For reasons as yet unknown, chemical treatment of privies with dieldrin, aldrin, BHC, and chlordane increases the breeding of Musca domestica, according to CDC studies at Savannah, Ga.

Fly Production in Treated and Untreated Privies

By JOHN W. KILPATRICK, M.S., and H. F. SCHOOF, Ph.D.

PRIOR to 1951 human excrement was not considered to be an important breeding medium for houseflies. However, since 1951 there has been considerable evidence of copious housefly breeding in human feces. Studies in the lower Rio Grande Valley, Tex. (*1*), and in Phoenix, Ariz., and Charleston, W. Va. (*2*), have indicated this intensive breeding to be associated principally with the use of dieldrin as a residual or as a larvicidal treatment in privies.

In 1953 the Technical Development Laboratories of the Communicable Disease Center, Public Health Service, undertook a long-range investigation in southeastern Georgia, near Savannah, to study this paradox of increased housefly production from treated privies. During 1953 the study of fly emergence from 100 untreated privies (10 in each of 10 areas) substantiated the pre-1951 observations that human excrement as a breeding medium normally contributed little to the overall housefly population (*3*). In 1954 the study plan was designed to determine what effect chemical treatment of privies with certain chlorinated hydrocarbon insecticides would exert upon housefly and other fly production.

Mr. Kilpatrick and Dr. Schoof are the co-authors of the article entitled "The Use of Insecticide Treated Cords for Housefly Control," in the February 1956 issue of Public Health Reports (p. 144). Dr. Schoof is chief of the Biology Section of the Technical Development Laboratories, Communicable Disease Center, Public Health Service, Savannah, Ga. Mr. Kilpatrick is an entomologist with the laboratories.

Assistance with the studies reported here was given at the laboratories by Dr. Harold R. Dodge, who identified the majority of the species in the lesser known dipterous groups and helped in processing the copious collections of Diptera, and by Fred Freeman and Bernard O. Smith, who helped in preparing the study structures and collecting the fly samples.

Procedure

In 1953 the study included the trapping of flies from 10 privies in each of 10 areas (*3*). In 1954 the same privies were used in studies as follows:

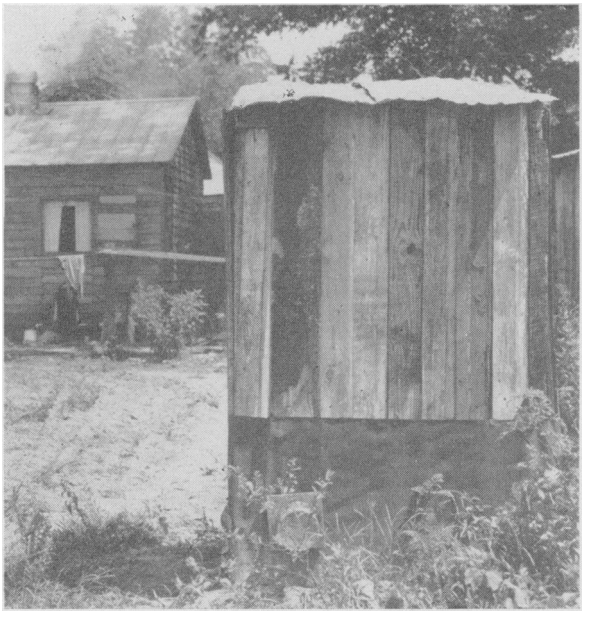
Series I (Dieldrin and DDT)

(*a*) Untreated control—20 privies (10 each in 2 areas).

(*b*) Overall DDT treatment at 200 milligrams per square foot (late March)—10 privies (1 area).

(*c*) Overall dieldrin treatment at 50 mg./sq. ft. (early April)—30 privies (10 each in 3 areas).

In series Ib and Ic, all animal pens and porches on the premises were treated, as well as the privies. Overall privy treatment included the pits and their contents.



Fly trap in place on privy in Georgia studies.

Series II (Dieldrin, Chlordane, BHC)

(*a*) 3 privies treated with dieldrin at 50 mg./sq. ft. (August).

(*b*) 3 privies treated with chlordane at 100 mg./sq. ft. (August).

(*c*) 3 privies treated with BHC (benzene hexachloride) at 40 mg./sq. ft. (August).

(*d*) 3 untreated control privies.

Treatment was restricted to the privy contents, riser walls (inside and outside), and the inside of the privy superstructure. All privies were within the same 3- to 4-block area.

Series III (Dieldrin)

Ten privies treated with dieldrin at 50 mg./sq. ft. (August). Treatment made to inside walls of structure and to pits and their contents.

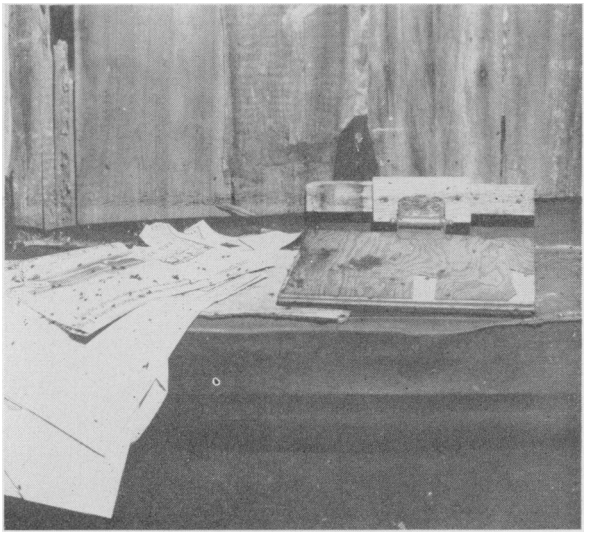
Series IV (Dieldrin and Aldrin)

(*a*) 3 privies treated (September) with dieldrin at 50 mg./sq. ft. Treatment restricted to the inside of the privy risers. Surfaces not treated were protected from spray drift by paper barriers.

