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OBSERVATIONS ON THE BEHAVIOUR AND CONTROL OF HOUSE-FLIES IN A RURAL AREA IN ISRAEL (*)

Riassunto. — Il problema delle mosche si pone in modo molto urgente nelle regioni agricole. Il letame e le altre materie organiche accumulate per i fini dell'agricoltura sono i principali rifugi dell'insetto. Pare che per lo sviluppo dell'agricoltura in questa regione sia necessario radunare, manipolare e conservare grandi quantità di queste materiali propizi alla moltiplicazione delle mosche. I metodi attualmente utilizzati per queste operazioni, preconizzate persino dalle autorità agricole, contribuiscono a fare di questi materiali importanti focolai di mosche.

Converrebbe mettere al punto, in collaborazione con gli agricoltori e gli specialisti di problemi agricoli, metodi di stockaggio del letame e dei rifiuti che non permettessero la moltiplicazione delle mosche e che siano adatti ai diversi sistemi di colture. Bisogna riuscire a ridurre la densità di questa popolazione di ditteri nelle regioni agricole limitando la loro riproduzione in modo da rendersi padroni, con tutti gli altri mezzi disponibili, del flagello costituito da questi insetti per gli abitanti.

Résumé. — Le problème des mouches se pose de manière très aiguë dans les régions agricoles. Le fumier et les autres matières organiques accumulées à des fins agricoles sont les principaux gîtes de l'insecte. Pour développer l'agriculture dans cette région, il semble qu'il soit nécessaire de réunir, de manipuler et de conserver en grandes quantités ces matériaux propices à la multiplication des mouches. Les méthodes actuellement utilisées pour ces opérations ou même préconisées par les autorités agricoles, contribuent à faire, de ces matériaux, des gîtes importants de mouches.

Il conviendrait de mettre au point, en collaboration avec les

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exploitants agricoles et les spécialistes en matière d'agriculture, des méthodes de stockage du fumier et des ordures qui ne permettraient pas la multiplication des mouches et seraient adaptées aux différents systèmes de culture. Il importe de réduire la densité de cette population de diptères dans les régions agricoles en limitant leur reproduction de manière à se rendre maître, par tous les autres moyens disponibles, du fléau que constituent ces insectes dans les habitations.

Summary. — The problem of the house fly takes a very acute form in agricultural areas. The principal hiding-places of these insects consist of manure and other organic matter, accumulated for agricultural purposes. In order to develop agriculture in this area, it would appear necessary to collect, handle and store these materials in large quantities, although they favour the multiplication of flies. The methods now in use for these operations — even the methods advocated by the agricultural authorities — help to make such matter a significant hiding-place for flies.

It is desirable to investigate methods of storing manure and refuse, in collaboration with agriculturists and farmers, in such a way that they cannot allow multiplication of flies and can be adapted to different systems of cultivation. It is important to reduce the density of diptera in agricultural areas by limiting their reproduction, in order to master, by every other possible means, the domestic plague represented by these insects.

Zusammenfassung. — Das Problem der Fliegen hat in den ländlichen Gegenden eine besondere Bedeutung. Die Düngerhäufen und die andere organischen Stoffen, die für landwirtschaftliche Zwecke angehäuft werden, sind die wichtigsten Herde der Insekten. Um die Landwirtschaft in diesen Gegenden zu entwickeln, scheint es nötig zu sein diese Stoffe, die für die Entwicklung der Fliegen günstig sind, in grossen Mengen zu versammeln, handeln und aufbewahren. Die Methoden, die gegenwärting angewendet werden und sogar von den Behörden für dieses Verfahrens empfohlen werden, tragen dazu bei aus diesem organischen Stoffe einen wichtigen Zufluchtsherde für die Fliegen zu machen.

Es wäre nötig mit der Mitarbeitung der Landwirtschaftlichen Unternehmer und Fachleute einige Methoden für die Ansammlung des Düngers und des Kehrichtes festzustellen, um die Fliegenvermehrung zu verhindern und gleichzeitig könnten diese Methoden zu den verschiedenen Kulturmethoden angepasst werden.

