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MASS TRAPPING FOR THE CONTROL OF EGYPTIAN COTTON LEAFWORM *Spodoptera littoralis* (BOISD.) IN EGYPT

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Summary Mass trapping of *Spodoptera littoralis* moths was carried out in a semi-isolated area of approximately 450 ha in the Fayoum Province, Egypt using plastic funnel traps baited with synthetic pheromone Z-9, E-II, tetradecadiene-I-yl acetate at a trap density of 3 per ha. The total number of moths trapped in each season exceeded 0.5 million. During 1978 and 1979 the number of egg masses found on cotton in the treated areas were generally lower although the differences were not statistically different.

Résumé On a procédé au piégeage à grande échelle de *Spodoptera littoralis* adultes dans une zone semi-isolée d'environ 450 ha dans la province de Fayoum en Egypte en utilisant des pièges-entonnoirs en plastique appâtés avec la phéromone synthetique Z-9,E-II, tetradécadiène-I-yl acetate a une densité de pièges de 3 par ha. Le nombre total de noctuelles capturées durant chaque saison a dépassé 0,5 million. En 1978 et 1979, le nombre de masses d'oeufs trouvées sur le coton était en général plus bas dans les zones traitées que dans les zones non-traitées bien que les différences ne fussent pas statistiquement significatives.

INTRODUCTION

The Egyptian cotton leafworm, *Spodoptera littoralis* (Boisd.), is an important pest of cotton and other crops in Egypt and sometimes only controlled by extensive spraying with insecticides which are often not effective. As part of a programme aimed at developing an integrated strategy for the control of cotton pests in Egypt, an investigation was undertaken to study whether control could be achieved by mass trapping of adult moths in pheromone traps. The synethic pheromone, Z-9, E-II, tetradecadiene-I-yl acetate, was isolated and identified by Nesbitt *et al.* (1974).

MATERIALS & METHODS

A semi-isolated area of approximately 450 ha (IIOO feddan) of mixed cultivation was selected as the test site in the Fayoum Province (Fig.I). Plasti funnel traps as described by McVeigh et al. (1979) were distributed throughout the area at the rate of 3 traps/ha. Traps were baited with polythene vials each containing 2 mg of the synthetic attractant; the vials were replaced after 4 - 6 weeks. During 1978 the traps were installed in early May and maintained until after the end of the cotton growing season at the end of September. During 1979 the traps were maintained from early February and again to the end of September. The numbers of moths attracted to the traps were counted twice a week.

Control of *Spodoptera littoralis* is attempted by hand picking of egg masses from all young cotton plants throughout Egypt and the numbers per feddan recorded The effectiveness of mass trapping was therefore possible to assess by comparing the mean number of egg masses per feddan per day in the treatment area with those in the control areas. For convenience of analysis, the treatment area was designa according to the names of local villages, Demeshkein and Menshat Kamal, with cont areas either immediately adjacent to the test area (Hawaret Adlan and Hawaret Maq with two other control areas (Sanufar and El Lahun) a further distance away (Fig. Egg mass data was also available from these areas prior to mass trapping as suppl by the Ministry of Agriculture Fayoum Governorate.

RESULTS

During the 3 month period 24 April - 23 July 1979, an estimated total of 520,000 moths were trapped (mean of 5.9/trap/day) and the distribution of catch in relation to crop habitat is at present being analysed. However, the most important criterion as a result of mass trapping is whether the numbers of egg masses oviposited had been reduced.

Preliminary analysis of the egg mass data converted to log (n+I) suggested that the mean numbers per feddan during the month of June was generally lower inside the treated area than in either control area immediately adjacent to or distant from the test site (Table I). However, comparison of the egg mass data from previous years, 1975-77, indicated that similar trends occurred in the absence of pheromone traps (Fig. 2). There is some indication that the differenc between the treated and control areas were greater when the traps were present but this could be attributed to the fact that the number of egg masses was greater in 1978 and 1979 than they were in the years 1975 - 77. The differences were not, however, statistically significant (Table 2).

DISCUSSION

The results presented in this paper illustrate the difficulties in interpreting data obtained from experiments of this kind. There is a need for the relative ecological isolation of the experimental area to reduce the possibility of the migration of mated female moths from elsewhere. However, because of the relative isolation of the treatment area, insect populations may well be lower than elsewhere so as to give the impression that control is being achieved. It is fortunate that in Egypt there is available an enormous amount of data on the number and distribution of egg masses throughout the country for a number of years and therefore the changes of such erroneous conclusions are reduced. There was no evidence to suggest from the results of the mass trapping experiment in the Fayoum that the numbers of egg masses had been reduced. However, in Israel, Teich et al. (1979) report a reduction in the number of insecticide sprays required to control S. littoralis following mass trapping at trap densities of between 1 and 2 traps/ha. Similar results have been reported from Japan for the control of Spodoptera litura (F.) by mass trapping in an area of up to 2000 ha at a trap density of 3 traps/ha (Tamaki, unpublished data). It is possible, therefore, that the relative lack of control in Egypt is because the test area of 450 ha is too small to exclude migrational effects. There is evidence not presented in this paper that considerable moth movements occur in relation to the prevailing winds. Further experiments are being planned to extend the mass trapping area to at least 5000 ha in the Fayoum to exclude these possibilities.

Acknowledgements

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Table I

Comparison of mean numbers of egg masses per day per deddan inside and outside the mass trapping area both prior and during mass trapping based on log (n+I) converted data.

	Inside the area	At the ends of the area	Away from the area
Before trapping (1975-77)	1.193	1.210	1.403
During trapping (1978&79)	2.272	2.348	2.627

Table 2

Comparison of egg mass data in villages inside and outside the mass trapping area in the years 1975 to 1979.