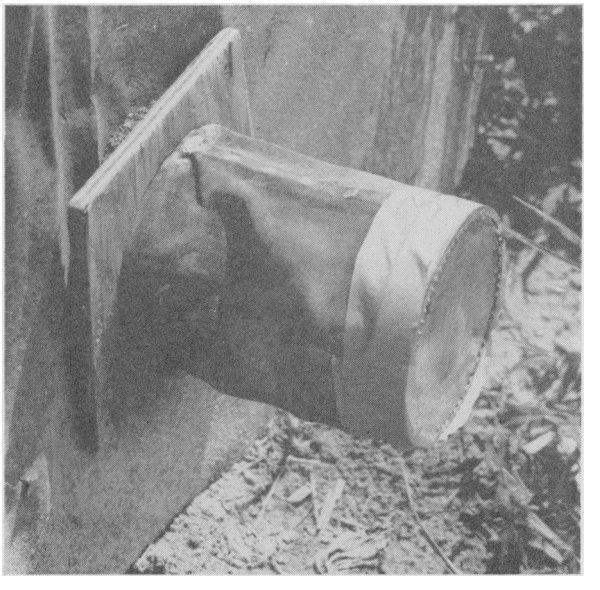
(*b*) 3 privies treated (September) with dieldrin at 50 mg./sq. ft. Treatment was applied only to the excrement. Adjacent riser surfaces protected from spray drift by paper barriers.

(*c*) 4 privies treated (September) with aldrin at 50 mg./sq. ft. Treatment applied to the inside walls of the structures and to the pits and their contents.

In evaluating the effects of the dieldrin and DDT treatment (series I) on privy fly production, flies were trapped in 5 privies from each of the 6 areas over a 3-week period. At the end of the 3-week period, flies emerging from the alternate privies in the same area were trapped. During a trapping period each privy was sealed and made fly tight with the aid of new boards, building paper, masking tape and banked earth around the bottom edges of the building. Each riser was fitted with a seat-hole cover equipped with a spring hinge and lined with foam rubber to provide a close fit when installed over the opening. A hole 6 inches in diameter was cut in the outside wall of the privy approximately 12 inches above ground level on that side of the privy exposed to the



Interior of privy shows seat lid installed.



Closeup of fly trap on exterior of privy.

greatest amount of light. A cone-type trap, constructed of copper wire (36 x 40 mesh) was then attached over the hole. Sponge rubber affixed to the bottom of the plywood base of the trap assured a tight seal. At the end of each trapping cycle the privies were reopened to allow a resumption of fly breeding. (See photographs.)

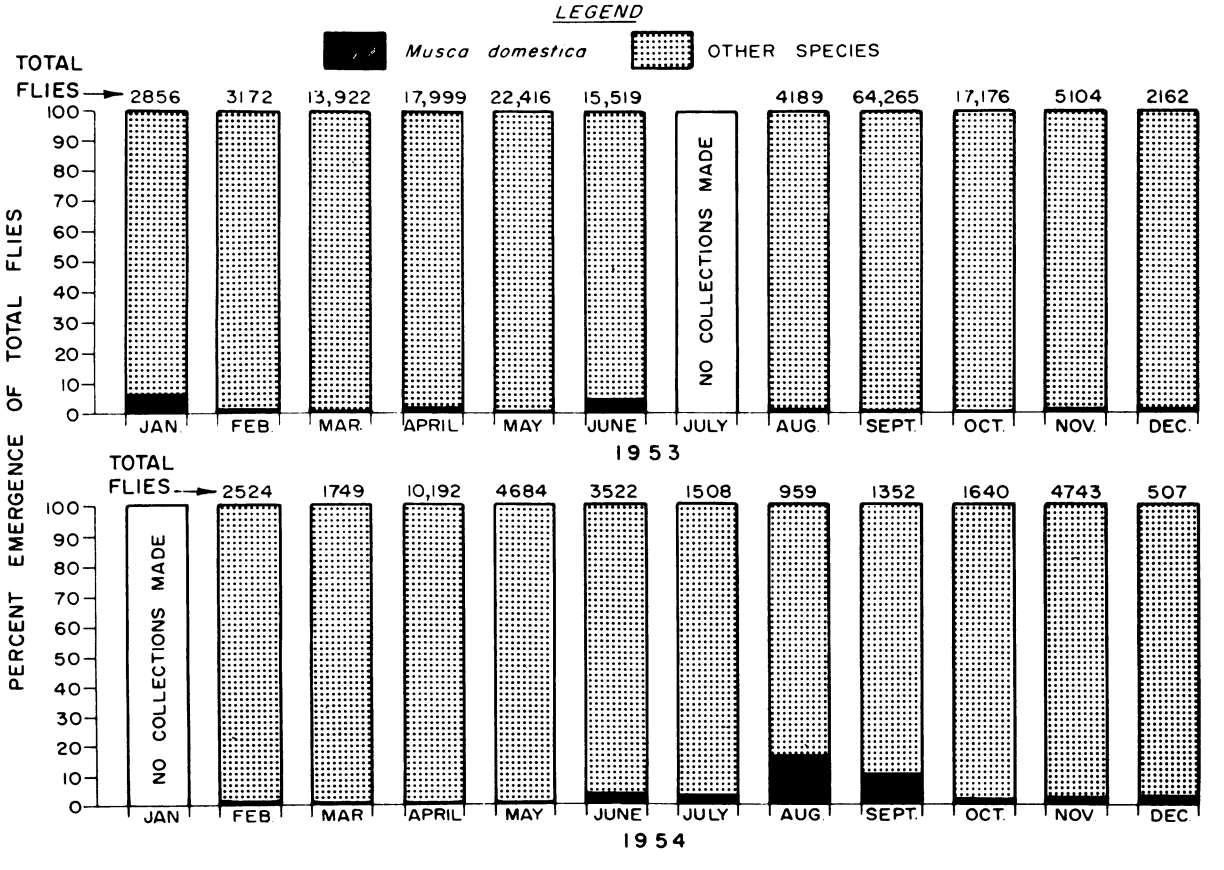
In privy studies involving only 3 or 4 privies for each type of treatment, the flies emerging from the privies were trapped for 3 weeks, and then the privies were allowed to remain open for the 3 succeeding weeks. Then another trapping cycle was begun.