Es ist wichtig die Dichtigkeit dieser Dipterenbevölkerung in den landwirtschaftlichen Gegenden zu vermindern und ihre Reproduktion zu beschränken, um durch allen verfügbaren Mittel diese Insektenschädlinge innerhalb der Wohnungen bemächtigen zu können.

Attempts to control the house-fly pest by widespread application of residual insecticides to buildings has failed in many countries including Israel. This has caused considerable disappointment everywhere and especially in rural areas where the fly problem is extremely acute. The failure of DDT to control house-flies was followed by the regrettable practice of acquiring other residual organic insecticides and using them in the same indiscriminate way. Very often these were by far more toxic to man and animal than DDT. This practice has very soon brought new disappointments and disbelief in the possibility of fly control by any method. The studies reported below were undertaken with the hope that exact appreciation of the situation as to: extensions of fly breeding, its distribution, age, composition and distribution of adult flies and their behaviour may help to select the right methods of fly control to be applied in present circumstances. The possibility of controlling fly breeding by the larvicide Thiourea was examined. The conclusions arrived at are based on the observations carried on during the past two years and published ([1, 2]), and on the few data collected during the period May-August 1953, and are not claimed to be final.

A) Fly breeding survey.

Eleven agricultural settlements in Nothern Israel were surveyed. In some villages the whole area was examined, in others only a part of it, typical of the whole village. Villages 1, 4, 7, 9, 11 are communal agricultural settlements with mixed farming. Population 300-800. The settlements keep up to a hundred head of dairy cattle, large herds of goats and sheep, hundreds of poultry and a few horses, mules and donkeys. Barns, stables and other farm buildings are situated on one side of the settlement. The living quarters which in many instances are well screened are situated at a distance of 100 to 500 yards from the farm buildings. The dining hall-kitchen-storeroom complex is situated in the centre between the farm buildings and the living quarters.

Manure of all kinds is collected and stored, rubbish and kitchen refuse are collected in barrels and carted away at least twice a week to be deposited in a heap in the surrounding fields or on the manure pile. All of them have a sewage system. Here and there a dry pit system latrine is still in use.

Settlements 2, 3, 5, 6, 10 are Arab villages of 800 to 2,000 inhabitants, mostly peasants. Each keeps a few head of dairy cattle, a larger number of sheep and goats, poultry not confined in coops, but running in the yard, a horse, mule and donkeys. Some of the manure may be collected daily in form of fuel cakes. The rest is thrown out with rubbish and refuse on the outskirts of the village or near the house. People defaecate outside the yard here and there. Cattle is kept in the yard or in a small barn; in exceptional cases in a portion of dwelling: horses and mules are stabled. The yards and some houses have cobbled stone floors; water supply is scarce.

Settlement 8 is a village of 2,000 Jewish inhabitants. Farm yards and houses for non-farming inhabitants alternate. The farmers keep a few cows, some poultry in the yard, horses, mules and donkeys. Manure is collected, but not taken care of and is piled somewhere near the yard and barn. Rubbish and refuse are carried away twice a week and deposited in the fields far from the village. Latrines are mostly of the dry pit type. Some people defaecate outside the buidings in the backyards. Poor central water supply.

Detailed information on the findings is summarized in Table 1.

All potential fly breeding places were examined by digging in 5-6 spots to different depths. The density of breeding was recorded as follows:

Larval Density - Slight - not more than ten maggots seen at a point
Moderate - more than ten maggots seen
Heavy - uncountable maggots seen.

Adult flies were counted in the way described in the previous publication (²). The fly counts were carried out between 10 a.m. and noon.

It is evident that dung and manure in any form and of any origin are the main source of house-flies in the surveyed villages. It is not so much the quantity of manure produced as the quantity of manure accumulated and stored that determines the extension of fly breeding. The species of manure seems to be of secondary importance. Of greatest importance is the way in which the manure is handled. The cow manure

Table 1.

