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Monitoring of flight periods of *Agrotis segetum* using sex traps baited with virgin females

Registrering af ageruglens flyvning ved hjælp af feromonfælder med jomfruelige hunner

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Summary

At irregular intervals cutworms (*Agrotis segetum*) have caused severe damage to different Danish crops. Since 1960 monitoring of the flight period of the turnip moth has taken place by means of 8 light traps in different parts of the country.

An increase of the number of light traps would be very costly. Therefore the possibility of using simple sex traps to improve the monitoring has been investigated. The sex trap catches have been compared to light trap catches. The catches started earlier in light traps. However, the catching period was longer in sex traps and in some cases the sex traps showed a second generation which was not discovered by the light traps. The peak catch of the sex traps occurred at a later time than that of the light traps.

It is suggested that an improved monitoring system should be based on few light traps and many sex traps.

Despite the sex traps proved to be as simple to handle as desired, further improvement can be obtained with a synthetic bait. In this way the variation of female attractivity will be eliminated. Also the significance of trap position which was demonstrated should be investigated in details.

Key words: *Agrotis segetum*, sex traps, monitoring.

Resumé

Alvorlige knopormeskader forekommer tilbagevendende på danske afgrøder. Gennemsnitstabet taler for en effektiv overvågning af ageruglens tilstedeværelse med henblik på prognoser angående risikoen for knopormeangreb. Siden 1960 har 8 lysfælder været i drift med dette formål; men en udvidelse af dette net ville blive meget kostbar. Derfor har den forhåndenværende undersøgelse søgt at sammenligne lysfælder og simple feromonfælder og belyse feromonfældernes egnethed som varslingsredskab. Den anvendte fældetype ses på figur 2. Fældens hovedbestanddele er 45 cm PVC-nedløbsrør lukket med netruser, der er limet i plastichonningdåser. Fælden orienterer sig efter vindretningen, og vinden fører duften fra en jomfruelig hun i det lille bur med sig. Lokkehunnen er forsynet med sukkervand i et lille glasrør, hvis vatprop sommerfuglen kan slikke på. Fælderne stod ca. 1 meter over jorden og normalt med en indbyrdes afstand på ca. 50 meter. Lokkehunnerne blev udtaget af en laboratoriekultur opfodret på kunstig ernæring og derpå sendt til bestemmelsesstederne pr. post. Hunnerne blev udskiftet én gang ugentlig, mens fangne hanner blev talt og tilintetgjort 2 gange ugentligt. Fangstallene

pr. fælde pr. uge for alle lokaliteter ses af tabel 1 (1977) og tabel 2 (1978). Forløbet af fangsten i henholdsvis lysfælder og feromonfælder er på figur 4 sammenlignet for visse lokaliteter.

Fangsterne startede tidligst i lysfælderne. Til gengæld strakte de sig over en længere periode i feromonfælderne, som også afslørede en anden generation i tilfælde, som ikke vistes af lysfælderne. Den vigtigste forskel var imidlertid feromonfældernes generelt senere fangsttop (figur 4). Denne forskel lader sig i øjeblikket ikke forklare. Man kan imidlertid konkludere, at et varslingsnet bestående af nogle få lysfælder og væsentlig flere feromonfælder med al sandsynlighed vil give et betydelig mere detaljeret og forbedret billede af ageruglens optræden end lysfælderne alene.

Undersøgelsen godtgjorde, at feromonfælderne opfylder de ønskede egenskaber i retning af betjeningsenkelhed. Betjeningen kan dog yderligere simplificeres ved brug af syntetisk feromon, som er udviklet så vidt, at praktisk brug kan påbegyndes. Ageruglehunnernes forskellige tiltrækningsevne, som har vanskeliggjort denne undersøgelse, vil også være elimineret ved brug af syntetisk feromon. Dermed kan også indflydelsen af fældeplacering, som kunne påvises i visse tilfælde (tabel 4) undersøges tilbundsgående.

Nøgleord: *Agrotis segetum*, feromonfælder, registrering/varsling.

Introduction

At irregular intervals heavy populations of cutworms have caused severe damage to agricultural and horticultural crops in Denmark. Registration of attacks and damages has taken place at the Plant Pathology Institute since 1906. This central registration has been based on local reports from scientists and extension officers. On the basis of the collected information *Stapel* (1977) estimated the attack level for each year. His results have been used in figure 1 to give an impression of the economic importance of cutworm attacks. The loss due to cutworm damages on potatoes, carrots, leeks, onions and red beets in 1969 was estimated at 15.5 million Danish kroner by *Thygesen* (1970). The loss in 1975 was estimated at nearly 40 million Danish kroner by *Zethner* and *Jørgensen* (1976), and the 1976 loss was estimated at 74 million Danish kroner by *Zethner* (1977). The mean value of losses which can be calculated from the black, shaded and high open columns shows the need for efficient monitoring of the moths as basis for cutworm forecasting.