To evaluate the possible effect of dieldrin resistance on housefly breeding potential in treated and untreated privies, one of the untreated areas was located between 2 treated zones (series Ia) approximately one-fourth mile from either zone. As a result, housefly populations from all 3 areas could intermingle readily. Pretreatment and post-treatment levels of dieldrin resistance in the fly populations of the various areas were measured. These determinations were made by collecting adult flies from the various areas, obtaining eggs from these flies and testing their progeny by 30-minute exposures to plywood panels treated with dieldrin at the rate of 25 mg./sq. ft. Mortality counts were made at 48 hours.

Untreated Privies (Series Ia)

In the untreated areas (fig. 1), the prevalence of *Musca domestica* was low throughout each entire 12-month period. The largest percentage emergence of *M. domestica* during any one month was 6.3 in 1953 and 16.9 in 1954. Considerable variations occurred from month to month in the total number of flies trapped. This fact can be partly explained by seasonal emergence of various species. *M. domestica*

Figure 1. Percent of Musca domestica and other flies emerging from untreated pit privies: 1953 (100 privies) and 1954 (20 privies).



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was not a major emerging species at any time, representing only 1.2 percent in 1953 and 2.2 percent in 1954. In regard to 1954, the total fly emergence during the month of highest percentage emergence (August) was the lowest in magnitude (959 specimens) during the April to October period. Thus, the pattern of housefly emergence from untreated privies is similar for both years.

DDT-Treated Privies (Series Ib)

The effect of DDT residual treatments on housefly emergence from privies is shown in figure 2. Although treatment occurred in March, no substantial change in *M. domestica* emergence was noted until July. During that month houseflies represented 29.5 percent of the 1,741 specimens collected. However, of the total of 514 houseflies trapped in the 5 privies during the period, 396 specimens were produced by 1 privy. Subsequent trappings from the privy failed to show a sustained increase in housefly production so that the apparent increase for a single privy in July appears to be incidental to the general pattern. In general the housefly emergence in the DDT-treated areas was comparable with that from untreated privies.

Dieldrin-Treated Privies (Series Ic)

The percentage emergence of *M. domestica* from dieldrin-treated privies is contrasted with other species in figure 3. Although the 3 dieldrin-treated areas received residual applications early in April, increases in the emergence of houseflies were noted in May. Continued increases of housefly production on both percentage and numerical bases also were evident during the ensuing months in all 3 areas. During August, 87.9 percent of the 20,538 flies trapped were *M. domestica*. Increased emergence was apparent for October, November, and

Figure 2. Percent of Musca domestica and other flies emerging from 10 DDT-treated privies: 1954