N. Place	Nature of breeding medium	Estimated quantity of the medium breeding maggots	Instar of Larvae	Intensity of breeding	Species bred from maggots	Density of fly population
1. Comm Settl. « H »	1. Manure in heap mixed with kitchen refuse and rubbish	3 m^3	All	Heavy	?	?
	2. Manure in covered shed	2 m^3	»	Slight	?	
	3. Mud wet, mixed with manure in the cow yard	1 m^3	»	»	?	
	4. Mud on edges of a ditch leading from the barn	?	»	Moderate	?	
2. Part of Arab Village « R »	1. Manure in a communal heap, horse, donkeys and cow	0.5 m^3	All	Slight	?	A few in rooms
	2. Manure in fuel cakes	0.1 m^3	»	»	?	
	3. Mud with kitchen refuse	0.01 m^3	»	»	?	
	4. Deposits of human faeces in field	Few	1	Heavy	?	
3. Part of Arab Village « J »	1. Manure horse, donkey, cow and rubbish in a communal heap	0.2 m^3	All	Slight	?	A few to 100 in houses
	2. Manure in fuel cakes arranged in pile	1.0 m^3	All	Slight	Vic.	
	3. Manure sheep goat and poultry in barn	0.1 m^3	»	Moderate	?	
	4. Mud wet, mixed with manure and kitchen refuse	0.2 m^3	»	Heavy		
	5. Human faeces droppings	Few	2	»	?	

Table I. (contd.)

N. Place	Nature of breeding medium	Estimated quantity of the medium breeding maggots	Instar of Larvae	Intensity of breeding	Species bred from maggots	Density of fly population
4. Commun. Settl. « A »	1. Manure in heap	5 m^3	All	Intense	M. Vic.	1,704 dining hall & Kitchen
	2. Manure in open yard mixed with wet mud	3 m^3	»	Slight	?	
	3. Manure in cow and calf sheds	4 m^3	»	Moderate	Vic.	
	4. Wet poultry manure	1 m^3	»	»	?	
	5. Horse stable manure	0.5 m^3	»	»		
	6. Wet mud near bakery, kitchen, laundry, sewage outlet, etc.	1 m^3	»	Slight to moderate	Vic.	
	7. Kitchen refuse and rubbish heap	2 m^3	»	Heavy	Call. Sp.	
5. Part of Arab village « H »	1. Individual cow dropping	Few	All	Heavy	Temp.	2-20 per room
6. Part of Arab Village « J »	1. Manure fuel cakes piled up	1.0 m^3	All	Slight	Vic.	Few up to 100 per room
	2. Manure fuel cakes on the ground	0.5 m^3	»	»	?	
	3. Wet mud	0.1 m^3	»	Heavy	?	
7. Commun. Settl. « K »	1. Heap of manure mixed with kitchen refuse and rubbish	3 m^3	All	Heavy		1,400 in dining hall
	2. Manure of goats and sheep mixed with vegetable waste	1 m^3	»	»		
	3. Wet poultry manure	3 m^3	»	»	Vic.	In store room uncountable
	4. Wet mud mixed with manure	2 m^3	»	Slight		
	5. Cow droppings in yard	Several	3	Heavy	Crassir.	

Table I. (contd.)

N. Place	Nature of breeding medium	Estimated quantity of the medium breeding maggots	Instar of Larvae	Intensity of breeding	Species bred from maggots	Density of fly population
8. Part of Jewish Village « R »	1. Manure heap 2. Wet mud 3. Human faeces in cellar	0.5 m^3 0.1 m^3 Several	All » »	Heavy Slight Heavy	Vic. ?	14-60 per house 70 per cow in barn
9. Commun. Settl. « M »	1. Manure in heap 2. Manure in open shed 3. Horses manure in stable 4. Kitchen refuse and rubbish in barrels	5.0 m^3 4.0 m^3 0.1 m^3 0.5 m^3	All » » »	Heavy Moderate Heavy »	Vic. » » »	230 per cow in barn
10. Arab Village « M »	1. Horse manure in the yard 2. Manure in barn 3. Manure in fuel cakes stuck to wall	0.2 m^3 0.5 m^3 0.1 m^3	All » »	Moderate Slight »	? ?	10 to 240 per house
11. Commun. Settl. « H »	1. Manure in heap 2. Manure in shed 3. Wet mud mixed with manure 4. Mule manure in stable 5. Faeces in privy pit 6. Barrels filled with kitchen refuse and rubbish	3.0 m^3 0.5 m^3 0.25 m^3 0.5 m^3 0.5 m^3 0.5 m^3	All » » » » »	Heavy Moderate Slight Moderate Heavy Moderate	Neb. Vic. » » Sorb. Neb. Vic. Vic. Neb.	1,500 in dining hall and kitchen 190 per cow