Mean numbers of egg masses/day/feddan converted to log(n+I)

	Inside the area			Outside the area		
	Demesh-kein	Menshat Kamal	Hawaret Adlan	Hawaret El Maqta	El Lahun	Sanufar
1975	1.465	1.951	1.764	1.618	1.918	1.676
1976	0.556	0.491	0.799	0.732	0.690	1.250
1977	1.223	1.470	1.079	1.265	1.369	1.513
1978	2.361	2.766	2.797	2.499	3.384	2.757
1979	1.874	2.089	2.163	1.933	2.273	2.092

Fig. 1

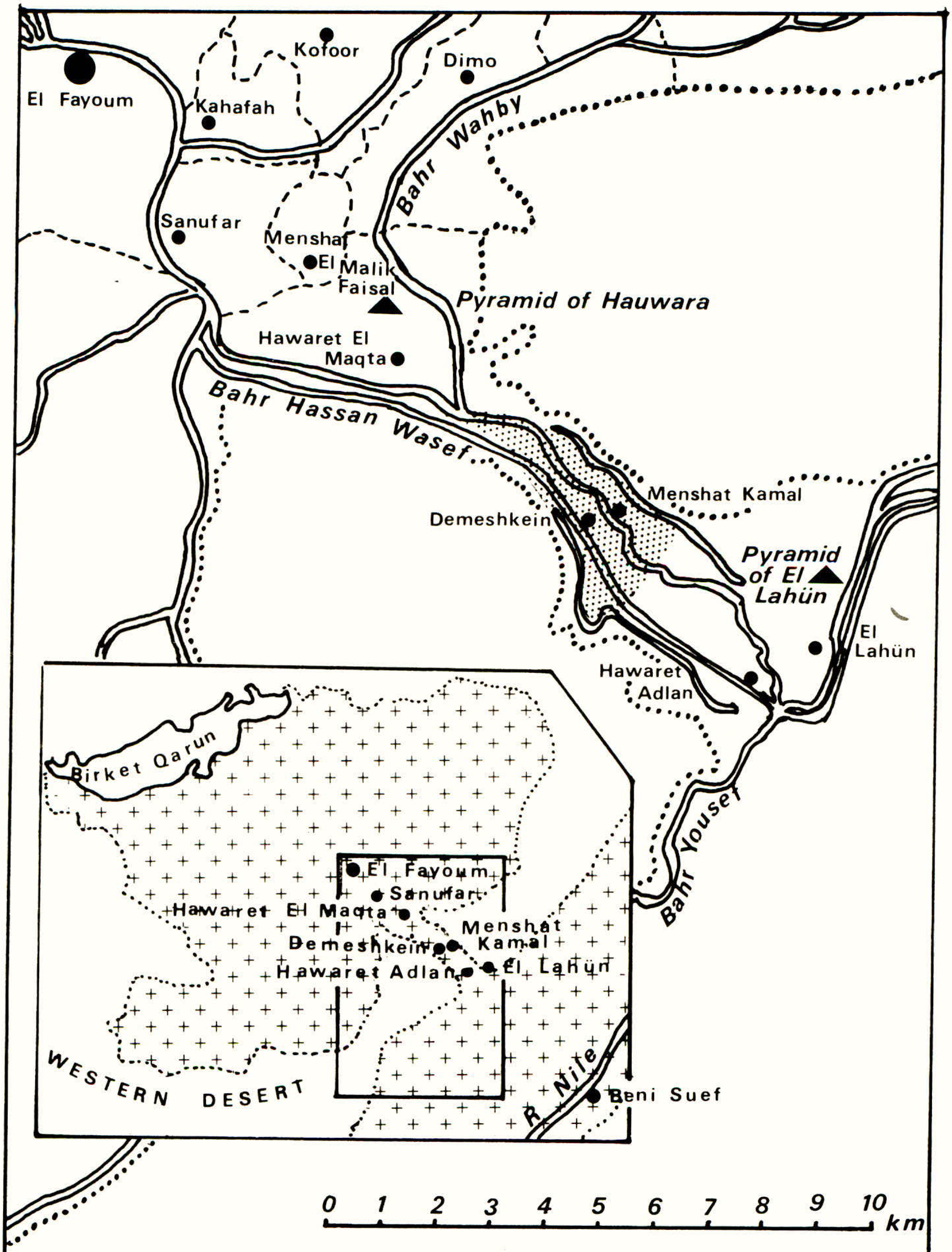
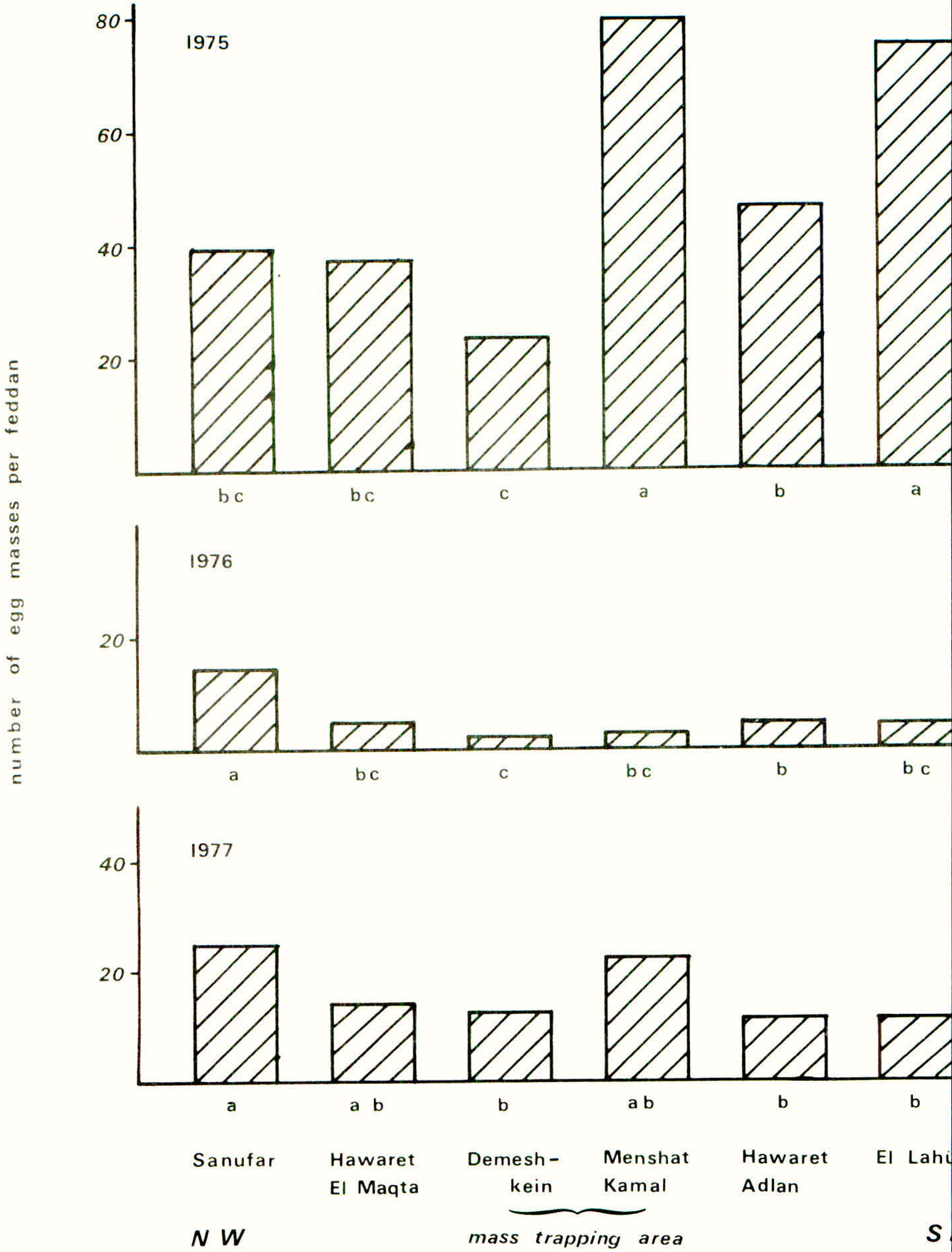