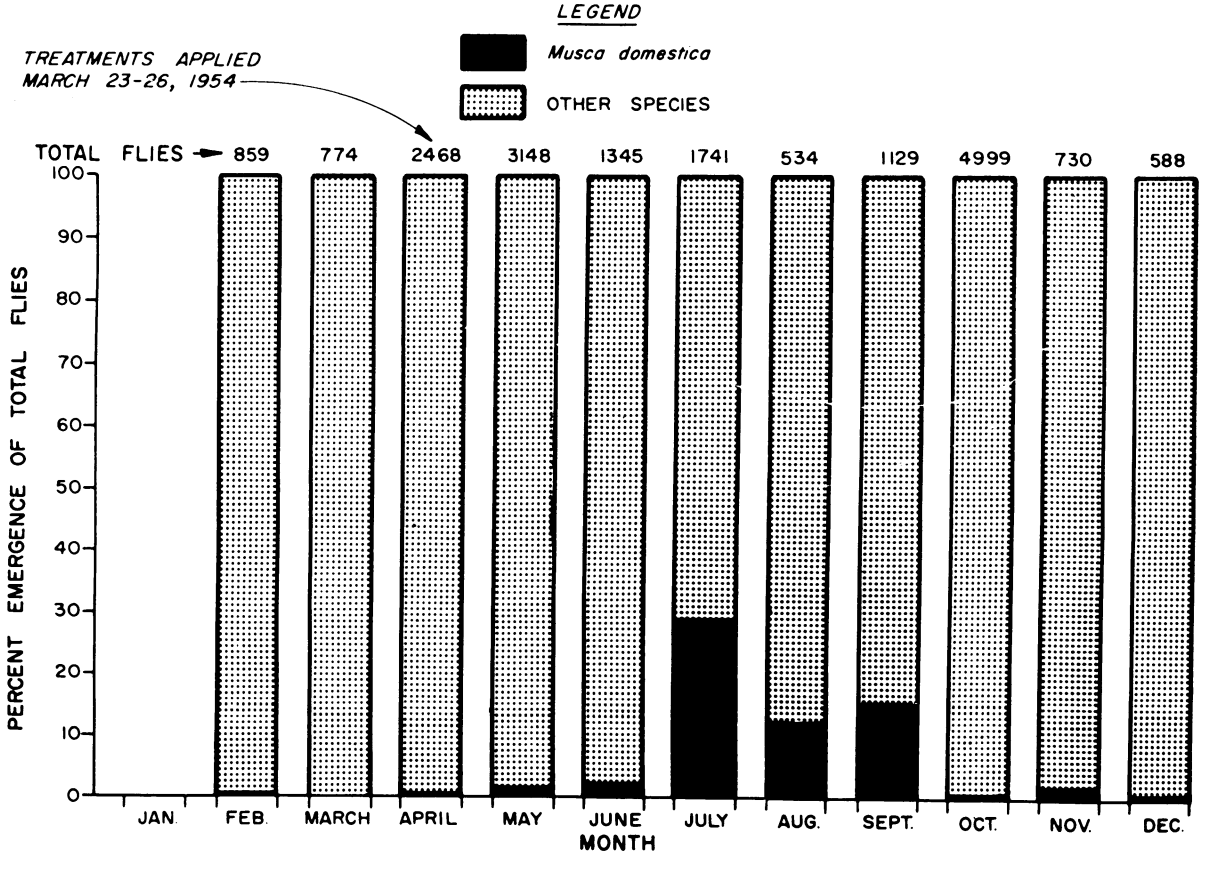
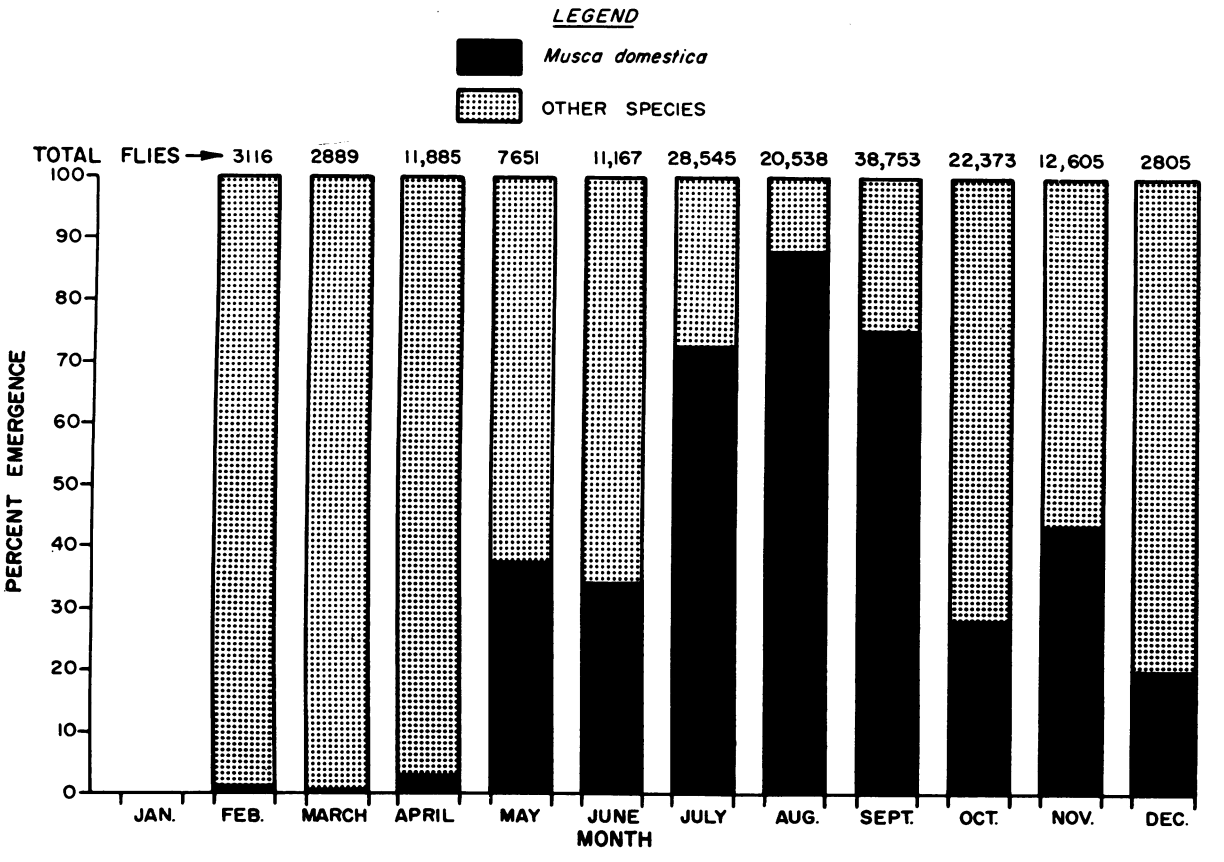


Figure 3. Percent of Musca domestica and other flies emerging from 30 dieldrin-treated privies: 1954.



