10:Ac ratios.

Sex attractant Z5-12:Ac + Z3-10:Ac (mg)	Mean number of males captured per trap
8 + 2	2.58 ± 1.20 a
8 + 4	3.00 ± 0.82 a
8 + 8	4.67 ± 0.73 b
8 + 16	3.08 ± 0.17 a

Table 9 - Dispenser P replacement interval.

Interval (days)	Mean number of males captured per trap
15	3.81 ± 0.32 a
30	4.19 ± 0.64 a
60	2.00 ± 0.71 b

Dispenser replacement interval

Table 9 shows that the mean number of trapped males decreased if the dispenser was not replaced at least every 30 days.

CONCLUSIONS

Of the dispensers compared, the Bimatrix (B) showed the strongest and most constant performance during throughout EGM emergence. The reason is probably related to B's structure, which permits the ratio of the two active ingredients to remain nearly constant in time despite their differing volatility.

The data indicate that the (2+1) mg quantity of Z5-12:Ac and Z3-10:Ac was less effective as compared to (16+8) mg. It should be noted too, that even with frequent (15-and 30-day) bait replacements, the (2+1) mg was less effective than the other two amounts. It follows that its poor attractivity cannot be related to either dispenser replacement interval or dispenser type.

Bait replacement at the four intervals tested showed that with 15-day and monthly replacements, the only determinant variable affecting capture was the amount of sex attractant; whereas with less frequent replacements (60 and 120 days), the type of dispenser also took on importance. As shown in both trials, the P type lost some of its efficacy after one month in the field. It can be said that the type of dispenser is not very important when replacing frequently. The situation changes, however, when the replacement intervals are longer: in this case the B dispenser was the most suitable.

With regard to the sex attractant, the 1:1 ratio resulted in the greatest number of captures. This result should, however, be evaluated on the basis of the analytical data and is therefore valid only for the P dispenser. In effect, the greater initial concentration of Z3-10:Ac compensated for its faster release, permitting the attractant components to remain around the optimal ratio over a longer span of time.

We can conclude that the Bimatrix dispenser is the most effective and very likely the most suitable for all sex attractants having components with very different volatilities.

ACKNOWLEDGEMENTS

The authors would like to thank Prof. G. Briolini, Dr. P. Fanti and Dr. M. Borgatti of the «G. Grandi» Entomology Institute of the University of Bologna for their invaluable collaboration.

We should also like to acknowledge our gratitude to the owners of the «Azienda Ferrari» and «Azienda Zambelli» orchards for their cooperation.

SUMMARY

In order to improve the effectiveness of mass trapping of *C. cossus* L. we compared Standard, Bimatrix and Polyethylene-fibril dispensers at varying amounts and ratios of Z5-12:Ac and Z3-10:Ac. We also compared the dispenser replacement intervals: 15, 30, 60, 120 days.

The resulting data indicated that the amount of the two components was the most important factor influencing the number of captured males. This number increased as the attractant amounts increased.

The optimum ratios of the two synthetic chemicals for the polyethylene-fibrils proved to be 1:1, i.e. 8 mg of Z5-12:Ac and 8 mg of Z3-10:Ac.

The constant release over time and the good performance of the Bimatrix dispenser made it preferable to the others, especially when bait was left without change for at least one month. If replacement is more frequent, then the other two dispenser types are equally good.

Confronto fra quantità di attrattivo sessuale e fra vari tipi di erogatore in trappole per *Cossus cossus* L. (Lepidoptera: Cossidae).

RIASSUNTO

Al fine di migliorare la tecnica della cattura di massa per *C. cossus* L. sono stati messi a confronto, in trappole ad imbuto tipo Mastrap® modificato, diversi modelli di erogatore (Standard, Bimatrice, Fibrille), diversi dosaggi e diversi rapporti dei componenti dell'attrattivo sintetico composto da Z5-12:Ac e Z3-10:Ac. Sono anche state considerate sostituzioni quindicinali, mensili, bimestrali e quadrimestrali degli erogatori stessi.

I risultati ottenuti indicano che l'aumento del dosaggio dei componenti dell'attrattivo determina un incremento del numero dei maschi catturati.

Il rapporto ottimale fra le due sostanze sintetiche, per l'erogatore a fibrille polietileniche, è secondo questi dati 1:1 e, più precisamente, 8 mg di Z5-12:Ac + 8 mg di Z3-10:Ac.

Il modello di erogatore Bimatrice, per il costante rilascio nel tempo e per il maggiore numero di maschi catturati, è da preferire agli altri soprattutto se non si sostituisce l'innesco almeno ogni mese. In caso contrario, anche il tipo Standard e quello a Fibrille polietileniche mostrano una buona efficacia.

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