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PERFORMANCE OF *CYDIA POMONELLA*, *ARGYRESTHIA CONJUGELLA*, *PLUTELLA XYLOSTELLA*, AND *ARCHIPS PODANA* ATTRACTANT DISPENSERS IN ESTONIA

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Abstract. The Minifer UM dispenser was designed and tested to meet the requirements of a monitoring and mass-trapping system for codling moth (*Cydia pomonella*). A three-component lure loaded with (E,E)-8-10-dodecadien-1-ol, dodecan-1-ol, and (E)-8-dodecen-1-yl acetate (1 : 1.5 : 0.1) was used in the dispensers. The mean evaporation rate constant of (E,E)-8-10-dodecadien-1-ol in the traps in orchards was 0.048 ± 0.005 [day^{-1}]. The trap catches of the Minifer UM dispensers exceeded those of the A-traps (Ciba). Minifer TM dispensers loaded with (Z)-11-tetradecenyl acetate and (E)-11-tetradecenyl acetate 1 : 1 mixture were also successfully used to monitor populations of the fruit tree tortrix, *Archips podana*. Another apple-tree pest moth, *Argyresthia conjugella*, was monitored using Feroflor CA-71 dispensers loaded with (E)-13-octadecenyl acetate and (Z)-11-hexadecenyl acetate (3 : 7). Trap catches of diamondback moth (*Plutella xylostella*) that were high and equally stable for more than two months were achieved using a DispK dispenser loaded with a blend of (Z)-11-hexadecenal, (Z)-11-hexadecenyl acetate, and (Z)-11-hexadecen-1-ol (1 : 1 : 0.01). Optimal doses of the active blend for the different species studied were 50 µg for *P. xylostella*, 500 µg for *C. pomonella*, and 2000 µg for *A. podana*.

Key words: *Cydia* (*Laspeyresia*) *pomonella*, *Argyresthia conjugella*, *Archips podana*, *Plutella xylostella*, dispenser, evaporation rate, (E,E)-8,10-dodecadien-1-ol, (E)-8-dodecen-1-yl acetate, (E)-13-octadecenyl acetate, (Z)-11-hexadecenyl acetate, (Z)-11-tetradecenyl acetate, (E)-11-tetradecenyl acetate, (Z)-11-hexadecenal.

INTRODUCTION

Successful management of a pest insect requires an efficient and practical monitoring system to determine its population density. Pheromone and sex attractant traps can offer a reliable technique for monitoring many different moth pests. To achieve a good correlation between population density and trap catches the attractant dispenser should release a sufficient amount of the attractant over the required period of time and have high species specificity.

In areas where pest insects have one generation per year, direct control of insect pests of crops can sometimes be achieved by using pheromones in a mass trapping system. Pheromone dispensers for codling moth, *Cydia* (*Laspeyresia*) *pomonella* L., were used twenty years ago to trap out males in isolated apple orchards (Madsen et al., 1976). In Estonia, this method was introduced to many small private orchards after successful demonstration of the technique by Leivategija (Лейватегия, 1982). Pheromone kits have been available from KV Flora, Tartu, Estonia, for about 15 years.

Success of mass-trapping (or attraction-annihilation) programs is enhanced by the competitiveness of the lure. Increases in attractiveness will be non-linear with an increasing evaporation rate (loading) of the attractant (Колесова et al., 1984; Ahmad & Ali, 1989; Preiss & Priesner, 1988; McDonough et al., 1993). The greatest gains in numbers of the target species caught can be achieved by increasing the numbers of traps in the orchard. To avoid competition between the traps the loading of the attractant should be minimal. The Minifer UM dispenser was designed and tested in 1993–95 to meet these requirements of the monitoring system and the mass-trapping method for *C. pomonella*. A three-component lure loaded with (E,E)-8-10-dodecadien-1-ol, dodecan-1-ol, and (E)-8-dodecen-1-yl acetate was used in the dispensers. The component (E,E)-8-10-dodecadien-1-ol was identified by Roelofs et al. (1971). Later more compounds were identified (Einhorn et al., 1988), two of which influenced male orientation (Arn et al., 1985; Causse et al., 1988). In this paper we summarize our tests, conducted over several years, of the Minifer UM dispenser in Estonia.