Manure = Cattle manure
Commun. settl. = Communal settlement with mixed farming
M^3 = Cubic metres
P. room = Average count in single room
P. house = Average count in single house
P. cow = Average count of flies sitting on cows

Fuel cakes in piles = See photo No. 1
Vic. = Musca dom. Vicina macq.
Neb. = Nebule Fabr.
Temp. = Tempestiva Fall.
Sorb. = Sorbens Patt.
Crassir = Crassirostris Stein
Call. sp. = Calliphora Species

is the main source of fly breeding in our area, first, because there are many more cows than horses, mules or donkeys, and also because horse manure is not stored in heaps as cow manure. The communal settlements and Arab villages keep many sheep and goats; the dung of these is never a source of fly breeding because it is dry, but moistened artificially or mixed with other wet organic matter breeds many flies. The same is true of poultry manure which in its natural state never breeds flies except when moistened.

The essential difference in manure handling between the modern communal settlements with their intensive farming on one hand and the Arab and Jewish villages with primitive farming systems on the other is that in the former manure is considered to be an important by-product of the animal husbandry while in the latter most of the manure is thrown out after cleaning the yard, barn or stable. The manure dries in the outskirts of the village and at the best serves as poultry food. But as soon as the Arab village begins to store manure in form of fuel cakes or for agricultural purposes, favourable fly breeding conditions are created and the density of the fly population rises. Poultry is the natural enemy of fly maggots in any stored manure. If not for poultry many more flies would breed from the manure thrown away in Arab and Jewish villages. The same refers to individual cow droppings and human faeces. In one case 100 chickens in a closed yard kept the manure produced by two cows completely free from maggots and other insects.

In communal settlements the manure is stored in two ways.

1. Manure is removed daily from the barn and distributed in a layer of approximately 30 cm^3 over a certain area not far from the main barn. It is covered by a layer of straw or other litter. Next day's manure is spread over the litter layer and so on until the height of 1.80 or 2 metres is reached, when another similar structure is built beside the completed one. Thus slowly a quadrangular pile several metres long and wide is constructed (see photos 2 and 3). The manure in these piles is carted away and distributed in the fields after months of storage. The pile in construction is sprayed with water from time to time in order to keep the manure moist. The fermentation temperature of the manure layers in the pile is seldom higher than 50° C during the first week or so, and prolific breeding takes place in them. The straw and the manure on the sides of the pile exposed to the air dry up quickly and the flies pupate in them as well as in the soil around the pile (see photos 4 and 5). It was observed that whenever manure was

Photo No. 1. - Fuel cakes pile.

Photo No. 2. - Manure pile in costruction.

Photo No. 3. - Manure pile completed.

Photo No. 4. - Pupae found on the sides of the manure pile, in places pointed out by sticks.

conveyed directly from the barn to the pile and covered with litter the fly breeding was less heavy than if the manure remained for a day or longer in the barn or outside it before piling.

2. This method is practised in the communal settlements and also by individual Arab and Jewish farmers. The manure is left over for weeks and months on the floor of the barn, shed or yard to be trodden down by the cattle. Every day some litter is added and the layer of manure grows slowly in thickness; sometimes it grows 50-60 cm thick. Fly breeding is always found in it up to the depth of 25-30 cm. The pupae are found in dry manure on the edges. The breeding density is never as high as in the pile, but the quantity of manure in which actual breeding is taking place is considerable, and the manure so stored still remains an important source of flies.