Since 1960 the Plant Pathology Institute has monitored the flight period of *A. segetum* by means of 8 light traps on different sites in Denmark (*Thygesen*, 1968, 1971). The trapping efficiency and the infestation levels vary so much within short distances that many more traps are necessary to give a reliable forecast. Such a solution, however, would be very costly. Therefore a

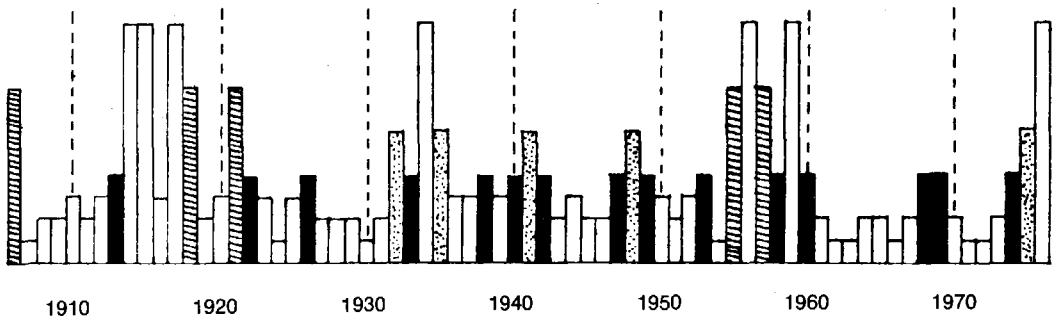


Fig. 1. Levels of cutworm attacks 1906–76 according to *Stapel* (1977).
Knopormeangrebenes styrke 1906–76.

simple sex trap with virgin females as baits was made and tested in 1976 (*Bromand et al.*, 1976). This trap was used more widely during 1977 and 1978 to evaluate the possibility of establishing a monitoring network of traps as a basis for forecasts.

Materials and methods

The sex trap and its holder is shown in figure 2.

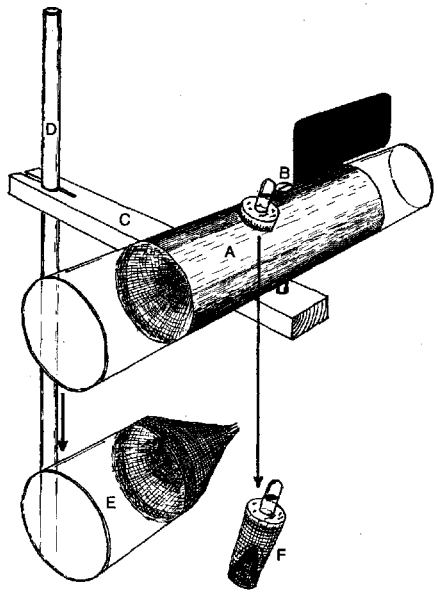


Fig. 2. The design of the sex trap used.
Feromonfældens udformning.
The shaded pipe is a piece of plastic reed, 45 cm long (A). This pipe may revolve on the fitting screw (B) (down in the wooden arm (C)) depending on changes of the wind. The wooden arm is attached to a piece of water pipe (D) which is beaten down into the soil. Below the trap is shown the clear plastic cylinder with the net barring permitting only the entrance of moths (E) and the lady bower (F).

The trap is made up of a piece of plastic reed, 45 cm. long, with a diameter of 10 cm. Each end is closed with a clear plastic cylinder fitted with a net barring serving as a one-way passage for the moths so they can enter the trap but not escape from it. The bait of the trap is a virgin female placed in a small »lady's bower« near the centre of the trap. To supply the virgin female with water and food a glass tube with 2 per cent sugar solution is mounted in the cork closing the top of the lady's bower. The tube is placed upside down and the opening is closed with cotton wool from which the virgin female can lick the sugar solution.

The traps were placed roughly one metre above the ground and with a mutual distance of 50 metres. An exception was those at Højbakkegård which had only 10–20 metres in between the traps.

The trap positions in 1978 were not exactly the same as they were in 1977. However, a major change of placement took place only at Årslev. Here the sex traps were placed about 400 metres away from their 1977 position. The number of traps on each location can be seen from tables 1 and 2. Each trap was emptied twice a week and the females were replaced once a week.

The virgin females originated from a culture of *A. segetum* reared on artificial diet as described by *Hansen* and *Zethner* (1979). Females and males were separated during the pupal stage. Just after emergence the females for the traps were placed in the lady's bowers and supplied with sugar solution. The small cages were packed in plastic boxes and sent by mail (1–2 days) to the destinations. These females were 2–5 days old when they arrived at the trapping localities. The youngest females available were always used. On some occasions there was a shortage of females, hence some results are missing.

The type of light trap used is shown in figure 3. The light source is a 125-W mercury-vapour bulb. At most localities there were 30 metres or more from the light trap to the nearest of the sex traps. Exceptions are Blangstedgård and Lyngby. At Blangstedgård the distance from the light trap to the nearest sex trap was only 6 metres while the corresponding distance was 10 metres at Lyngby.