Beside *C. pomonella* there are two other pests in the apple orchards in Estonia: tortrixes *Argyresthia conjugella* Zell. and *Archips podana* (Scop.). As no *A. conjugella* female sex pheromone has been identified yet, an attractant mixture of two compounds, (E)-13-octadecenyl acetate and (Z)-11-hexadecenyl acetate (3 : 7) (Feroflor CA-71 dispenser) was tested. Traps baited with (Z)-11-hexadecenyl acetate and (Z)-13-octadecenyl acetate were tested for their attractivity for males of Microlepidoptera in an apple orchard in the Netherlands. In particular, (Z)-11-hexadecenyl acetate was described to attract some species of *A. conjugella* on apple (Booij & Voerman, 1984). In Estonia and Finland, *A. conjugella* is considered to be an apple-tree pest of sporadic importance in years following summers when rowanberries produce a good harvest. Feroflor CA-71 attractant dispensers were tested for their capability for monitoring this potentially important pest. The ratio of the components for the dispenser has not yet been optimized. The evaporation rate of (E)-13-octadecenyl acetate from dispensers is extremely low, 4–7 times lower than the evaporation rate of (Z)-11-hexadecenyl acetate, and the ratio of the components should be varied in a wide range to determine the optimum ratio of the components.

The female pheromone of *A. podana*, identified by Persoons et al. (1974), is a 1 : 1 mixture of (E)- and (Z)-11-tetradecen-1-ol acetates. The Euro-Caucasian species *A. podana* is polymorphic for structure of male genitalia. Two morphs, one with an apical crotchet and the other with a lateral one, were first described by Ivanova and co-authors (Иванова et al., 1986; Иванова & Мыттус, 1986). These two morphs appeared to respond differently to the identified pheromone (Kozlov et al., 1991), but later this was shown not to be the case as 1 mg doses of pheromone per Feroflor septum (red rubber) gave unpredictable trap catches (Mõttus & Ivanova, 1991). When (Z)-11-tetradecen-1-ol or (E)-11-tetradecen-1-ol was added to the pheromone mixture the trap catches of *A. podana* males increased by 300% and more (Mõttus & Ivanova, 1991). Higher doses of the pheromone blend produce trap catches similar to the blend with a synergetic compound (Mõttus, Ivanova, and Buleza, unpublished results). Here we describe the use in Estonia of Minifer TM dispensers, loaded with 2 mg of the pheromone blend, with the initial evaporation rate equal to that of Feroflor dispensers loaded with 3 mg of the attractant (Mõttus et al., 1996b) and summarize the tests of attractant dispensers for *A. conjugella* and *A. podana*.

Plutella xylostella L., the diamondback moth, has in recent years caused economic damage to cabbage and some other cruciferous crops in Estonia. Its population density is normally relatively low in Estonia and in adjacent areas of Russia (Копвиллем, 1965; Макарова et al., 1990) and it causes slight damage to the leaves of cabbage and other cruciferous plants during their early growth period. Occasionally, however, due to long-distance migration, the population reaches outbreak densities and extensive crop damage may occur. It has one generation per year.

The pheromone can be used to monitor *P. xylostella* and indicate the need for pest control. Female *P. xylostella* pheromone, identified by Tamaki et al. (1977) is a 1 : 1 mixture of (Z)-11-hexadecen-yl acetate (Z11-16 : Ac) and (Z)-11-hexadecenal (Z11-16 : Ald). Koshihara & Yamada (1980) found that the attractiveness of the mixture of Z11-16 : Ac and Z11-16 : Ald to males could be increased by adding (Z)-11-hexadecen-1-ol (Z11-16 : OH). The results of our research on the optimization of pheromone dispensers for *P. xylostella* will be published elsewhere (Mõttus et al., 1996a). In this paper, we describe the use of the optimized dispenser to demonstrate its properties for monitoring *P. xylostella*. We also present the results of the field tests, which demonstrated the stability of catch by the DispK dispenser in the field.

MATERIALS AND METHODS

Chemicals. (E,E)-8,10-dodecadien-1-ol (Codlemone, E8,E10-12 : OH), (E)-8-dodecen-1-yl acetate (E8-12 : Ac), (E)-13-octadecenyl acetate (Z13-

18 : Ac), (Z)-11-hexadecenyl acetate (Z11-16 : Ac), (Z)-11-tetradecenyl acetate (Z11-14 : Ac), (E)-11-tetradecenyl acetate (E11-14 : Ac), and (Z)-11-hexadecenal (Z11-16 : Ald) were obtained from KV Flora (Tartu, Estonia); all chemicals were of pheromone purity. (Z)-alkenyl acetates were prepared via the acetylenic route and consisted of $1.0 \pm 0.1\%$ E-isomers and $1.9 \pm 0.1\%$ of the saturated compounds. Z11-16 : OH was prepared from Z11-16 : Ac by alkaline hydrolysis at the laboratory of Ecochemistry of the Estonian Agricultural University. E8,E10-12 : OH was of isomeric purity >97%, common purity 95%, and melting point 31–32 °C. Before using, all monoalkenoic compounds were purified by distillation or column chromatography on silica gel, E8,E10-12 : OH was used without additional purification. Compounds were assayed by gas chromatography of OV-1 or Carbowax 20M capillary columns, 30 m, i.d. 0.25 mm. The ratio of the components and doses in the dispensers was also determined by gas chromatography.