El Fayoum
Kofoor
Dimo
Kahafah
Bahr Wahby
Sanufar
Menshat El Malik Faisal
Pyramid of Hauwara
Hawaret El Maqta
Bahr Hassan Wasef
Menshat Kamal
Demeshkein
Pyramid of El Lahün
El Lahün
Hawaret Adlan
Bahr Yousef
Birket Qarun
El Fayoum
Sanufar
Hawaret El Maqta
Menshat
Kamal
Demeshkein
Hawaret Adlan
El Lahün
WESTERN DESERT
R. Nile
Beni Suef
0
1
2
3
4
5
6
7
8
9
10
km

Fig. 2

Comparison of egg mass data from villages within and without the mass trappin area in Fayoum, prior to trapping.



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IMPROVED MEANS OF OBTAINING SUSTAINED UNIFORM EMISSION OF BIOACTIVE SUBSTANCES

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Summary. The ideal pheromone dispenser is defined and devices giving uniform and reproducible rates of emission are described. A constant concentration gradient is maintained across a fixed diffusion barrier. The composition of the contents of the device can be determined during the course of experiments.

On définit le diffuseur idéal des phéromones et decrit des dispositifs donnant des taux d'émission uniformes et reproducibles. Un gradient constant de concentration est maintenu à travers d'une embouchure fixe. La composition du contenu du dispositif peut être déterminée au cours des essais.

There is now extensive knowledge of the nature of the pheromones of pest insects and field trials have demonstrated the potential of pheromone based techniques in aiding the control of many pests of economic significance. For such techniques to acquire a practical role in pest control it is certainly desirable, probably necessary, that their cost effectiveness should match that of alternative systems of control. Siddall and Olsen (1976) have examined a model situation relating to codling moth, in this context.

A key component of any pheromone based system is the means used for dispensing the active substance. A number of means have been employed ranging from evaporating dishes and cotton wool plugs to the hollow fibres described by Coplan and Brooks (1977).

The ideal vapour dispenser should meet the following criteria :

(1) The release rate should be uniform throughout the life of the charge and should be predictable.

(2) The duration of effective life should match the needs of the control objective and local conditions.

(3) The device should only emit at appropriate times, that is to say, the times when its biological action is effective.

No existing dispensers satisfy these criteria but examination of their mechanisms indicated the origin of many defects. In general all dispensing devices comprise a store of active material and a means of controlling emission. Emission is usually controlled by a diffusion process in which the emission rate is controlled by two factors, the parameters of the barrier to free emission and secondly the concentration gradient across that barrier. In many existing dispensers one or other of these two factors is not held constant and the emission rate is time dependant. The origin of this defect is a failure to separate the functions of storing the charge of active component and of controlling the release rate.

The point is well illustrated by considering the performance of closed capillary dispensers as described by Coplan and Brooks (1977). Figure 1 shows the shape of the curve of emission rate against time. Arbitrary units were assigned so that unit rate of evaporation occured when one mass unit had evaporated. As also shown in the reference cited, there is an initial high rate of evaporation but from t = 50, point A to t = 200, point B, the rate is moderately uniform falling steadily from 0.1 to 0.05 units. The emission rate is in fact approximately proportional to $t^{-\frac{1}{2}}$ so that if the length of the capillary were increased to give t = 800 the rate at that time would again be halved to 0.025 units.

Figure 2 shows the shape of the curve of emission rate against quantity emitted. Points A and B mark the same emission rates as on Figure 1 and it is clear that half the charge has evaporated before point A is reached.

In this particular device the capillary provides both store and diffusion barrier. As active substance evaporates so does the length of the capillary through which its vapours must diffuse increase. If the emission rate at B is adequate then at all earlier times it must be more than adequate and in fact the excess amounts to half the total loading of active material.

Figure 3 shows two members of a family of dispensing devices in which the storage function and the rate controlling function are separated (Nightingale 1979). In both examples Y is the storage container. X is a simple capillary, Z is a porous membrane. Active material is held in Y either by capillary action or on a porous wick. Since the cross section of Y is large compared with that of X, or the effective cross section of Z, the air in Y is saturated with the vapour of the active substance. Hence the concentration of active material at the entrance to the diffusion barriers is constant at any given temperature. The concentration at the neighbourhood of the exit from the capillary is, for practical purposes, zero. Thus there is an invariant diffusion barrier and at any given temperature a constant concentration gradient and hence a constant emission rate virtually throughout the effective life of the charge. On the other hand Y can accommodate any desired quantity of active material without affecting the emission rate.

A number of useful secondary benefits are available from these devices. They provide the investigator in the field with a much more precisely defined source permitting correlation of release rate against trapping efficiency for example. In addition it is possible at any time to sample the contents of the store to establish the extent of any degradation of its contents or change in composition.