Results

Catch in relation to time and sex ratio

Number of males caught per sex trap per week in all localities is shown for 1977 in table 1 and for 1978 in table 2. As was to be expected there is a considerable variation between localities both

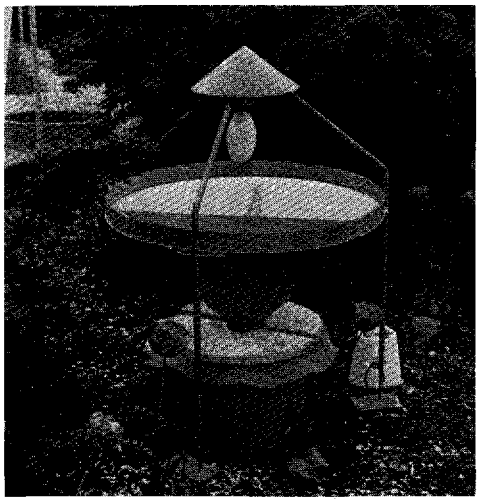


Fig. 3. The type of light trap used.
Den anvendte lysfældetype. (Foto: B. Welling)

concerning the length of the catching period and the time of the peak catch. Catches in sex traps and in light traps are compared graphically in figure 4. It can be seen that the peaks of catches appear at different times depending on the type of trap used. However, it is clear that the light traps tend to give earlier peaks of catches than the sex traps (7 of 8 cases). A reliable comparison of the time of the first catch is only possible in six cases: Lyngby 1977 and 1978, Årslev 1977 and 1978, Blangstedgård 1977 and Studsgård 1978. Comparison of light traps and sex traps showed that catches started earlier in the former and, except from the trap at Årslev, lasted for a longer period in the latter.

The examination of sex ratios in light trap catches showed a higher proportion of males than of females as can be seen from table 3. Furthermore the catches indicated an earlier appearance of males than of females.

Table 1. Number of *Agrotis segetum* males caught per sex trap per week on the different sites in 1977
Antallet af fangne Agrotis segetum hanner pr. fælde pr. uge på forskellige lokaliteter i 1977

	Hem, Skanderborg	Grenå	Permelille, Samsø	Årslev	Blangstedgård	Strandholt at Odense	Lundegård at Odense	Bonderup at Frederikssund	Brogård	Sølyst	N.R.C.P.P.[1])	Frederiksdal	Virumgård	Højbakkegård	sites
Number of traps:	3	3	3	3	3	3	2	2	3	2	2	2	2	5	
Week no.															
20	0.0	–	–	–	0.0	0.0	–	–	–	–	0.0	0.0	0.0	–	0.0
21	0.0	–	–	0.0	0.0	0.7	–	0.0	0.3	3.5	0.0	0.0	0.0	0.0	0.4
22	0.3	0.7	8.0	0.0	0.0	0.7	0.5	1.0	8.7	5.5	0.0	0.0	0.0	0.4	1.8
23	2.0	3.3	12.7	0.3	5.0	1.0	0.0	16.0	13.7	29.5	1.5	1.0	1.5	3.8	6.5
24	5.0	2.0	5.7	2.3	3.0	1.0	1.5	20.0	4.0	7.0	0.0	0.0	0.0	2.4	3.9
25	7.0	3.0	16.7	2.0	2.0	1.7	1.0	22.0	13.0	9.5	3.5	0.5	1.5	3.2	6.2
26	6.0	12.0	17.7	3.7	5.0	2.3	–	8.5	12.0	18.5	8.5	16.5	13.5	13.6	10.6
27	10.0	4.0	14.3	1.0	0.7	3.0	0.5	8.5	–	–	4.0	2.0	4.0	–	4.7
28	3.7	2.7	4.0	5.7	0.7	2.0	0.5	0.5	–	–	2.0	0.5	2.5	3.4	2.4
29	–	4.7	3.0	2.7	0.7	2.0	0.0	8.5	–	–	0.0	3.0	3.0	7.0	3.2
30	0.0	7.3	–	2.7	0.0	0.3	0.0	0.5	–	–	0.0	0.5	0.0	1.4	1.2
31	–	0.7	0.0	0.0	0.7	0.7	–	0.0	–	–	0.0	0.0	1.0	–	0.3
32	–	0.0	1.7	0.0	0.3	–	–	0.0	–	–	0.0	0.0	0.0	–	0.3
33	–	0.0	1.7	0.7	2.3	–	–	0.0	–	–	0.0	0.0	0.0	–	0.6
34	–	3.3	8.3	2.0	2.3	–	–	3.0	–	–	0.5	0.0	0.0	–	2.4
35	–	2.0	7.0	0.0	0.0	–	–	5.0	–	–	0.0	0.0	0.0	–	1.8
36	–	–	3.3	1.3	1.0	–	–	0.0	–	–	0.0	0.0	0.0	–	0.8
37	–	–	–	4.0	1.7	–	–	8.5	–	–	–	–	–	–	4.7
38	–	–	–	0.7	–	–	–	1.5	–	–	–	–	–	–	1.1