Dispensers. Two kinds of rubber were used to prepare septa. Natural red rubber (FSU GOST 3399-76) was used as substrate for stable pheromone substances and technical black rubber (FSU GOST 5496-78, composition 297) for degradable compounds. The technical black rubber contains a number of antioxidants and carbon powder.

Three different septa were used as dispensers. The cylindrical Feroflor® dispenser, supplied by KV Flora (Estonia, Tartu), has an outer diameter of 8.6 mm, inner diameter of 5 mm, length of 18 mm, and weight of 800 mg. Minifer dispensers are disks cut from Feroflor, they are 3.0 ± 0.1 mm long and weigh 130 mg. Feroflor dispensers have the evaporating surface area-to-volume ratio of 1.2 mm^2/mm^3, and Minifer dispensers 1.5 mm^2/mm^3. A smaller piece of rubber than a Minifer dispenser was used for the *P. xylostella* traps; this DispK dispenser weighed 40 mg, and its evaporating surface area-to-volume ratio was 1.8 mm^2/mm^3 (Mõttus et al., 1996a, b). Prior to use, the rubber septa were washed with acetone in a vapour evaporator for 30 min and dried in the air. The dispensers were impregnated with the chemicals in a rotary evaporator, using the mixture of diethyl ether and toluene (1 : 1) or a similar mixture of hexane and toluene as a solvent. The impregnated dispensers were stored in glass tubes for at least five days at room temperature before field tests. The characteristics of the dispensers are summarized in Table 1.

Traps and field tests. Field trap tests in five replicates were conducted in different places in Estonia in 1993–96. In all tests, traps were at least 20 m apart and were inspected every 5 to 10 days. In the orchards the traps were hung on trees at a height of 1.8 m, the traps for *P. xylostella* were hung on sticks at *c*. 0.6 m above the ground.

The traps were cardboard deltatraps Atrakon® A or Atrakon® AA with base areas of 225 cm^2 and 310 cm^2, respectively (from KV Flora, Tartu, Estonia). The entomological glue Pestifix® (KV Flora, Tartu) was used in the traps. Pheromone dispensers and A-traps® for *C. pomonella* (from

Table 1

Main characteristics of the tested dispensers

Dispenser type	Substrate used	Loaded compounds	Amount of blend, µg
Minifer UM (for *C. pomonella*)	Black rubber	E8,E10-12 : OH	200
		12 : OH	300
		E8-12 : Ac	20
Feroflor CPK* (for *C. pomonella*)	Black rubber	E8,E10-12 : OH	800
Feroflor CA-71* (for *A. conjugella*)	Red rubber	E13-18 : Ac	300
		Z11-16 : Ac	700
Minifer TM (for *A. podana*)	Red rubber	Z11-14 : Ac	1000
		E11-14 : Ac	1000
Feroflor PX* (for *P. xylostella*)	Black rubber	Z11-16 : Ald	500
		Z11-16 : Ac	500
		Z11-16 : OH	10
DispK (PX) (for *P. xylostella*)	Black rubber	Z11-16 : Ald	25
		Z11-16 : Ac	25
		Z11-16 : OH	0.5

* Dispensers produced by KV Flora, Tartu, Estonia

Ciba-Geigy Ltd, Basle, Switzerland) were tested in the orchard of the Estonian Agricultural University, Tartu, in 1994.

Determination of the evaporation rate from the dispensers. The evaporation rates for E8,E10-12 : OH, 12 : OH, Z11-16 : Ac, and Z11-16 : Ald from the dispensers were determined after exposure of the dispenser for different periods in the field. The compounds remaining in the dispensers were subjected to gas chromatographic analysis using appropriate alkanyl acetates as internal standards. The method of analysis has been described earlier (Вылегжанина et al., 1984; Анточ et al., 1987).

Calculation of the evaporation rate from the dispensers. The pheromone components are released from the formulation in keeping with the first-order evaporation loss order (McDonough & Butler, 1983; Mõttus et al., 1993). The integral form equation of the first-order process is

$$c_0 = c_t \times e^{-kt}, \qquad (1)$$

where c_0 is the amount of compound at the beginning of evaporation;
c_t is the amount of compound present at time t in the dispenser, and
k is the evaporation rate constant.

The constant k characterizes the evaporating compound, and it depends on the temperature, wind speed, and surface structure of the dispenser. Halflife $\tau_{1/2}$ is the time needed for the evaporation of half of the chemical loaded into the dispenser. The value of halflife may be calculated from formula (2)

$$\tau_{1/2} = \ln 2/k . \qquad (2)$$

The values of k have been published for many pheromone components (McDonough & Butler, 1983; McDonough et al., 1989). Evaporation rate constants from Feroflor dispensers were measured for most alkenols and alkenyl acetates in laboratory conditions for different wind speeds (0.08–2.1 m/sec) and various temperatures (Mõttus et al., 1993).