This aspect may be of particular value in the case of multi-component pheromones. The composition of the natural pheromone must surely be understood to be the composition of the mixed substances as perceived by the responding insect.

For a number of reasons it is unlikely that analysis of insect extracts will identify correctly the proportions of the emitted and perceived components. Reports on trials with mixture of synthetic substances usually report the initial proportions of the liquid mixture.

It may be assumed in general that the vapour emitted from a multi-component mixture will not have the same composition as the liquid. Hence as evaporation proceeds the liquid composition will change and the proportion of the active components in the vapour will also change. The magnitude of the change will depend on the system used and the physical properties of the substances. It follows that in any prolonged experiment the test insects are exposed to a vapour of changing proportions and this fact must bear on the validity of any conclusions which are drawn.

It is suggested that devices of the nature described here may afford some relief from this problem. In experimental work on multi-compound mixtures it is possible to employ a quantity of the liquid mixture such that only a small part of this is evaporated during the course of the experiment. This will minimise compositional changes. Analysis of the residual liquid will determine its proportions, and permit an estimate of the mean vapour composition to which the test insects have been exposed.

For economical, long life commercial dispensers it may be necessary to use separate dispensers for each compound to ensure an optimum vapour composition.

Referring again to Figure 2, curves of this kind will be obtained by plots of release rate against free capillary length. It is therefore possible to use a closed end capillary device as a test system to discover what length of capillary gives the required release rate for any substance.

In the case of devices using a macroporous membrane to control the emission rate, changes in emission rate are achieved by altering the surface area of that membrane.

Although specifically created as dispensers for pheromones and lures, vapour devices of this class can be used to dispense other vapours including volatile insecticides, room odorants, etc. The principle can also be applied to the dispensing of active material into water and other liquids.

The commerical implications are two fold. First the quantity of pheromone required to maintain a given minimum emission rate is significantly reduced. Secondly the costs of placing dispensers is reduced since the only limit on the duration of emission is stability of the bioactive under the conditions of storage in the reservoir. The value of these gains will depend on specific circumstances and this must be compared with the costs of achieving the improved performance.

This latter point must be stressed. There will be situations in which the simple closed end capillary dispenser is an adequate and least cost solution or where a linear retrievable tape dispenser is appropriate.

In addition, no attempt is made to ensure the device emits only at appropriate times. Its emission rate rises with temperature, as does that of the capillary dispenser. In the case of insects which are scarcely active in the heat of noon but seek their mates at dusk it is clear that maximum emission occurs under the wrong conditions. It is possible to postulate devices which can distort a flexible capillary or otherwise increase its resistance to diffusion under specific conditions. Bimetallic and other thermal expansion devices can provide the motive power for such distortion. Humidity sensors may be similarly employed. The additional complication and consequent cost of these refinements are not thought at present to be justifiable. The devices can provide an optimum uniform rate of release at the time when the target insect is active. Emission at all other times is wasteful and the costs of this waste must significantly exceed the costs of providing additional controls for these to be of interest commerically.

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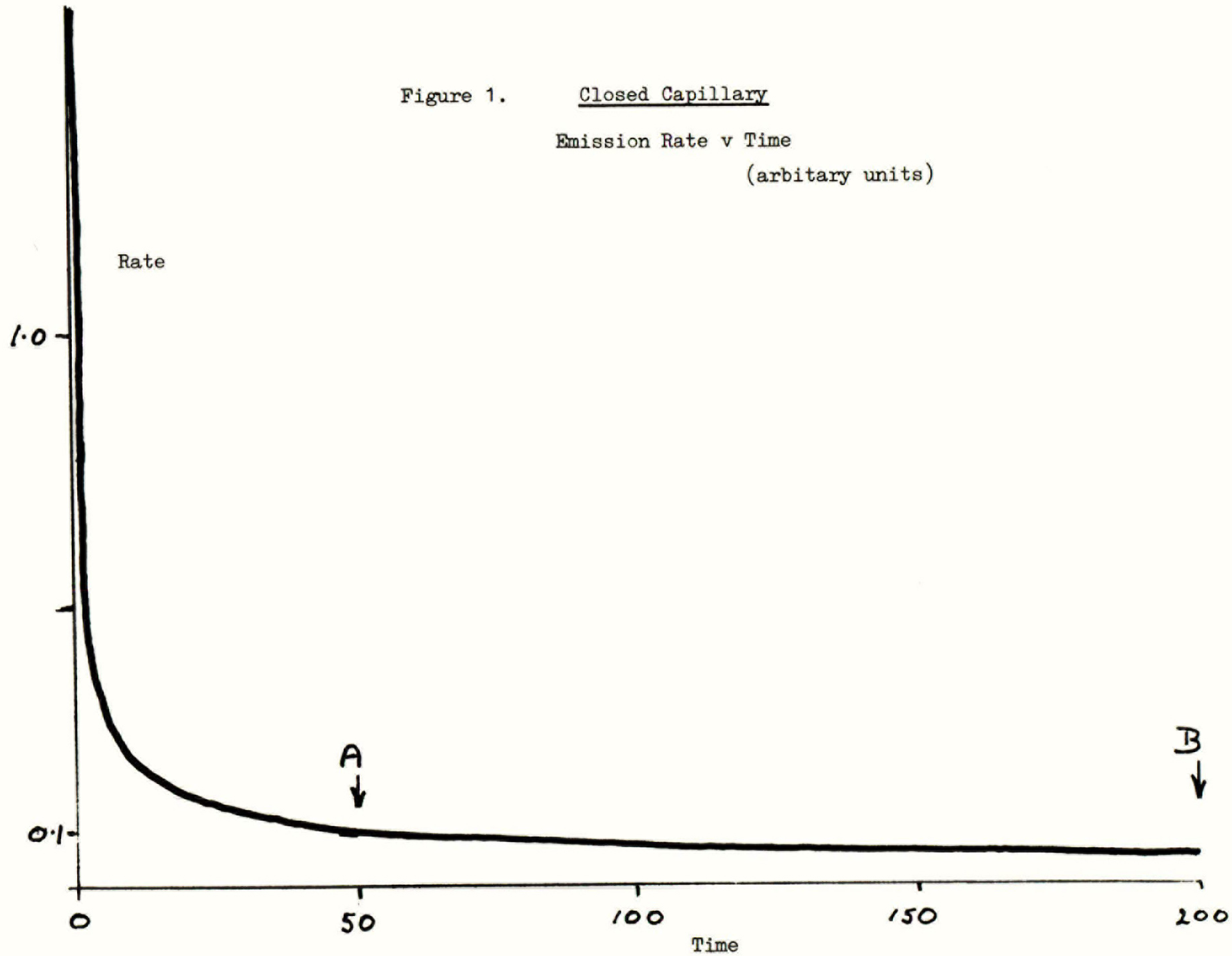