[1]) National Research Centre for Plant Protection

Table 2. Number of *Agrotis segetum* males caught per sex trap per week on the different sites in 1978
Antallet af fangne Agrotis segetum hanner pr. fælde pr. uge på forskellige lokaliteter i 1978

	Hem, Skanderborg	Svendborg	Permelille, Samsø	Årslev	Studsgård	Strandholt at Odense	Lundegård at Odense	Bonderup at Frederikssund	N.R.C.P.P.[1]	Højbakkegård	Mean of all sites	
Number of traps:	3	3	5	3	3	3	2	3	2	6		
Week no.												
21	–	–	0.4	–	–	–	–	–	–	–	0.4	
22	–	–	0.0	–	–	–	–	–	0.0	–	0.0	
23	3.7	–	0.2	–	–	–	–	–	0.0	–	1.3	
24	3.0	–	6.6	12.7	1.0	0.0	–	20.3	16.2*	–	8.5	* 3 fælder
25	23.3	0.0	10.2	11.7	7.7	2.7	12.0	17.7	6.0	–	10.1	
26	11.0	0.0	13.4	37.3	2.3	1.0	11.5	0.7	2.5	1.0	8.1	
27	7.0	0.0	18.2	18.0	2.3	0.3	5.0	4.7	2.0	0.2	5.8	
28	3.3	0.0	5.8*	8.0	3.7	2.3	6.0	2.0	2.0	1.0	3.4	* 4 fælder
29	2.0	0.0	1.6*	5.7	2.3	4.3	10.0	2.0	–	3.0	3.4	* 4 fælder
30	0.0	0.0	1.2	2.3	0.3	0.7	0.5	0.3	0.5	0.0	0.6	
31	0.3	0.0	–	0.3	0.0	0.3	0.0	0.3	–	0.0	0.2	
32	0.7	0.0	–	1.0	0.0	0.7	0.0	0.7	0.0	0.0	0.3	
33	0.0	0.0	–	4.0	0.0	1.3	0.0	1.0	0.0	0.0	0.7	
34	–	0.0	–	11.3	0.0	1.3	–	1.0	–	0.3	2.3	
35	0.0	–	–	3.7	0.0	0.3	–	0.0	–	1.3	0.9	
36	0.3	–	–	0.7	0.0	–	–	0.3	0.0	0.5	0.3	
37	0.0	–	–	1.7	–	–	–	0.0	0.5	storm	0.6	
38	0.3	–	–	0.7	–	–	–	0.3	0.0	(0.0)	0.3	
39	–	–	–	1.0	–	–	–	0.3	0.0	0.7	0.5	
40	–	–	–	0.0	–	–	–	0.3	–	–	0.2	
41	–	–	–	0.3	–	–	–	–	–	–	0.3	

[1]) National Research Centre for Plant Protection

Table 3. Sex ratios of *Agrotis segetum* in light traps
Forholdet mellem hanner og hunner af A. segetum i lysfælder

Period	Localities: Skanderborg 1977		Samsø 1977		Samsø 1978	
	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂
1–10 June	0	6	0	2	0	0
11–20 June	18	23	0	6	2	5
21–30 June	9	14	25	46	3	6
1–10 July	5	14	1	8	1	1
11–20 July	1	5	0	0	1	0