The fly breeding medium second in importance to manure in our area is the mixture of kitchen refuse and garbage. Intensity of breeding in this medium is often much higher than in manure but the quantity is more limited. It loses its fly breeding properties slowly and often a month old heap is still breeding many flies even in spite of exposure to sun during the hot summer months. Thick pieces of vegetables dry slowly and flies find in them suitable conditions for breeding even when the rest of the heap has dried completely. Pupation takes place in the soil below and around the heap or in dry portions of it. Inclusion of kitchen refuse into the manure of the pile creates exceptionally favourable breeding. conditons. Prolific breeding may be found also in the barrels or other receptacles for refuse and rubbish, but as most of them are cleaned twice a week or so pupation seldom occurs there.

A third type of fly breeding medium is produced by careless handling of manure and refuse containing organic matter — carelessly thrown on wet mud it supports fly breeding of low intensity. Such mud is found in small quantities everywhere near houses, barns, stables, kitchens, etc.

Less important than the fly producing media mentioned are human faeces and individual animal droppings. The human faeces accumulated in the privy pit are a prolific fly breeder, but such pits are rare in the communal settlements and practically non-existent in Arab villages; in the Jewish village they are hewn in rock and very deep. In Arab villages human faeces in separate droppings are deposited in the field, on the outskirts of the village, and they dry very quickly in summer. Faeces are probably a more important source of flies in the Jewish village where they may be deposited in cellars and do not

dry quickly. Hundreds of individual cow and horse droppings were examined in the course of the survey; only in a few was fly breeding found.

B) Distribution of adult house-flies in an agricultural settlement according to species sex and age.

These observations were carried out in the communal settlement « H » during the first week of August. A number of flies were caught at random daily in places with the largest number, put on ice and dissected on the same day. The fly counts reported below were all made on the same day between 10 a.m. and noon.

In this study an attempt was made to determine the age of flies by the persistence of larval fat body cells in the image after its emergence from the pupae. This phenomenon was studied in our flies (see appendix I). Results of the examination and dissection of flies caught are summarized in Table II.

Flies belonging to five different species were identified in the settement. Flies of species other than Musca Dom. Vicina Macq. were found in significant numbers only « on cows ». Recently emerged flies of both sexes were found in all places but their distribution was not uniform. Approximately one fourth of all the flies caught and dissected had emerged recently, probably two to three days before dissection. With few exceptions the older flies dissected all contained food in the midgut.

Among the recently emerged flies food in midgut was found in:

11 flies out of 46 with many larval fat cells
20 flies out of 27 with moderate larval fat cells
21 flies out of 36 with few larval fat cells.

The adults of Musca Dom Vicina were found everywhere in the settlement. It is striking that comparatively few flies were found in the kitchen, while so many were present in the barn and the manure heap only 150 yards away. The kitchen door was kept open and some windows had no screening or a torn one.

DISCUSSION OF ANTI-FLY MEASURES IN A RURAL COMMUNITY IN ISRAEL

The anti-fly campaign is justified only because the flies interfere with our health and comfort. If the house-fly's activities during its entire life cycle were limited to the manure or garbage heap and

Table II.

Location	*Number of flies Estimated E or Counted C*	*Species and sex of flies caught*			*Number of Larval fat body cells in abdominal cavity of dissected flies*				
					No Dissected	*Sex*	*No. of flies with-cells*		
		Species	*M*	*F*			*Many*	*Moderate No.*	*A few*
Manure heap and surrounding	Ten to twenty thousand E	Vic.	18	78					
		Sorb.	1	2	11	M	2	—	1
		Larvip.	1		33	F	1	3	1
		Tempest.	1	1					
Barn total of these	cca 7,000 C	Vic.	3	16					
		Tempest.		1	6	M	1	1	—
on cows	cca 7,000 C	Crassir.		1	25	F	2	2	—
		Larvip.		3					
Resting on beams etc.	cca 8,000 C	Vic.	18	14	56	M	12	2	13
					44	F	7	5	2
Dairy room	cca 1,600 C	?			27	M	3	2	5
					22	F	2	2	1
Refuse barrels	Two to three thousand E	Vic.	3	8					

TABLE II (contd.)