December despite the fact that during those months housefly activity usually is low. In November, 12,605 flies were trapped, 5,514 of which were houseflies. A majority of the other fly species trapped during this month were either *Desmometopa* spp. or *Leptocera* spp.

Series II, III, IV

Emergence data from the privies (series II) treated with dieldrin, chlordane, and BHC are shown in figure 4. Although these data represent emergence from only 3 privies treated with each chemical, they do show that both chlordane and BHC applications can induce increased housefly breeding similar to that obtained with dieldrin residues. Although applied late in August, the treatments resulted in immediate increases in housefly production in September. In contrast, the untreated privies in the same area (3 to 4 blocks) failed to show any augmentation in housefly production. In general, housefly production from the 3 dieldrin-treated privies was considerably higher in magnitude than that from privies treated with BHC and chlordane.

Treatments were applied early in August to the inside and outside walls and pits of 10 privies (series III) in an untreated area. Pretreatment emergence of *M. domestica* averaged 1 fly per privy. In October the average housefly emergence was 228 per privy and in November, only 11 per privy. Although housefly production from this group of privies was not extremely high, it does show a significant increase, especially in October. The average production of houseflies from untreated privies during that month was only 7 flies.

Data for the 4 privies treated with aldrin and for the 6 privies that received selective treatments of dieldrin (series IV) are shown in figure 5. Housefly emergence from the 10 priv-

ies during the pretreatment period from May through September was low. However, immediately after treatment in late September, spectacular increases in housefly emergence were evident, ranging from 56.8 percent to 83.7 percent *M. domestica*. The data indicate that aldrin also induces increased housefly production, and they demonstrate that dieldrin treatment of either the riser walls or pit contents is capable of stimulating the production of *M. domestica*.

A more detailed analysis of the data from treated and untreated privies in 1953 and 1954 is shown in table 1. The average emergence of all species of flies from untreated privies in 1953 and 1954 and from DDT-treated privies in 1954 was generally of about the same magnitude. The increase in average emergence for untreated privies in September of 1953 was influenced greatly by the collection of more than 35,000 *Culex quinquefasciatus* during that period. In contrast the total fly emergence from

Figure 4. Percent of Musca domestica and other flies emerging from 3 privies treated with dieldrin, 3 with chlordane, and 3 with BHC: 1954.

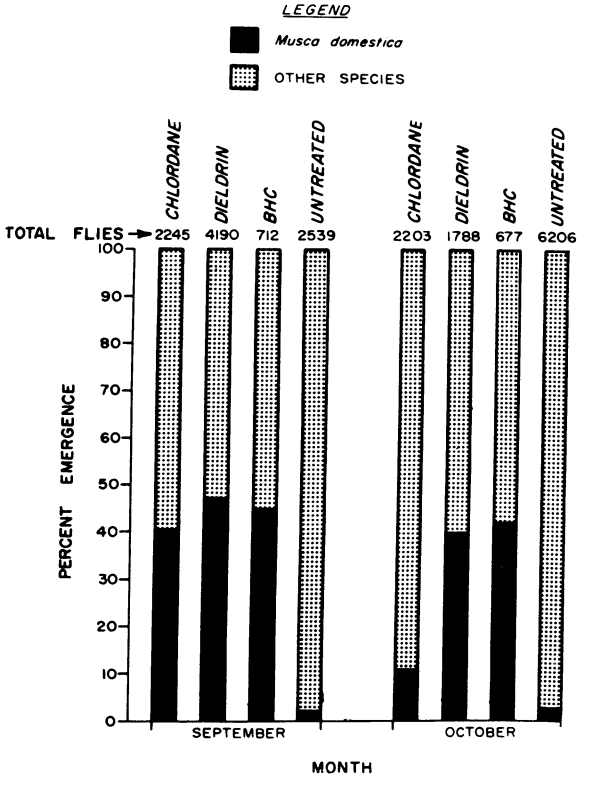
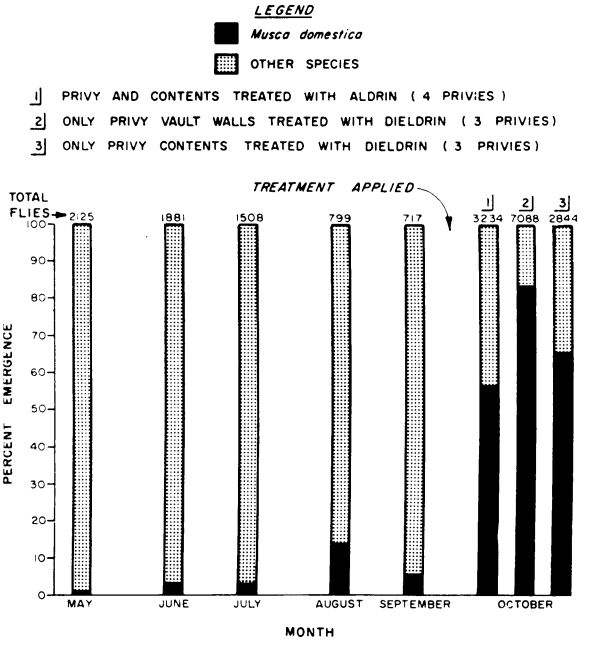


Figure 5. Percent of Musca domestica and other species emerging from dieldrin- and aldrin-treated privies: 1954.



dieldrin-treated privies shows a sharp increase immediately after the treatments were applied. This was particularly evident from July through October.