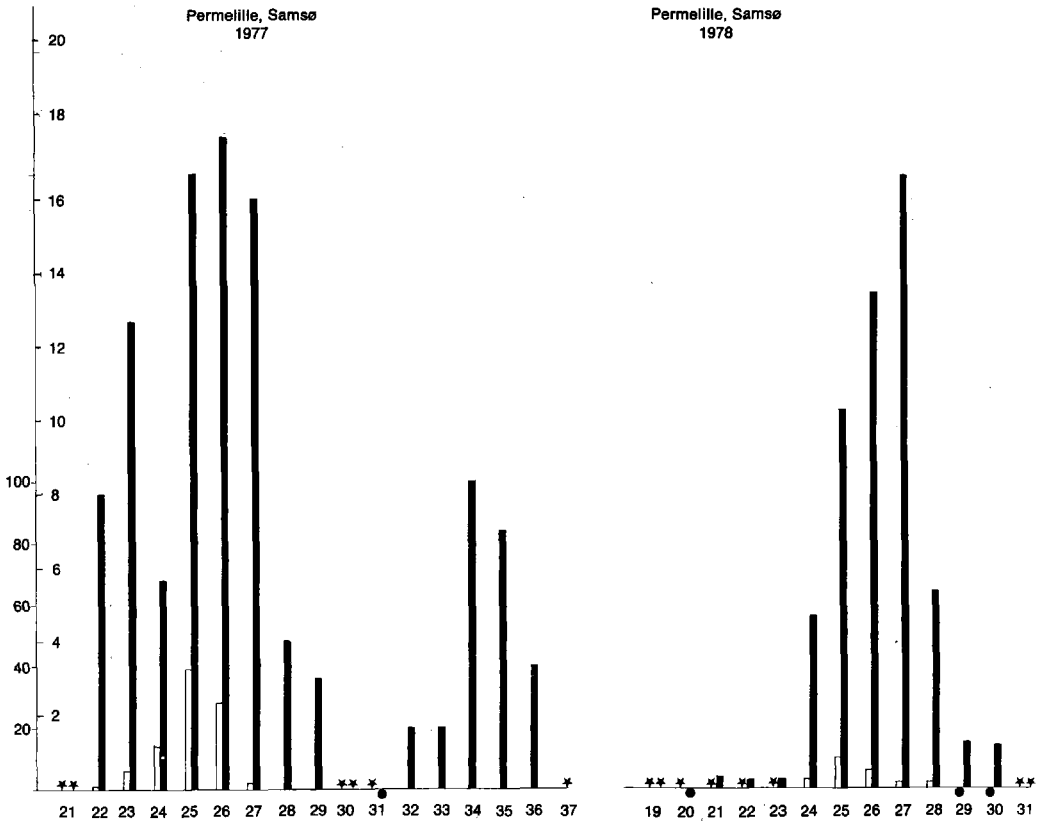


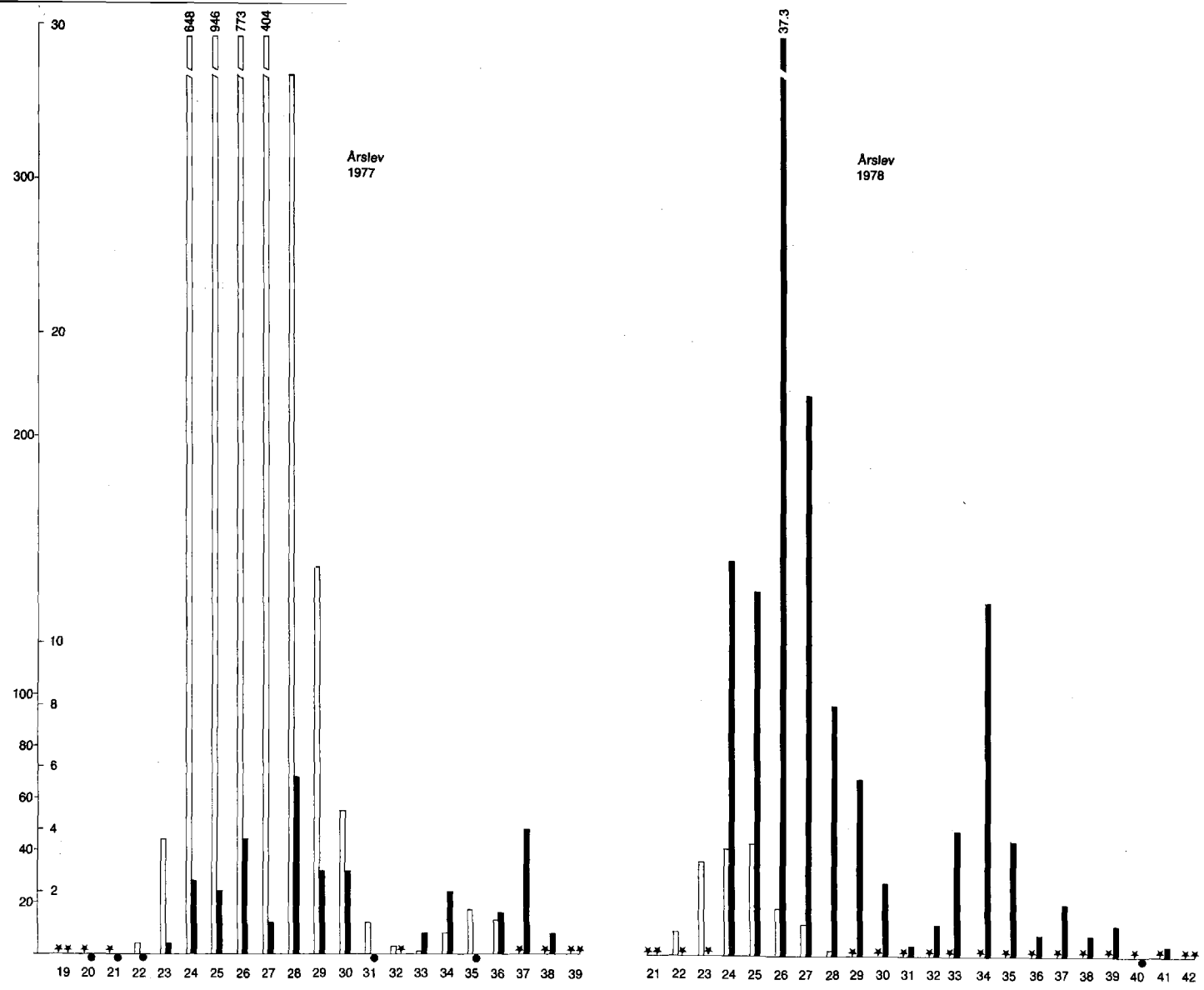
Fig. 4. (pp. 392–394). Catches of *A. segetum* per week per trap in light traps and sex traps respectively.
Fangster af A. segetum pr. fælde pr. uge i henholdsvis lysfælder og feromonfælder.
Signatures: Open columns = catches in light traps (left scale)
Black columns = catches in sex traps (right scale)
★ = trap not yet started (beginning of period)
★ = trap removed (end of period)
★ = trap out of work (during period)
● = no catch
Week numbers are given below the columns.