Location	*Number of flies Estimated E or Counted C*	*Species and sex of flies caught*			*Number of Larval fat body cells in abdominal cavity of dissected flies*				
					No. Diseected	*Sex*	*No. of flies wilh-cells*		
		Species	*M*	*F*			*Many*	*Moderate No.*	*A few*
Latrine	Four to six hundred E	Vic.	7	87	1	M	—	—	—
		Sorb.		1	14	F	2	—	—
Resting in store-room of cereals	cca 250 C	Vic.			25	M	4	4	2
			6	2	19	F	4	1	3
Kitchen Dining hall	cca 1,500 C	Vic.	51	62					
		Neb.	1	?	27	M	4	1	4
		Sorb.	1	1	38	F	2	4	4
Horse stable	Five to six hundred E								

Vic. = Musca Dom Vicina Macq.
Sorb. = Sorbens Patt.
Larvip. = Larvipira Port.
Tempest. = Tempestiva Fall.
Crassir. = Crassirostris Stein.
Neb. = Nebulo Fabr.

its close surroundings little thought would be given to the fly problem. It is possible, as L. West (3) points out, that different physiological races of flies exist in the same species. Separation of fly races which may be more dangerous than others of the same species would open possibilities of selective fly control. Meanwhile trying to eliminate those flies which for one or other reasons are the most undesirable to us would seem to be a more reasonable policy than to try to destroy all flies indiscriminately. But I doubt whether with house-flies having become resistant to insecticides protection of individual premises in rural communities by localized anti-fly measures only is possible at all.

The following procedures come into consideration for protection of living quarters from flies:

1. Screening: Not acceptable in rural communities because of high cost of installation and of upkeep.

2. Deviation of flies to other food sources: reduction of attractiveness of the human habitation and its surroundings as compared with other places where the flies are less undesirable. Examples of such deviations are frequently met with in the field. This presumes as good sanitation in a limited area and maybe the use of fly repellents on a large scale, if such were discovered.

3. Destruction of flies in the protected place. Residual insecticides for the whole building or as spot treatment, poisoned baits and traps of all kinds come into consideration for this purpose. It is doubtful if any of these methods would be of great value in rural communities with extensive fly breeding. The effect produced by any method of destruction depends largely on the rate at which entering flies are destroyed. The killing rate has to match the influx. The fly destruction methods available to us at present are slow killers; they would probably be sufficient in certain Arab and Jewish villages with comparatively limited fly breeding. Some of these methods such as poisoned baits were widely used in our communal settlements before the DDT era. Sodium Arsenite or a preparation known by the name of « Cattle dip » were used as the poison. Dying and dead flies were seen everywhere but the reduction of the total number of flies in the rooms was not impressive. It seems that in rural communities with extensive fly breeding, reduction of the total fly population is necessary in order to make possible the protection of individual buildings by the available means. *A priori* it would seem that the easest way to accomplish reduction of fly density is the use of larvicides. Tests with thiourea

reported (see appendix 2) seem to indicate that this is not easily accomplished.

No doubt the best possibilities of reducing fly breeding lie in improving the handling and storage methods of manure and other organic matter. It has been pointed out that prompt covering of the manure in the pile seems to reduce subsequent breeding. Such possibilities have to be explored. Methods recommended should be acceptable not only from the sanitarian's point of view, but they should meet the demands of the farmer, i.e., not to lower the value of the manure and if possible to enhance it, not to increase the production costs and to suit the varyng needs of the farming system.

CONCLUSIONS.

The fly problem in rural agricultural areas is very acute. Manure and other organic matter accumulated and stored for agricultural purposes are the main source of fly breeding. The progress of agriculture in this area seems to require collection, handling and storage of these fly breeding materials in large quantities. The methods of collection and storage at present in use or even as advocated by agricultural authorities permit extensive fly breeding in these materials.

It is suggested that methods of manure and refuse storage which would not permit fly breeding and adapted to different farming systems should be worked out in co-operation with farmers and specialists in agriculture. The reduction of fly density in rural areas by controlling fly breeding is indicated in order to control fly nuisance in individual premises by any other means available.

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APPENDIX 1.

PERSISTENCE OF LARVAL FAT BODY CELLS IN THE ABDOMINAL CAVITY OF RECENTLY EMERGED ADULTS OF MUSCA DOM VICINA MACQ.