Figure 1. Closed Capillary

Emission Rate v Time

(arbitary units)

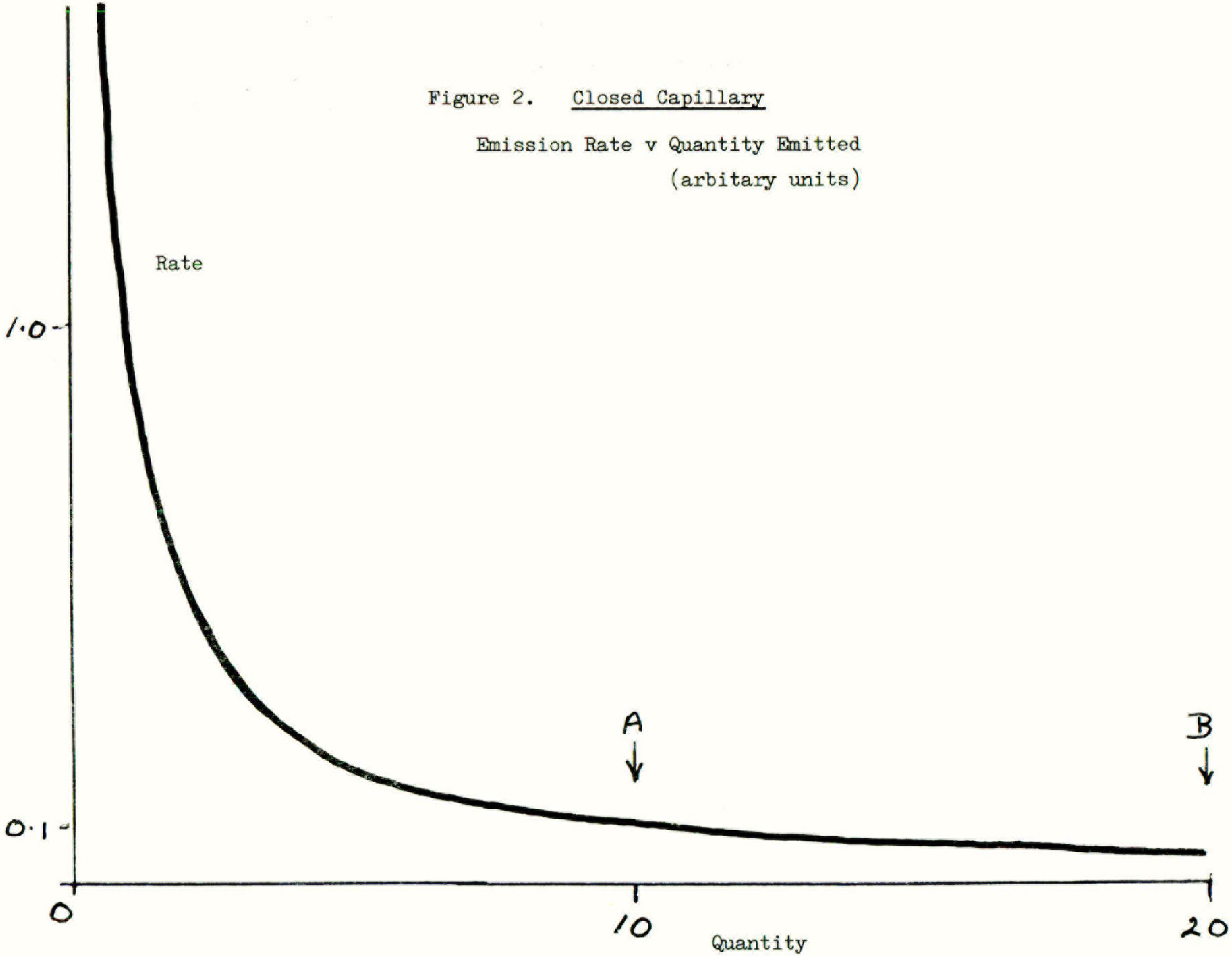
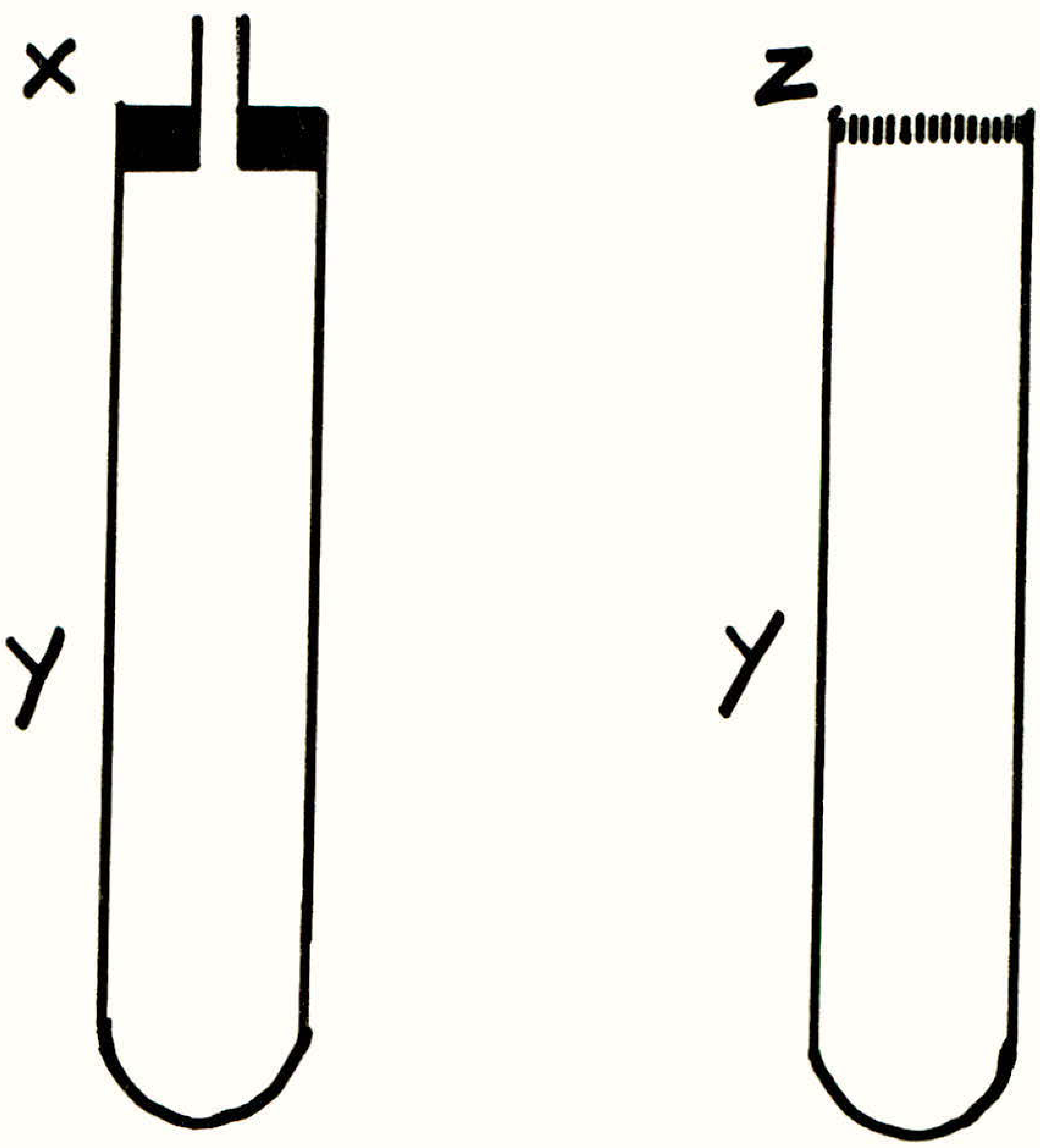