The value of k is not dependent on the concentration of the pheromone component in the dispenser, but it depends on the surface-to-volume ratio (area factor s_f):

$$s_f = S/V , \qquad (3)$$

where S is the surface area and V is the volume of the dispenser.

The evaporation constants measured for dispensers having s_f equal to 1 may be used as standard (k_{st}). Evaporation rate constants for dispensers with different surface constants may be calculated by formula (4)

$$k_s = k_{st} \times s_f . \qquad (4)$$

Formula (4) is correct if the evaporation of pheromones is not limited by diffusion process. It yields evaporation constants with an error exceeding 30% for tetradecenyl acetates for Minifer dispensers, which shows the significance of diffusion (Mõttus et al., 1996b).

Statistical analysis. The numbers of moths caught in the traps were subjected to Student's *t*-test or to ANOVA to determine the statistical significance between the mean values.

RESULTS

I. *C. pomonella*

Effect of dispenser type on male capture. Atrakon A traps baited with Minifer UM dispensers caught more male *C. pomonella* than standard A-traps from Ciba (Fig. 1). Total trap catches of Minifer UM dispensers exceeded those of A-traps 1.8 times. The greater attractivity of Minifer UM dispensers for the first period of 22 days was statistically significant at $P<0.05$. Although Minifer UM dispensers caught consistently more *C. pomonella* than Feroflor CPK dispensers throughout most of the trial, differences were not statistically significant at $P \geq 0.2$ (Fig. 2).

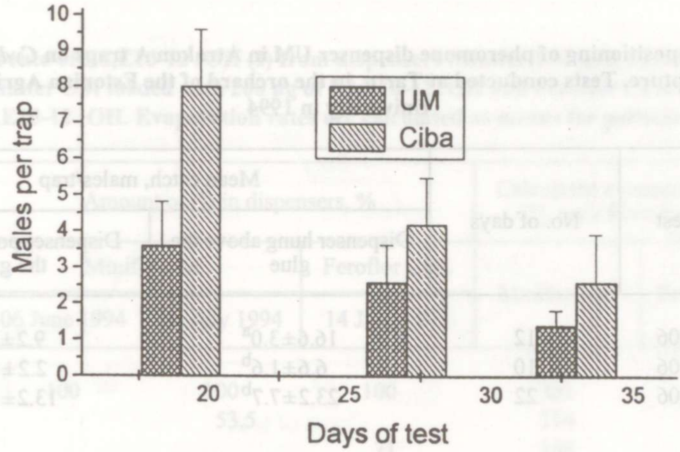

Fig. 1. Mean number of male *Cydia pomonella* in traps baited with Minifer UM dispensers (trap Atrakon A) and dispensers from Ciba (A-trap). Test started on 11 June 1994 at Tartu. The bars are significantly different ($P<0.05$) for the first 22 days of the test. Traps were used in five replicates.

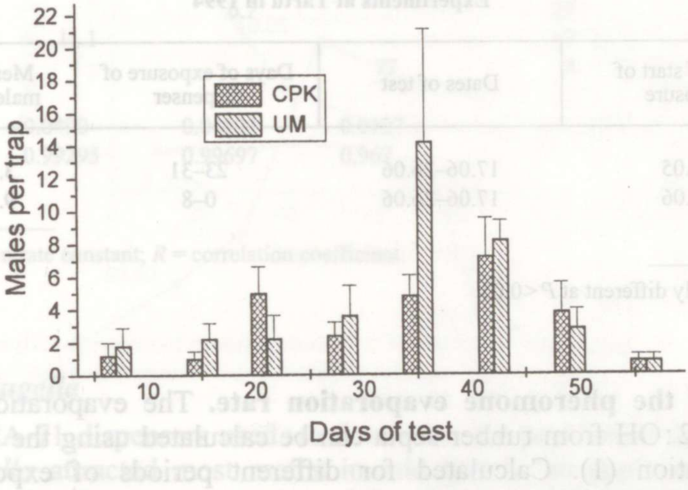

Fig. 2. Mean number of male *Cydia pomonella* in traps baited with Minifer UM dispensers and dispensers Feroflor CPK in traps Atrakon A. Test started on 11 June 1994 at Valtu. The bars are not significantly different at $P \geq 0.2$.

Effect of lure positioning in traps. Significantly more moths were caught by traps with Minifer UM dispensers hung above the glue than by traps with the dispensers positioned in the glue (Table 2).

Effect of field ageing of the dispensers. Traps baited with fresh Minifer UM dispensers caught significantly more moths than those with dispensers that had been exposed for 22 days prior to the test (Table 3).