This phenomenon was studied in Drosophila and Calliphora. (Wigglesworth p. 272, Chauvin p. 257. (3, 4). It seems that it was not studied in Musca sp. Flies of the laboratory strain of Musca Dom Vicina were kept at a constant temperature on milk and sugar and were dissected some time after their emergence from pupae. Larval fat body cells found in abdominal segments or in the whole of the abdominal cavity were counted or their number was estimated approximately.

Single segments were separated from the rest of the abdomen by cutting off with sharp angular iris scissors. The separated segments or the whole abdomen were torn up in a drop of saline and the floating larval fat body cells were counted or estimated as indicated below.

Series 1.

Number (counted) of larval body cells in the cavity of the fourth abdominal segment. - Flies kept at T. 23-24 C.

No. of flies dissected	*Sex*	*Age*	*No. of L. F. Cells counted*
17	Males	Up to 12 hours	250 – 573
16	Males	48-72 hours	0 – 63

Series 2.

Number (counted) of larval fat body cells in the cavity of the fifth and following abdominal segments. - Flies kept at T. 27°C.

No. of flies dissected	*Sex*	*Age*	*No. of L. F. Cells counted*
25	Males	4 to 24 hours	145 to 471
19	Females	4 to 24 hours	184 – 506
25	Males	48± 4 hours	0 - 62
18	Females	48± 4 hours	0 – 60
10	Males	72 - 96 hours	0
22	Females	72 - 96 hours	0

No. of flies dissected	*S e x*	*A g e*	*No. of L. F. Cells counted*
	(*Flies kept at T. 30° C.*)		
9	Males	24± 4 hours	26 – 70
11	Females	24± 4 hours	113 – 310

Series 3 Flies from one group, emerged from pupae between 8 a.m. and 16 p.m. the same day. Kept at T. 26°-27°C. on milk and sugar diet.
Larval fat body cells in the whole abdominal cavity were released into saline by tearing up.
Number of cells estimated as follows:
Many cells — Probably more than 200
Moderate number — More than 20
Few — Up to 20 cells

Age of flies	*No. of dissected*		*No. of flies found with:*			
	Males	*Females*	*Many*	*Modr. No.*	*Few*	*No cells*
24 to 36 hours	9		6	3	0	0
24 to 36 hours		6	4	2	0	0
52 to 60 hours	24		0	2	6	16
52 to 60 hours		15	0	2	6	7
72 to 80 hours	12		0	0	1	11
72 to 80 hours		9	0	0	1	8

The dissections were made under Reichert Binocular Dissect M Microscope ob 40 oc. III

The larval fat body cells are found in the abdominal cavity of adults Musca Dom Vicina for some time after their emergence.

Within 2-3 day after emergence the cells disappear. The rate of cell disintegration probably depends on the temperature of the environment.

The number of cells is considerably reduced after the first 24 hours of adult life.

Very few flies have recognizable cells after 80 hours of adult life at the temperature of 26-27 C.

It seems possible to determine the proportion of recently emerged flies and perhaps their approximate age in a fly population by examining flies for larval fat bodies.

APPENDIX 2.

LARVICIDE TESTS WITH THIOUREA

Tests in this laboratory carried out on fly larvae in glass jars with an artificial breeding medium or fresh cow dung have confirmed the excellent larvicidal properties of thiourea that have been reported by others (6).

Twenty four hours old maggots were killed by thiourea dilutions in the breeding medium 1:25,000. Maggots 48 hours old were killed by dilutions 1:10,000. Number of maggots pupating in medium containing one part of thiourea to 50,000 parts of medium was reduced as compared with controls, many pupae were abnormal and recalled by their form the « lethal line pupae » described by G. W. Barber (7). No adults emerged from 10 to 15% of these pupae. Identical results were obtained with two laboratory strains of flies one of which was approximately 10 times as resistant to DDT as the other. The present third generation of flies bred in medium

containing 1 to 50,000 thiourea does not show as yet any increase of resistance to thiourea or to DDT.