Figure 2. Closed Capillary

Emission Rate v Quantity Emitted (arbitary units)

Figure 3 Uniform Rate Dispensers



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FACTORS AFFECTING THE PERFORMANCE OF PHEROMONE TRAPS FOR MALE *SPODOPTERA LITTORALIS*

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Summary Several designs of pheromone trap baited with the synthetic sex pheromone of the Egyptian cotton leafworm moth, *Spodoptera littoralis*, were evaluated: plastic funnel-traps were consistently found to catch most male moths. The effects of varying the colour and size of the funnel and the size of the gap between the funnel and the trap lid were examined. Polyethylene pheromone dispensers were found to be better than rubber septa or a PVC laminate in these traps. The effects of trap location on catches of moths were also investigated.

Sommaire Plusieurs modèles de pièges-phéromones leurrés avec la pheromone sexuelle synthétique de *Spodoptera littoralis* étaient évalués: il fut constaté que les pièges-entonnoirs en plastique attrapaient toujours plus de papillons. Les effets des variations de couleur et de grandeur de l'entonnoir et de l'espace entre l'entonnoir et le couvercle du piège furent examinés. Il fut constaté que les dispensateurs de phéromone en polyéthylène étaient supérieurs aux septa en caoutchouc ou des laminés en PVC dans ces pièges. Les effets de location des pièges sur piégeage furent aussi mises à l'investigation.

INTRODUCTION

Metal funnel-traps baited with virgin female moths were used as survey tools for *Spodoptera littoralis* in Cyprus by Campion *et al.* (1972). However, it was subsequently found that with synthetic pheromone sources this design was less effective than square metal water-traps with lids (Campion *et al.* 1975). Such water-traps have been used for survey of *S. littoralis* populations in Egypt (Nasr, unpublished), Crete (Campion *et al.* unpublished) and Morocco (El Jadd, unpublished). Whilst effective, these water traps are expensive to make and cumbersome in use, and the development of techniques for control of *S. littoralis* by mass trapping of male moths in traps baited with synthetic pheromone (Teich *et al.* 1979; Hosny *et al.* 1979; Campion *et al.*, unpublished) has created a demand for a highly effective trap which is cheap to produce and which requires little or no maintenance in use.

Numerous alternative trap designs have been evaluated, including the above water-traps, traps in which the captured moths are held by an adhesive substance and dry traps. As was also found in Israel by Navon (1978) and Kehat (1978), plastic funnel-traps with lids were found to be very effective in capturing male moths, and the effects on moth catch of varying several features of these traps were examined. These included dusting the funnel surface with talcum powder (Navon, 1978), and changing the colour of the funnel (*c.f.* McLaughlin *et al.* 1975; Marks, 1978), the diameter of the funnel and the size of the gap between the rim of the funnel and the trap lid.

The manner in which the synthetic pheromone is retained in and released from these traps will also affect the ability to trap male moths, and will determine the frequency with which the pheromone source has to be renewed. Thus several different pheromone dispensers were evaluated in the most effective design of trap.

Effects on moth catch of the siting of pheromone traps have been reported by Saario *et al.* (1970), Sharma *et al.* (1971), Hirano (1976) and Marks (1978), among others, and some of these effects have been studied for *S. littoralis*.

METHODS AND MATERIALS

All the experiments on trap and dispenser design were carried out in lucerne fields located along the north-west coast of Crete, following procedures described by Campion *et al.* (1979). In particular, trap catches were recorded daily when the traps in each experiment were moved on one position to minimise position effects. Tests ran for up to 35 days, and the data was subjected to analysis of variance following transformation to log(10x+1), and the differences between the transformed means were tested for significance at the 5% level.

The trap designs tested are listed in Table 1. The metal funnel-traps (Campion, 1972), the water-traps (Campion *et al.* 1975; Marks, 1976) and the sticky board-traps and plastic funnel-traps (Campion *et al.* 1979) have been described previously. The delta trap was supplied by Oecos Ltd., Kimpton, Herts., UK. The sock-trap, bucket-trap and cardboard funnel-trap were supplied by International Pheromones Ltd., Bromborough Port, Wirral, UK. Details of the other trap designs can be obtained from the authors.