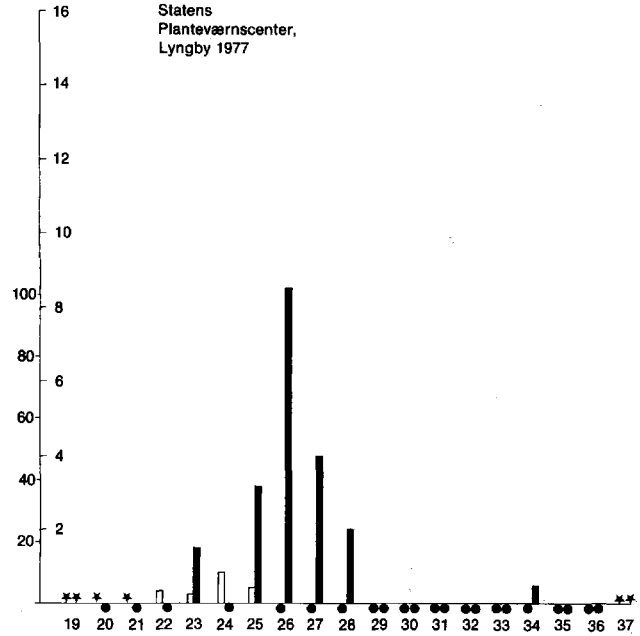
Number of generations

In several cases the sex traps showed a second generation of moths, which was not shown by the light traps except from that at Årslev (figure 4).

Influence of sex trap position

To elucidate the influence of the trap position on catches in the sex traps some results of the catches have been selected in table 4. These localities and years are the most obvious examples of differences between the numbers caught per trap in sex traps in different locations in the same locality. The numbers given are the catch per trap per half week, but cases of no catch in all traps in the same locality have been omitted. A t-test of means showed that the differences between cat-


Årslev
1977
Årslev
1978
648
946
773
404
37.3
30
20
10
8
6
4
2
300
200
100
80
60
40
20
19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42


Statens
Planteværnscenter,
Lyngby 1977
16
14
12
10
100
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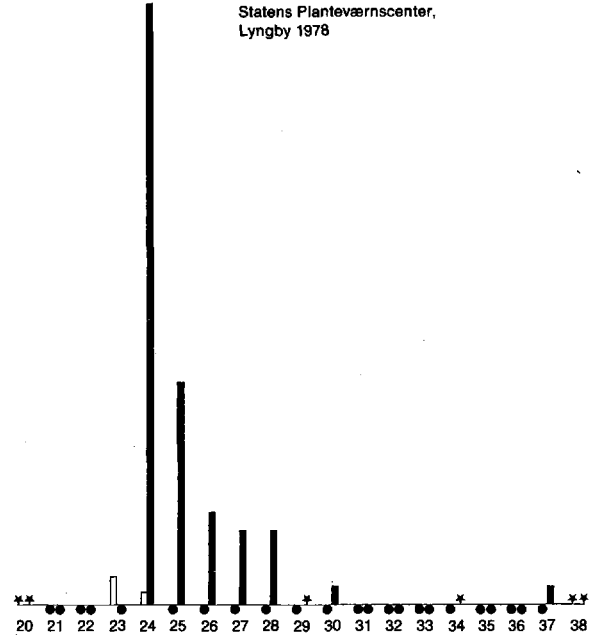
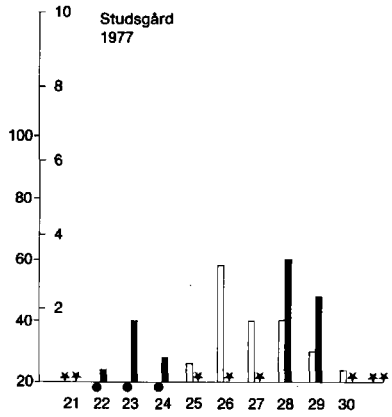
19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37


Statens Planteværnscenter,
Lyngby 1978
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38