The average emergence of *M. domestica* alone from treated and untreated privies is also shown in table 1. These data are most significant in that housefly emergence from untreated privies never exceeded an average of 27 flies per privy in either 1953 or 1954, but in September 1954 housefly emergence from dieldrin-treated privies averaged 1,946 flies per privy. As previously stated, the increase in housefly emergence from DDT-treated privies in July 1954 was due primarily to production in one privy. The data for the DDT-treated area in August and succeeding months show that housefly production again reverted to a low level.

A comparative tabulation of the major species which occurred in the untreated privies in 1953 and in the privies treated with dieldrin in the spring of 1954 shows the average fly emergence per privy by months (table 2). Although variations in the magnitude of different species occur, the significance of these fluctuations appears of little consequence with the exception of *M. domestica*. *Dendrophaonia*

hilariformis occurred in fewer numbers; however, that was evident both on a pretreatment and post-treatment level. *Telmatoscopus albipunctatus*, although occurring in lesser magnitudes in September and October 1954 than in 1953, was still recorded in considerable numbers in those months (average of 168 per privy in September), and its overall influence on the increased housefly production in dieldrin-treated privies is doubtful.

In general, the changes in prevalences for species other than *M. domestica* were insignificant during the months when the housefly normally is most abundant.

Dieldrin-resistance levels of housefly populations in the treated and untreated areas are shown in figure 6. Pretreatment mortality levels in *M. domestica* from the 3 areas ranged from 53 percent in the untreated zones to 73 percent in the DDT-treated zone. Throughout the entire year mortality levels for houseflies collected in the DDT-treated area were 64 percent or above. In the dieldrin-treated areas housefly resistance increased so that in August 1954 an average mortality of only 1 percent was obtained. Housefly populations in area 5, untreated until September and situated between 2 dieldrin-treated areas, also showed a rapid increase in resistance, a fact presumably explainable by the interchange of flies between the treated and untreated areas. However, the untreated area, area 6, which was isolated approximately 10 miles from any treated area also manifested an increase in dieldrin resistance that defies a logical explanation.

Discussion

When the 1954 studies were begun, it was anticipated that several treatments and more than one fly season might be required before changes in the species composition of the fly populations would be apparent. However, within 4 weeks after the dieldrin treatments were applied, housefly indexes manifested an increase. The average emergence level per privy for April was 20 *M. domestica*. In May, it was 193, and in July, 1,374. This rapid rise also was evident in the privies receiving treatments with chlordane, aldrin, and BHC in early fall. These findings weaken the hypothesis that the cause underlying the increased housefly production is associated with a change in the physiological or behavioristic pattern of dieldrin-resistant strains. Other data antagonistic to this premise are apparent in the absence of increased housefly production in the untreated areas where the level of dieldrin resistance was high.

Despite the chemical treatments of the privies in 1954, it does not appear that any fly species was eliminated. In 1953, 97 species, 65 genera, and 33 families were recorded in emergence

Table 1. Average emergence per privy of all fly species and of Musca domestica from treated and untreated privies: 1953 and 1954

Month	All species				*M. domestica*			
	Untreated		DDT	Dieldrin	Untreated		DDT	Dieldrin
	1953	1954	1954	1954	1953	1954	1954	1954
February	142	252	172	208	1	2	1	3
March	79	175	[1] 155	193	3	1	[1] 0	1
April	696	1, 019	494	[1] 792	24	1	1	[1] 20
May	900	468	630	510	10	3	15	193
June	388	352	269	744	20	13	7	254
July	[2]	151	348	1, 903	[2]	5	103	1, 374
August	209	96	107	1, 369	3	16	14	1, 204
September	1, 607	135	226	2, 584	6	10	36	1, 946
October	859	328	1, 000	1, 492	1	7	7	420
November	127	949	146	840	4	27	3	368
December	108	101	118	187	1	3	1	38

[1] Treatments applied. [2] No collections made.

traps. In 1954, 123 species, 76 genera, and 36 families were recorded as coming from both treated and untreated privies. The only flies taken in 1953 and not present in 1954 were of the family Bibionidae, and only token numbers of this group were taken in 1953. Of the specimens collected in 1954, 273,046 flies (38,306 from the untreated areas and 234,740 from the treated areas) were identified; 90,209 were houseflies. Of that number, 88,443 were taken from privies that had been treated with dieldrin, and only 1,766 were taken from an equal number of either DDT-treated (945 houseflies taken) or untreated (821 houseflies taken) privies. The species captured are listed in the accompanying insert (p. 796).