Table 1

Trap Designs Tested

Trap Design	Catching Medium	Trap Design	Catching Medium
Water Trap	water	Sock Trap	holding box
Kitterman Trap	adhesive	Bucket Trap	"
Vertical Open Trap	"	Closed Funnel Trap	"
Cylinder Trap	"	Cardboard Funnel Trap	"
Horizontal Cylinder Trap	"	Metal Funnel Trap	"
Delta Trap	"	Plastic Funnel Trap	"
Sticky Board Trap	"		

The synthetic pheromone, (*Z*,*E*)-9,11-tetradecadienyl acetate (Nesbitt *et al.* 1973; Campion *et al.* 1974), was used at a loading of 2 mg per dispenser, and in later experiments this was combined with 0.2 mg of tetradecyl acetate (Campion *et al.* 1979). All chemicals were combined with an equal weight of 2,6-di-*tert*-butyl-4-methylphenol (BHT) as antioxidant. Except in experiments to compare dispenser design, the synthetic pheromone was dispensed from polyethylene vials (36 mm x 16 mm with 1.5 mm thick walls) supplied by Fisons Scientific Apparatus, Loughborough, Leicestershire, UK. Other dispensers tested were smaller polyethylene vials (37 mm x 9 mm with 1.5 mm thick walls) from Azlon Products Ltd., Glyn Street, London SE11 5JG, "Beem" polyethylene vials from Zoecon, USA, rubber septa from Perkin-Elmer Ltd., Beaconsfield, Buckinghamshire HP9 1QA, UK, and PVC laminated strip supplied by International Pheromones Ltd.

Experiments to examine the effects of trap siting were carried out during a two-month period in 1978 when *S. littoralis* populations were highest. Traps were spaced evenly (about 5 per ha) over 50 ha of mixed cultivation, and comparisons made of mean weekly catches in traps situated in lucerne or vegetable fields and in traps surrounded by olives, vines, grass or scrub.

RESULTS

Table 2 shows the results of experiments comparing the catches of male *S. littoralis* moths in water-traps with catches in other designs of trap. All designs tested here caught significantly fewer moths than the water-traps and were not investigated further.

Table 2

Catches of male *S. littoralis* moths in different designs of trap

Trap Design	Mean Catch per Night	Trap Design	Mean Catch per Night
Experiment A		Experiment B	
Water trap	26.9 a	Water trap	25.9 a
Kitterman trap	3.1 b	Sticky board trap	12.4 b
Cylinder trap	0.1 c	Delta trap	1.1 c
Vertical open trap	0.1 c	Closed funnel trap	0.1 d
		Cardboard funnel trap	0.1 d
		Bucket trap	0.0 d
		Horizontal cylinder trap	0.0 d
		Sock trap	0.0 d

catches followed by the same letter in each experiment are not significantly different at P = 0.05

However, plastic funnel-traps (funnel diameter 16 cm) dusted with talcum powder caught just as many moths as the water-traps, and significantly more than plastic funnel-traps without talcum powder or metal funnel-traps with talcum powder (Table 3).

Table 3

Catches of male *S. littoralis* moths in water-traps and different designs of funnel-trap

Trap Design	Mean Catch per Night
Water trap	26.5 a
Plastic funnel trap with talc	26.3 a
Metal funnel trap with talc	6.4 b
Plastic funnel trap without talc	4.5 b

mean catches followed by the same letter are not significantly different at P = 0.05

Further experiments were carried out to optimise the effectiveness of the plastic funnel-traps. In most tests, traps with yellow funnels caught more moths than those with green, red, white or blue funnels (Table 4), but the colour of the holding box did not seem to affect catches.

Table 4

Catches of male *S. littoralis* moths in different coloured plastic funnel-traps

Colour	Mean Catch per Night	Colour	Mean Catch per Night
Experiment A		Experiment B	
Yellow	7.1 a	Yellow	20.3 a
Green	2.3 b	Green	12.2 b
Experiment C		Experiment D	
Green	34.7 a	Yellow	24.5 a
Red	30.2 ab	Green	22.2 a
Yellow	29.6 b	Red	15.2 a
White	7.7 c	White	7.5 b
Blue	2.2 c	Blue	1.3 c

mean catches followed by the same letter in each experiment are not significantly different at P = 0.05

Comparison of catches in traps with 10 cm, 12 cm and 16 cm diameter funnels showed that those traps with 16 cm diameter funnels caught most moths (Table 5).

Table 5

Catches of male *S. littoralis* moths in yellow plastic funnel-traps with different diameter funnels

Funnel Diameter (cm)	Mean Catch per Night
16	68.5 a
12	43.1 b
10	34.4 b

mean catches followed by the same letter are not significantly different at P = 0.05

Altering the size of the gap between the rim of the funnel and the trap lid in the plastic funnel-traps did not seem to have much effect on moth catches. Catches of moths in traps having gaps of 1 cm, 2 cm, 4 cm and 8 cm were greatest in traps with the 2 cm gap, but the differences in catches were not statistically significant at P = 0.05 (Table 6).

Table 6

Catches of male *S. littoralis* moths in plastic funnel-traps with lids at different heights above the funnel

Gap between Funnel and Lid (cm)	Mean Catch per Night
2	6.4
1	5.5
4	4.5
8	2.8

mean catches not significantly different at P = 0.05.

Various slow-release devices for the synthetic pheromone were compared in the plastic funnel-traps (Table 7). There were no significant differences in moth catches using any of the three patterns of polyethylene vial, but catches were generally lower in traps with rubber septa as dispensers. Overall catches in traps baited with pheromone-impregnated PVC laminate were significantly lower, with most moths being caught during the first few days.