Studsgård
1977
10
8
100
6
80
4
60
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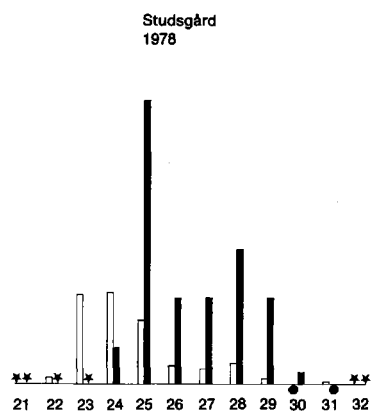
40
20
21 22 23 24 25 26 27 28 29 30


Studsgård
1978
21 22 23 24 25 26 27 28 29 30 31 32

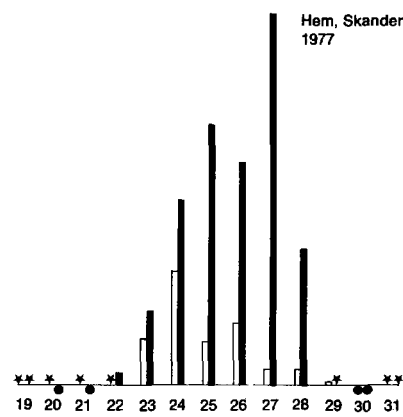

Hem, Skanderborg
1977
19 20 21 22 23 24 25 26 27 28 29 30 31

Table 4. Catches in sex traps per half week for comparison of influence of trap position within the single locality
Halvugentlige fangster i feromonfælder med henblik på belysning af fældeplaceringens betydning på den enkelte lokalitet

All cases with no catches in any trap at a locality have been omitted. Significance levels found in t-test for the difference between traps are given at the bottom of the table. Catches apparently caused by extremely attractive females are in italics

Grenå 1977			Samsø 1977			Skanderborg 1977			Skanderborg 1978			Årslev 1978		
Trap			Trap			Trap			Trap			Trap		
3.	5.	13.	I	II	III	12.	14.	19.	12.	14.	19.	11.	15.	22.
0	2	0	5	3	11	0	0	1	7	4	0	0	*24*	0
0	2	1	2	0	3	2	0	1	3	1	1	0	1	8
0	4	3	5	13	3	2	0	1	4	0	0	0	1	4
0	3	1	2	14	1	4	1	2	11	3	0	0	15	4
0	1	1	0	16	1	8	0	0	*40*	12	4	5	9	2
0	4	0	3	37	4	13	0	2	9	9	3	11	*52*	8
0	3	2	0	4	2	6	0	0	9	3	0	27	7	7
1	2	*30*	2	16	3	8	0	3	13	0	4	24	3	12
0	3	0	2	*29*	1	0	0	7	2	2	0	5	4	6
1	2	0	6	14	7	4	4	16	2	0	1	6	5	5
1	3	5	0	16	0	4	1	1	2	0	1	3	4	1
4	0	3	3	7	0	6	0	1	0	0	1	6	3	0
0	0	1	0	2	0	4	0	0	2	0	0	3	5	0
0	0	3	2	1	2				1	0	0	2	4	0
0	2	9	1	0	3				1	0	0	1	0	0
0	4	13	1	0	1							1	0	0
0	0	5	2	1	0							1	0	0
0	0	1	1	0	1							2	0	0
0	0	4	0	3	1							3	0	0
0	2	4	0	8	7							3	5	1
0	0	5	0	4	6							6	10	5
0	0	1	10	6	2							3	10	0
			2	0	1							1	9	0
			0	6	0							0	0	1
			0	2	2							0	0	1
												0	0	1
												2	2	1
												2	0	0
												2	0	1
												1	0	0
7	37	92	49	202	62	61	6	35	106	34	15	120	173	68

Levels of significance

3–5:	I-II:	12–14:	12–14:	11–15:
98< p< 99	99< p< 99.9	99.9< p	95< p< 98	80< p
3–13:	I-III:	14–19:	14–19:	15–22:
98< p< 99	80< p	95< p< 98	80< p< 90	90< p< 95
5–13:	II-III:	12–19:	12–19:	11–22:
90< p< 95	99< p< 99.9	80< p	95< p< 98	90< p< 95

ches in traps in the same locality were statistically significant in 8 out of 15 cases. Significance levels are given in table 4. In all of the 8 cases of significant differences the numbers caught in the trap in the better location was more than 3 times (3.1–13.1) higher than that from the trap it was compared with. In the 7 insignificant cases the most successful trap caught less than 3 times (1.3–2.6) more than the trap it was compared with.

Attractivity and longevity of the females

The attractivity of females appears to vary quite a lot. This material does not make any evaluation possible but to give some impression some remarkable catches have been underlined in table 4.

Concerning the longevity of the females used in the traps there has also been some variation. In most cases females were still alive when they were brought back from the field (after about 9–10 days after mailing). However, in some cases the females died in the traps after a few days. Week no. 24 (13th to 19th of June) 1977 was remarkable in this respect, as quite a lot of females died in the trap. Accordingly the catch in the sex traps was lower in this week than in the previous and in the next (table 1) despite no unfavourable flying conditions (i.e. strong wind and heavy rain) in week 24 all over Denmark. (Daily Weather Bulletin of the Danish Meteorological Institute).