Table 2

Effect of the positioning of pheromone dispenser UM in Atrakon A traps on *Cydia pomonella* male capture. Tests conducted at Tartu, in the orchard of the Estonian Agricultural University in 1994

Dates of test	No. of days	Mean catch, males/trap	
		Dispenser hung above the glue	Dispenser positioned in the glue
25.05–06.06	12	16.6 ± 3.0^a	9.2 ± 3.0^a
07.06–17.06	10	6.6 ± 1.6^b	2.2 ± 2.1^b
25.05–17.06	22	23.2 ± 7.7^b	13.2 ± 6.5^b

[a] Significantly different at $P<0.10$.
[b] Significantly different at $P<0.05$.

Table 3

Effect of the ageing of dispenser UM on the male *Cydia pomonella* capture. Experiments at Tartu in 1994

Date of start of exposure	Dates of test	Days of exposure of dispenser	Mean No. of males per trap
25.05	17.06–26.06	23–31	3.8 ± 0.9^a
17.06	17.06–26.06	0–8	9.1 ± 2.1^a

[a] Significantly different at $P<0.05$.

Effect of the pheromone evaporation rate. The evaporation rate of E8,E10-12:OH from rubber septa can be calculated using the first order loss equation (1). Calculated for different periods of exposure, the evaporation rate constants differed by 2% (i.e. 0.048 and 0.049 [day^{-1}]), the correlation coefficient was higher than 0.99 (Table 4). Table 4 presents also the results of dispensers Minifer UM and Feroflor CPK in the traps, the evaporation rate constants resulting from the analysis, and the amounts of evaporated pheromone for different times of exposure.

Behaviour of moths near the traps. Observation of the behaviour of 14 male *C. pomonella* near the traps showed that they flew vertically zigzagging directly to the traps and that most of them were caught. Former observations in Krasnodar region indicated that with Feroflor CPK dispensers no more than 15% of the moths attracted to traps entered them and were caught (Mõttus & Ivanova, 1991).

Table 4

Evaporation rate of E8,E10-12 : OH (I) from dispensers Minifer UM and Feroflor CPK in field tests. Minifer UM loaded with 200 μg of E8,E10-12 : OH and Feroflor CPK loaded with 800 μg of E8,E10-12 : OH. Evaporation rates are calculated as means for periods of two days

Days of test	Amount of (I) in dispensers, %			Calculated evaporation rate of (I), ng/h from dispensers	
	Minifer UM		Feroflor CPK	Minifer UM	Feroflor CPK
	06 June 1994	06 July 1994	14 June 1993		
0	100	100	100	381	428
12		53.5		214	366
15			71	186	352
21	52.8			139	326
22		38.2		132	321
27			66	104	303
31	40.3			86	286
35		20.8		71	271
41			47	53	251
42	20.8			51	248
52	15.9			31	218
55		6.7		27	209
65	11.1			17	184
77			77	9	157
k [day^{-1}]	0.0490	0.04823	0.0127		
R	0.99295	0.99697	0.967		

k = evaporation rate constant; R = correlation coefficient.

II. *A. conjugella*

Feroflor CA-71 dispensers used to determine the population density of *A. conjugella* attracted most moths in mid-July in an apple orchard at Valtu (Fig. 3). The maximum trap catch on 10 July differed significantly from other catch periods ($P < 0.05$).

III. *A. podana*

In 1994, five Minifer TM baited traps attracted 128 *A. podana* moths and one *Tortrix viridana* Hb moth in the orchard of the Estonian Agricultural University, Tartu. Figure 4 gives the results of the monitoring of *A. podana* population density in a commercial orchard at Valtu, North Estonia. Maximum trap catch periods (18–25 July and 16 July–01 August) differed significantly from other catch periods ($P < 0.05$).

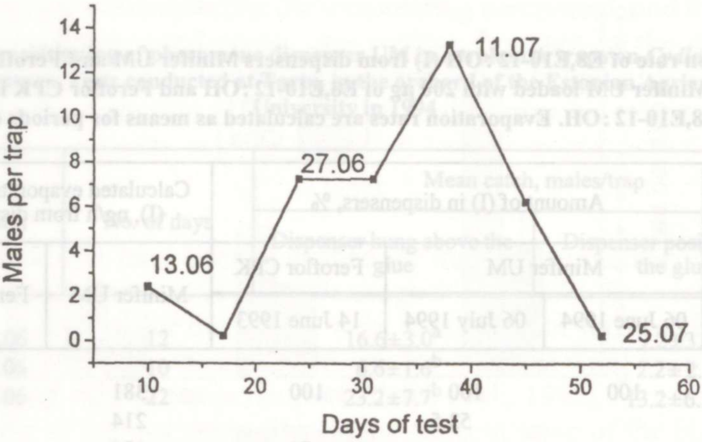

Fig. 3. Population dynamics of *Argyresthia conjugella* in an apple orchard at Valtu, North Estonia, in 1994. Dispensers Feroflor CA-71 in Ferokon A traps were used in five replicates. The traps were observed by the agronomist L. Kivimurd.