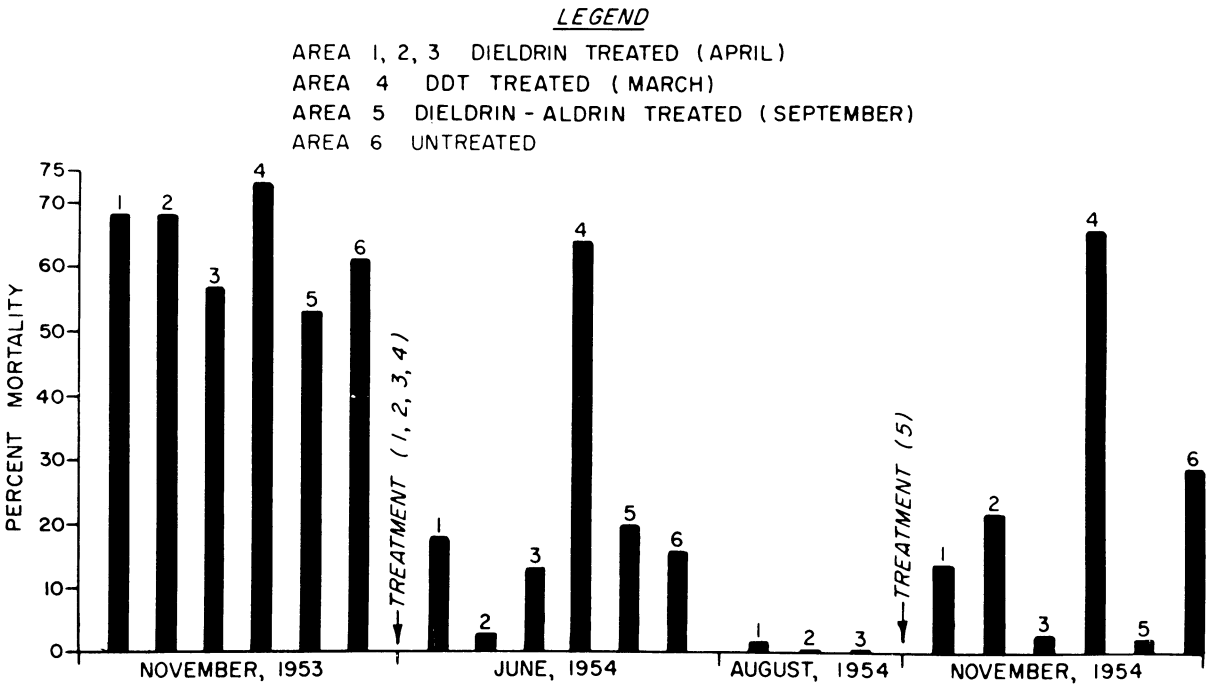
It was noted that in untreated privies larvae of the soldier fly, *Hermetia illucens*, were extremely prevalent, whereas in dieldrin-treated privies they were either absent or present in small numbers. However, in laboratory cultures seeded with *M. domestica* and *H. illucens* together in varying numbers, there appeared to be little or no detrimental effects upon

Table 2. Average emergence of 8 major fly species from untreated (1953) and dieldrin-treated (1954) privies,[1] by months

Month and year	*Musca domestica*	*Dendrophaonia scabra*	*Fannia canicularis*	*Hydrotaea hughii*	*Muscina stabulans*	*Ophyra leucostoma*	*Psychoda alternata*	*Telmatoscopus albipunctatus*
February:								
1953	2	5	32	22	21	5	0	[2]
1954	2	57	31	36	6	2	1	[3]
March:								
1953	3	280	33	20	52	77	3	[2]
1954	[3]	29	8	49	9	8	2	[3]
April:								
1953	4	327	26	25	33	35	14	[3]
1954	10	89	13	10	23	41	7	9
May:								
1953	8	51	2	[3]	38	150	538	29
1954	193	5	2	[3]	14	66	50	8
June:								
1953	20	51	[3]	0	1	89	5	84
1954	254	4	1	[3]	4	122	19	56
July [4]:								
1954	1,374	2	1	0	2	134	29	201
August:								
1953	3	18	0	0	1	15	[3]	75
1954	1,204	[3]	0	[3]	1	16	2	29
September:								
1953	7	11	0	[3]	1	3	7	605
1954	1,946	[3]	[3]	[3]	[3]	6	2	168
October:								
1953	4	7	1	6	[3]	2	23	623
1954	420	[3]	[3]	1	[3]	1	33	149
November:								
1953	4	6	2	10	1	4	6	42
1954	368	[3]	3	4	[3]	1	29	9
December:								
1953	1	21	[3]	27	[3]	1	[3]	7
1954	38	1	13	7	[3]	1	6	1

[1] Dieldrin treatments applied in April 1954. [2] Identified only to Psychodidae. [3] Average is less than 1 fly. [4] No collection made in 1953.

Figure 6. Dieldrin resistance levels in housefly populations in untreated areas: 1953 and 1954.



the survival of either species. Quantitative evaluation of *H. illucens* as a breeder in privies was not obtained since the 3-week trapping period employed was less than the developmental period of this species.

The 1954 data established several additional points:

1. Increased housefly production can be induced by residual treatments of BHC, aldrin, and chlordane as well as by dieldrin applications.

2. Dieldrin treatment of pit contents alone or of riser walls alone augments housefly production.

3. In the same general area of 3 to 4 blocks, treatment of privies selected at random increased housefly production, but untreated privies showed no augmentation.

None of these points defines the factor or factors responsible for the increase in production of *M. domestica*. The possible exclusion of a competitive agent, parasite, or predator is suggested by the last two points above, but little difference is apparent in the types of arthropods frequenting the treated and untreated privies. Both DDT and dieldrin are known to persist for extended periods, yet the effect of each is different on housefly production. In contrast, aldrin, which has little residual action, produced results similar to dieldrin.

Despite the absence of any clear-cut explanation for the phenomenon, it is obvious that treatment of privies with certain chemicals increases rather than decreases housefly production from that source. Since *M. domestica* is the principal house-frequenting species, the chance of disease transmission is likewise augmented. Since untreated privies produce few houseflies, it is apparent that chemical treatment of privies should be avoided.

Further studies are now in progress in an attempt to define the factor or factors responsible for the increase in housefly production in privies treated with various chlorinated hydrocarbons.