Generally the females lived for a shorter length of time in warm weather and for longer in cold weather. In a few cases females were mailed, used in traps, returned and still kept alive and attractive for up to 3 weeks.

Discussion and conclusion

Despite strong variation in female attractivity it has been possible to show, that the trap position has in some cases a significant influence on the amount caught (table 4). This influence may be due to topographic structures along which the moths may prefer to fly (i.e. roads, fences etc.). Also prevailing winds may cause different catching efficiency at different positions in the same field. Hence changes of prevailing winds from one season to the next may explain the difference between 1977 and 1978 catching efficiencies at Skanderborg (table 4).

The indication of catches beginning earlier in sex traps than in light traps (*Bromand et al.*, 1976) was not supported by the present investigation which showed the opposite. This result may be due to the low attractivity of pheromone to newly hatched males as demonstrated by *Otto et al.* (1976).

The earlier catch of males than of females and the generally higher proportion of males in the light traps as found (table 3) is in agreement with the results of *Peersson* (1971).

The later appearance of catch peaks and longer catch periods shown by sex traps (conf. fig. 4) is possibly the most important result of the comparison with light traps. At the moment there is no explanation for the difference and of course it is questionable whether the two seasons are fully representative. Long catch periods, including a second generation, appear from the 1968 and 1969 light trap results of both *Peersson* (1971) and *Thygesen* (1971), but in some other years *Thygesen* (1971) did not catch a second generation. The results of *Thygesen* (1971) may indicate a connection between sparse light trap catches and lack of second generations, which might be due to a low population level in general.

Knowledge of the length of the flight period and the time position of the peak is essential for the timing of control measures. Sex traps in connection with a few light traps may lead to an improved background for decisions since their combined picture of *A. segetum* flight is presumably more realistic and more detailed than that obtained with light traps alone.

Another noteworthy point which appears from the sex trap catches (table 1 and 2) is the local variation concerning both time of beginning catch and time of peak catch. This variation cannot be explained in detail, but it indicates the need for a monitoring network with not too few traps.

The final conclusion of the present experiment is that the use of sex traps during two growing seasons in a practical way demonstrated that these traps fulfilled the requirements of simplicity. To this can be added that the procedure will be-

come much simpler when synthetic pheromone as developed by *Arn et al.* (in print) is used as the bait. Use of a synthetic pheromone as bait will also eliminate the variation of virgin female attractivity and allow for more detailed examination of the influence of trap position.

Literature

Arn, H. et al. (in print): Multicomponent sex pheromone in *Agrotis segetum:* a preliminary report.

Bromand, B., Esbjerg, P., Philipsen, H. & Zethner, O. (1977): Knoporme – varsling – feromoner. Ugeskr. f. Agron., Hort., Forst. og Lic. 122, 374–376.

Hansen, L. Ø. & Zethner, O. (1979): Techniques for rearing 26 species of *Noctuidae (Lepidoptera)* on an artificial diet. Royal Vet. and Agric. Univ. Yearbook 1979, 84–97.

Otto, D., Pilz, R. & Behnish, Z. (1976): Sexualpheromon-Nachweis bei den beiden Noctuiden *Agrotis (Scotia) segetum* Schiff und *Mamestra (Barathra) brassicae* L. Arch. Phytopatol. u. Pflanzenschutz, Berlin, 12, 197–212.

Peersson, B. (1971): Flight activity of Noctuids (*Lepidoptera*). A study based on light trap experiments in South Sweden. Ph.d.Thesis, Entomological Dept., Zoological Institute, Lund, Sweden.

Stapel, Chr. (1977): Den økonomiske betydning af plantesygdommenes og skadedyrenes bekæmpelse i landbruget. Ugeskr. f. Agron., Hort., Forst. og Lic. 122, 735–746.

Thygesen, Th. (1968): Knoporme, iagttagelser over biologien samt resultater af bekæmpelsesforsøg 1959–66. Tidsskr. Planteavl 71, 429–443.

Thygesen, Th. (1970): Jordbrugets tab ved knopormeangreb i 1969 og forebyggelse af nye angreb. Ugeskr. f. Agronomer 115, 5–9.

Thygesen, Th. (1971): Om korrelationen mellem knopormeangreb, lysfældefangster og vejrforhold. Tidsskr. Planteavl 75, 807–815.

Zethner, O. & Jørgensen, A. S. (1976): Angreb af knoporme i 1975, skader, tab og bekæmpelsesmulighed. Ugeskr. f. Agron., Hort., Forst. og Lic. 121, 530–534.

Zethner, O. (1977): Losses caused by cutworms (*Agrotis segetum* Schift.) and approaches to their control in Denmark. Proc. British Crop Protection Conf. – Pest & Diseases, pp. 271–277.

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