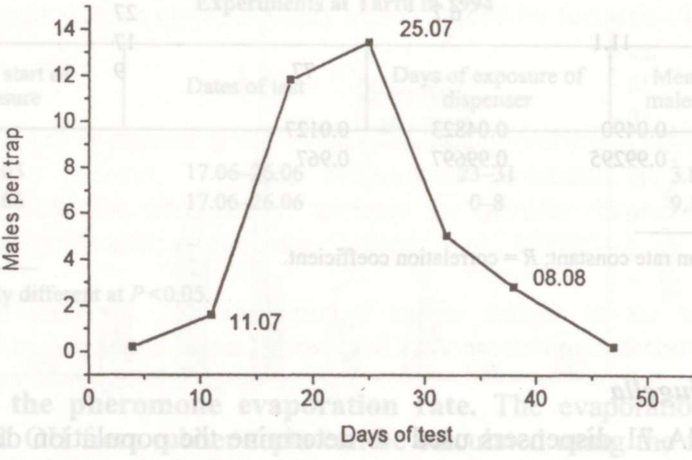

Fig. 4. Population dynamics of *Archips podana* in an orchard at Valtu, North Estonia, in 1994. Atrakon A traps baited with Minifer TM dispensers in five replicates. The traps were observed by the agronomist L. Kivimurd.

IV. *P. xylostella*

Similar numbers of moths were caught by traps with DispK dispensers that were left out continuously and changed every two weeks during the test period of two months (Table 5). The population dynamics of *P. xylostella* over three years (1993–95), measured using traps baited with DispK dispensers near Tartu, indicated a serious outbreak in 1995 (Fig. 5).

Table 5

Mean numbers of male *Plutella xylostella* caught by traps ($n = 5$ per treatment) baited with DispK dispensers loaded with 50 µg of pheromone (1 : 1 : 0.01 of Z11-16 : Ald, Z11-16 : Ac, Z11-16 : OH) and left out continuously or changed at least every two weeks in field tests near Tartu, test started on 10 June 1995. Differences are not significant ($P \geq 0.2$)

Date of test	Weeks of experiment	Dispensers of max. 2 weeks exposure	Dispensers not changed from the start of test
10.–25.06	1–2	124.2±17.7	99.8±5.5
26.06–02.07	3	62.0±13.5	59.0±7.7
18.–23.07	6	21.6±3.0	23.4±5.4
24.07–11.08	7–8	8.6±1.1	9.0±0.6

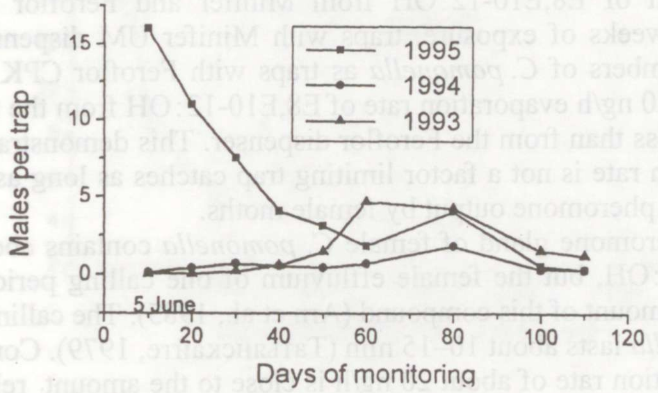

Fig. 5. Population dynamics of *Plutella xylostella* in the cabbage field near Tartu in 1993–95. Atrakon A traps baited with DispK dispensers in five replicates.

DISCUSSION

Pheromone dispensers for *C. pomonella*

Effect of dispenser types on male catch. Atrakon A traps baited with Minifer UM dispensers caught more males than A-traps baited with Ciba dispensers (Fig. 1). Minifer UM and Feroflor CPK dispensers were of similar attractivity (Fig. 2) when positioned in the glue on the trap bottom. However, when the Minifer UM dispenser was hung above the glue of the trap bottom, the trap catches were significantly greater than when the dispenser was positioned in the glue of the trap (Table 2). This conflicts with previous reports (Мыттус & Гранат, 1983; Kehat et al., 1994).

Diffusion of the pheromone from the dispenser to the glue would be expected to be proportionately greater from the low dose and higher surface concentration Minifer dispensers than from the Feroflor dispensers. E8,E10-12 : OH in glue is not protected from isomerization processes and may result in nonpheromone isomers of E8,E10-12 : OH. The inhibitory effect of nonpheromone isomers is known since Roelofs et al. (1972) reported a decreased trap catch when these compounds were present. The inhibitory effect of these isomers in wind-tunnel experiments has been recently reported by McDonough et al. (1993). Isomerization of E8,E10-12 : OH does not take place inside Feroflor dispensers exposed in orchards for six weeks (Анточ et al., 1987). Minifer and Feroflor dispensers are made from the same substrate, a highly stabilized rubber, and E8,E10-12 : OH is protected equally in both dispensers.