Table 7

Catches of male *S. littoralis* moths in plastic funnel-traps using different pheromone dispensers

Dispenser	Mean Catch per Night	Dispenser	Mean Catch per Night
Experiment A		Experiment B	
Beem vial	7.7 a	Beem vial	10.1 a
Azlon vial	7.3 a	Fisons vial	9.4 a
Fisons vial	4.2 a	Azlon vial	7.1 ab
Rubber septum	2.0 b	Rubber septum	6.4 b
		PVC laminate	1.2 c

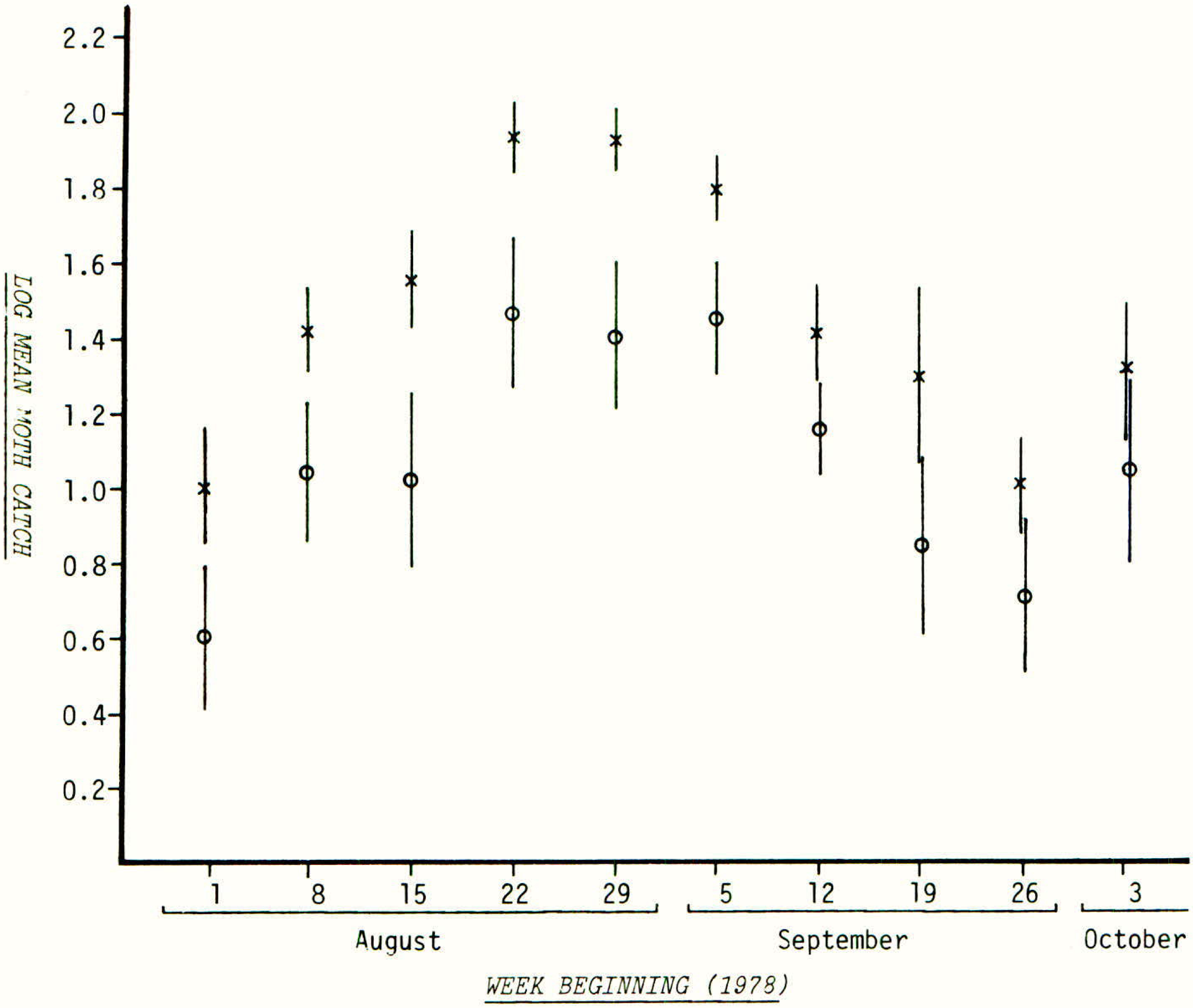
mean catches followed by the same letter in each experiment are not significantly different at $P = 0.05$

Analysis of moth catches in traps sited in different vegetation showed that the mean weekly catches by traps situated in lucerne and vegetable fields were higher than those in traps situated elsewhere (Fig. 1). In the last two to three weeks the differences were not so marked as earlier in the season.

DISCUSSION

The results described here show that, for trapping male *S. littoralis* moths with the synthetic pheromone, plastic funnel-traps provide an effective replacement for the water-traps used originally by Campion *et al.*(1974). They are also cheaper to construct and easier to maintain in use. The funnel should be dusted with talc, as advocated originally by Navon (1978), although it was noticed that catches in undusted funnel-traps increased with use, possibly due to the inside of

Fig. 1. Catches of male *S. littoralis* moths in traps sited in lucerne or vegetable fields (x) and in other crops (o). Log mean moth catch with 95% confidence limits



the funnel becoming coated with dust and scales from captured moths. Even when dusted with talc, a metal funnel was not as effective as the plastic, probably due to the inherent surface roughness of the former (Table 3).

The colour of the funnel in these traps was found to influence markedly moth catches (Table 4) with yellow being the preferred colour, implying at least some visual element in the attraction process. Traps with 16 cm diameter funnels were found to catch more moths than those with 12 cm or 10 cm funnels (Table 5), but, surprisingly, the size of the gap between the funnel rim and the trap lid did not seem to be critical for gaps of 1 cm and above in determining moth catches (Table 6). The size of this gap will affect the ease with which the moths both enter and leave the traps and will influence the shape of the pheromone plume, and interaction of these factors may be complex.

For maximum catches in pheromone traps, the release rate of synthetic pheromone must be optimised for different insects (Roelofs and Cardé, 1978) and for different trap designs. For *S. littoralis* using the plastic funnel-traps, various shapes and sizes of polyethylene dispensers were found to be most effective (Table 7). These are cheap, readily available and can be made of very uniform quality.

Although *S. littoralis* is a polyphagous insect, in Crete lucerne and vegetables are the preferred host plants. More moths were caught in traps placed in these crops (Fig. 1), particularly during the summer and early autumn when they are preferentially irrigated. By the end of September, rainfall is more frequent, vegetables have been harvested and lucerne growth reduced, and catches of moths were more uniform throughout all sites. Such considerations must be borne in mind when planning mass-trapping programmes and interpreting results from survey traps.

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