Summary

During late March and early April 1954, near Savannah, Ga., 30 privies were treated with dieldrin, 10 privies with DDT, and 20 privies remained untreated. Within 4 weeks the dieldrin-treated privies showed a sharp increase in housefly production. Average monthly indexes per privy were 193, 254, 1,374, 1,204, and

Fly Species Collected in Privy Studies

BORBORIDAE: *Borborus* spp., *Leptocera* spp., *Leptocera ferruginata, L. fontinalis, L. venalicia, Sphaerocera* spp., *Sphaerocera equinus, S. varipes.*

CALLIPHORIDAE: *Calliphora livida, C. vicina, Callitroga macellaria, Cynomyoposis cadaverina, Phaenicia caeruleiviridis, P. cuprina, P. sericata, Phormia regina.*

CHLOROPIDAE: *Ceratobarys culophus, Hippelates pusio, H. bishoppi, H. dissidens, H. flaviceps, Madisa cinerea, Monochaetoscinella nigricornis, Oscinella* spp.

CHIRYOMYIDAE: *Chryomya flava, C. salmarius.*

CULICIDAE: *Aedes vexans, Anopheles quadrimaculatus, A. crucians, Culex quinquefasciatus, C. erraticus, Culiseta melanura, Mansonia perturbans, Orthopodomyia signifera.*

DOLICHOPODIDAE.

DORILAIDAE.

DROSOPHILIDAE: *Drosophila busckii, D. affinis, D. guttifera, D. melanogaster* group, *D. repleta, D. robusta, Drosophila* spp., *Mycodrosophila dimidiata.*

EMPIDIDAE: *Drapetis divergens, Drapetis* spp.

EPHYDRIDAE: *Discocerina brunneonitens, Discocerina* spp., *Gymnopa* spp., *Paralimna decipiens, Scatella stagnalis.*

FUNGIVORIDAE.

HELEIDAE.

HELOMYZIDAE: *Amoebaleria defessa, Diastata ornata, Pseudeleria pectinata, Tephrochlamys rufiventris.*

ITONIDAE.

LAUXANIDAE.

MUSCIDAE: *Atherigona orientalis, Coenosia* spp., *Dendrophaonia scabra, D. querceti, Fannia canicularis, F. femoralis, F. howardi, F. manicata, F. pusio, F. pusio* group, *F. scalaris, Fucellia maritima, F. americana, Graphomya maculata, Hebecnema halterata, Hydrotaea acuta, H. houghii, H. occulta, Hylemya cilicrura, Limnophora arcuata, L. cilifera, Musca domestica, Muscina assimilis, M. aurantiaca, M. stabulans, Ophyra aenescens, O. leucostoma, Schoenomyza* spp., *Scopeuma furcatum, Stomoxys calcitrans, Synthesiomyia nudiseta.*

OMPHRALIDAE: *Omphrale fenestralis.*

OTITIDAE: *Delphinia picta, Euxesta notata, Rivellia* spp.

PHORIDAE.

PHYLLOMYZIDAE: *Desomometopa* spp., *D. m-nigrum, D. tarsalis, D. tibialis, Leptometopa latipes, Milichiella arcuata, M. lacteipennis, Stomosis luteola.*

PIOPHILIDAE: *Piophila* spp.

PSYCHODIDAE: *Brunettia nitida, Phlebotomus vexator, Psychoda alternata, P. severini, Telmatoscopus albipunctatus.*

SARCOPHAGIDAE: *Hypopelta scrofa, Sarcophaga* spp., *S. bullata, S. anandra, S. argyrostoma, S. assidua, S. dereicta, S. floridensis, S. galeata, S. haemorrhoidalis, S. importuna, S. laakei, S. latisetosa, S. morionella, S. ochracea, S. plinthopyga, S. pusiola, S. rapax, S. sarracenioides, S. singularis, S. ventricosa, Sarcophagula* spp., *S. impar, S. salva.*

SCATOPSIDAE: *Scatopse fuscipes, S. notata.*

SCIARIDAE: *Bradysia* spp., *Sciara* spp.

SEPSIDAE: *Meroplius stercorarium, Sepsis punctum.*

STRATIOMYIDAE: *Hermetia illucens.*

SYLVICOLIDAE: *Sylvicola altanatus, S. marginatus.*

SYRPHIDAE: *Meromacrus acutus, Tubifera tenax, T. dimidiatus.*

TENDIPEDIDAE.

TETHINIDAE: *Pelomyia coronata.*

TIPULIDAE: *Mumetopia occipitalis.*

TYLIDAE: *Taeniaptera lasciva.*

1,946 specimens for May through September, respectively. In contrast, average monthly indexes for the same period for DDT-treated and untreated privies were 15, 7, 103, 14, and 36, and 3, 13, 5, 16, and 10 specimens, respectively. Nine privies within a 3- to 4-block area, treated in groups of 3 with BHC, dieldrin, or chlordane, also showed increased housefly production with a low prevalence persisting in 3 adjacent untreated privies. Both aldrin-treated privies and dieldrin-treated privies with only the riser walls or the pit contents sprayed likewise produced increased housefly breeding. A total of 273,046 flies, representing 123 species, 76 genera, and 36 families, were trapped in all privies.

The low level of housefly production in untreated privies and the increased breeding of this species in privies treated with BHC, chlordane, aldrin, and dieldrin indicate that the use of these chlorinated hydrocarbon insecticides for housefly control in privies should be avoided.

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