The greater the dose in the dispenser, the faster the release rate (evaporation rate) of the pheromone blend leading to a diminished evaporation rate over the exposure period as can be expected of the first order process. Table 4 lists the experimental and calculated data of the evaporation of E8,E10-12: OH from Minifer and Feroflor dispensers. After six weeks of exposure, traps with Minifer UM dispensers caught similar numbers of *C. pomonella* as traps with Feroflor CPK dispensers but the *c*. 20 ng/h evaporation rate of E8,E10-12: OH from the former was 10 times less than from the Feroflor dispenser. This demonstrates that the evaporation rate is not a factor limiting trap catches as long as it exceeds the rate of pheromone output by female moths.

The pheromone gland of female *C. pomonella* contains about 2 ng of E8,E10-12: OH, but the female effluvium of one calling period contains twice the amount of this compound (Arn et al., 1985). The calling period of *C. pomonella* lasts about 10–15 min (Татьянскайте, 1979). Consequently, an evaporation rate of about 20 ng/h is close to the amount released by a female moth.

The existence of a wide equally active region (active plateau region) of loaded doses (or evaporation rates) of pheromone blend has been demonstrated in wind-tunnel experiments (Priess & Priesner, 1988; McDonough et al., 1993). This equally active range has been reported for doses of 1 to 100 μg (Preiss & Priesner, 1988) or 10 to 300 μg (McDonough et al., 1993).

Earlier field experiments on Feroflor dispensers demonstrated that doses of 0.6 and 2.0 mg in dispensers of the substrate of the same kind as the one used in our experiments yielded similar trap catches (Колесова et al., 1984). Similar effects have been reported for other dispensers. For instance, doses of 2, 4, and 6 mg of E8,E10-12 : OH per rubber septa from Wolfson Unit of Chemical Entomology, University of Southampton, UK, resulted in similar trap catches of 27–36 moths per trap, but doses of 8 mg/trap yielded total trap catches close to nonbaited traps (Ahmad & Ali, 1989). For practical use Israeli rubber dispensers with anti-UV agent and antioxidants have an active range of loading of 100 to 1000 μg of E8,E10-12 : OH per dispenser (Kehat et al., 1994).

Figure 6 demonstrates that the trap catches are significantly smaller if higher doses of E8,E10-12:OH are loaded into a substrate of red rubber, where isomerization processes of the pheromone are not inhibited (Кейсер et al., 1981). Amounts of 2000 µg were significantly less attractive than doses of 200 µg. Subsequently, isomerization products of E8,E10-12:OH may inhibit the attractivity of the dispenser. Dispensers with larger surface-to-volume ratio have more substances in the evaporating area, not only in the substrate, but in the pores as well. This evaporating part is not protected from isomerization and as a result, the evaporated pheromone contains more isomerized products than that remaining in the dispensers. This is one possible explanation why smaller dispensers, such as Minifer UM, have higher attractivity.

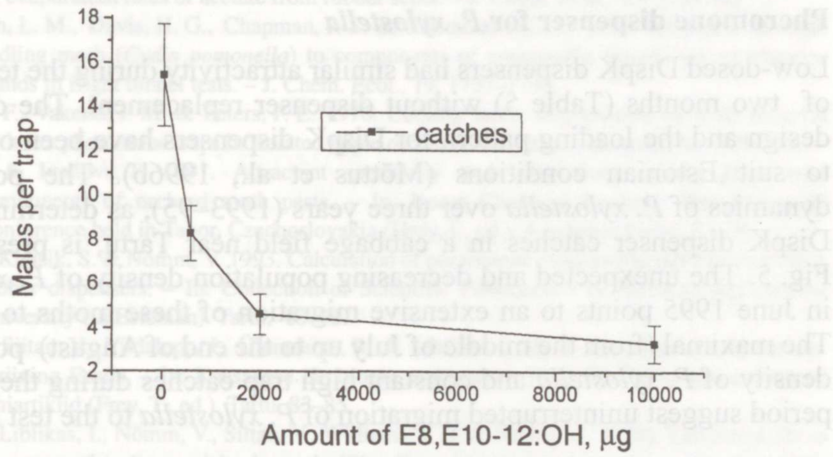

Fig. 6. Effect of pheromone doses on trap catches; pheromone dispensers of red natural rubber. Tests conducted in the Crimea in 1979 (Кейсер et al., 1981).