FIELD TESTS

In these tests both manure and garbage were sprayed with thiourea solutions. The quantity of manure and garbage present was measured when possible, or estimated. It was intended to experiment with a 1 in 10,000 concentration of thiourea in manure and kitchen refuse, but it was found subsequently that in treating scattered manure a third of the thiourea was lost on walls, dry litter etc., and that probably twice as much thiourea as intended was added to kitchen refuse. Thiourea was used diluted in water and the solution was prepared extempore.

Test 1.

Cow barn manure accumulated during past 24 hours was collected and arranged in small conical heaps in the morning. It was treated immediately after or before collection. Heaps 1, 2, 3 — manure sprayed on the heap. Manure sprayed in the barn before collection. Heaps 6, 7, 8, 12, 13. Every heap contained from 50 to 60 kgs. manure. Thiourea was sprayed on manure in water solution 1:150. — Similar quantity of water was sprayed on control heaps. Manure heaps were deposited on dry ground at intervals of 1-3 yards. Manure in heaps was examined some days after the spraying by breaking it up by hand; maggots found were counted.

Results of this test are summarized in the following table:

Heap No.	*Treated on*	*Examined on*	*Findings*	*Control Heap No.*	*Heaps put up on*	*Examined on*	*Findings*
1	20 V.	24 V.	Numerous maggots	2	20 V.	24 V.	Numerous maggots
3	20 V.	24 V.	Few maggots	4	23 V.	28 V.	More than 500 maggots in half heap
6	25 V.	28 V.	25 maggots	5	27 V.	31 V.	More than 500 maggots in half heap
7	26 V.	31 V.	3 maggots no pupae	9	27 V.	31 V.	More than 300 maggots in half heap
8	26 V.	31 V.	No maggots no pupae	10	27 V.	31 V.	More than 400 maggots in half heap
12	29 V.	2 VI.	24 maggots				
13	31 V.	6 VI.	No pupae no maggots	11	29 V.	2 VI.	More than 500 maggots in half heap

Fly breeding was controlled in the heaps made up from manure sprayed in the barn before collection, but not when manure was sprayed in the heap.

Manure was collected in cow barn every day and added to one heap for seven consecutive days. When inspected on the ninth day numerous fly maggots were found in all layers of the heap. During the following seven days the manure was sprayed every morning in the barn before collection and piled up in a heap of approximately the same dimensions as the former. Inspection on the ninth day revealed only one cluster cca 1 kg of manure infested with fly larvae.

Test 2.

A cattle yard covered with manure and a layer of litter 5 to 20 cms thick was sprayed with a solution of thiourea in water 1+1,000 every day for six days. The presumed final concentration of thiourea in manure should have been 1:25,000. Inspection made two days after the last spraying did not reveal any reduction of fly breeding.

Test 3.

Manure in one cell of a covered cattle shed was sprayed daily for ten days with a thiourea and water solution 1:1,000, 1:2,000, 1:3,000. The presumed final concentration of thiourea in the manure was 1:10,000. Before the treatment numerous fly maggots of all sizes were found in the manure of this and the adjacent control cell. The thickness of the manure layer was approximately 10-20 cms. Daily 15 kgs of straw and approximately the same quantity of calf droppings were added to the manure layer. The manure was examined every two days and only on the sixth day some reduction in breeding as compared with the adjacent cell was noted. On the tenth day a certain number of third instar larvae could still be found in deeper layers. No reduction of breeding was noted in the adjacent cell.

Test 4.

Contents of kitchen refuse and rubbish cans were sprayed once daily with a solution of thiourea in water 1:500, for two periods of seven days each. The presumed final dilution of thiourea in the refuse and rubbish was 1:10,000. Refuse and rubbish were added to the cans several times per day, the cans were cleaned every three to four days. The contents were piled up in a heap in the field. The fly breeding usually started in the cans, the number of fly maggots and pupae in the heap was very large. The heap was frequently examined during the test, but no reduction of breeding was noted.

Many clusters of dense breeding remained in vegetable and fruit waste.

These tests show that in spite of the excellent larvicidal properties of thiourea its effectiveness is probably limited to manure which is stirred well during the process of collection and piling. The thiourea treatments have to be repeated daily, and carefully carried out. It is of little value where thick layers of litter or manure are present. It does not control fly breeding in kitchen refuse. Such or similar limitations would probably apply to any true larvicide.