Our field experiments in Estonia have demonstrated the need to replace Minifer UM dispenser every 2–3 weeks to maximize trap catches for mass trapping. They have also shown that dispensers of the above-mentioned type can be used successfully to monitor population dynamics of *C. pomonella* for six weeks without dispenser replacement.

Attractant dispensers for *A. conjugella*

Figure 3 demonstrates that trap catches with dispenser Feroflor CA-71 indicate the population density of *A. conjugella*. The peak numbers differ significantly from those of previous and subsequent ones ($P<0.05$). A blend of (E)-13-octadecenyl acetate and (Z)-11-hexadecenyl acetate (3:7) may be recommended as attractant for this moth.

Pheromone dispensers for *A. podana*

The Minifer TM dispensers tested have an initial evaporation rate of Z11-14:Ac and E11-14:Ac 1:1 mixture equal to the Feroflor AP dispenser, loaded with 3 mg of pheromone blend. Surprisingly this high-dosed dispenser had a very high (more than 90%) species specificity in different small private orchards in Tartu. Moreover, its species specificity was high not only in orchards. In 1994, five Atrakon A traps baited with Minifer TM dispensers caught 129 male *A. podana* moths placed in different biocoenosis (orchard, forest clearing, birch stand) while only one *Pammene insulana* Gn. and *Syndemis musculana* Hbn. were attracted (Mõttus et al., 1994). Minifer TM dispensers are effective for monitoring population density dynamics, top catches are fixed with significantly differing ($P<0.05$) trap catch values (Fig. 4).

Pheromone dispenser for *P. xylostella*

Low-dosed DispK dispensers had similar attractivity during the test period of two months (Table 5) without dispenser replacement. The dispenser design and the loading pattern for DispK dispensers have been optimized to suit Estonian conditions (Mõttus et al., 1996b). The population dynamics of *P. xylostella* over three years (1993–95), as determined after DispK dispenser catches in a cabbage field near Tartu, is presented in Fig. 5. The unexpected and decreasing population density of *P. xylostella* in June 1995 points to an extensive migration of these moths to Estonia. The maximal (from the middle of July up to the end of August) population density of *P. xylostella* and constant high trap catches during the summer period suggest uninterrupted migration of *P. xylostella* to the test area.

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KAHJURPUTUKATE *CYDIA POMONELLA*, *ARGYRESTHIA CONJUGELLA*, *PLUTELLA XYLOSTELLA* JA *ARCHIPS PODANA* FEROMOONPREPARAATIDE KATSETUSTULEMUSI EESTIS

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Eestis oluliste põllumajanduskahjurite *Cydia pomonella* L., *Argyresthia conjugella* Zell., *Archips podana* Scop. ja *Plutella xylostella* L. mitmekomponentsete feromoon- või suguatraktant-dispenserite laboratoorsed ja välikatsetused osutasid, et väiksemate mõõtmetega Miniferi tüüpi dispenserid on teistest atraktiivsemad ja töökindlamad. Aktiivaine optimaaldoos sõltub suuresti putukaliigist. Kapsakoi (*P. xylostella*) korral on optimaalne kogus 50 mkg (Z)-11-heksadetsenüülatsetaadi, (Z)-11-heksadetsenaali ja 11-heksadetsenooli segu (1 : 1 : 0,01) dispenseri kohta (dispenser DispK), õunamähkuril (*C. pomonella*) on selleks 500 mkg (E,E)-8,10-dodekadieen-1-ooli, (E)-8-dodetsenüülatsetaadi ja dodekanooli segu (1 : 0,1 : 1,5; dispenser Minifer) ja taramähkuri (*A. podana*) korral on soovitav kasutada 2000 mkg (Z)-11-tetradetsenüülatsetaadi ja (E)-11-tetradetsenüülatsetaadi segu (1 : 1; dispenser Minifer). Õuna-pihlakakoi (*A. conjugella*) peibutisena kasutati edukalt (E)-13-oktadetsenüülatsetaadi ja (Z)-11-heksadetsenüülatsetaadi segu (0,3 : 0,7; dispenser Feroflor) koguses 20 000 mkg. Õunamähkuri peamise atraktiivkomponendi (E,E)-8,10-dodekadieen-1-ooli aurustumise keskmine kiiruskonstant oli $0{,}048 \pm 0{,}004$ [päev^{-1}] ja teise töökuu lõpuks oli dispenseritelt aurustuva toimeaine kogus ligilähedane emasliblikate poolt eritatavale ainekogusele. Katsetatud feromoondispenserite tööomadused võimaldavad nende kasutamist Eesti ja Põhja-Euroopa kliimas. Aastatel 1993–1995 selgitatud kapsakoi populatsioonidünaamika viitab võimalusele, et selle kahjurputuka arvukus on tingitud peamiselt või ka ainult sisserändest meie aladele.