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Title ATTRACTANT, BEHAVIORAL, AND TOXICOLOGICAL STUDIES OF FANNIA CANICULARIS L. (DIPTERA:MUSCIDAE) IN ASSOCIATION WITH A MINK FUR FARM

Abstract approved [redacted] (Major professor)

Fannia canicularis is concentrated in areas where animal husbandry is practiced and frequently comprises more than 50 percent of the fly population. There is a need for more critical fly control where suburban expansion has invaded animal raising regions. The purpose of this study is to investigate the use of organophosphate insecticides in controlling *Fannia canicularis* associated with a mink fur farm in the Willamette Valley of Oregon. Studies of population dispersal and attractants also were conducted to provide biological information for more efficient control.

Acute and chronic tests of insecticide toxicity to mink resulted in the selection of ronnel, malathion, and dimethoate as being relatively non-toxic to these animals.

Ronnel and dimethoate at one percent concentrations produced rapid knock-down of *Fannia canicularis* held captive in large cages. Residual fly mortality did not decrease rapidly over a two week period. Ronnel was consistently more toxic than

dimethoate. Malathion toxicity was low and resistance indications were present.

Fannia canicularis was not attracted in any significant quantity to a selection of candidate substances using a McIndoo olfactometer.

Blacklights stimulated Fannia canicularis and induced a positive response which decreased as natural lighting increased. There was no attraction under field conditions, and stimulation occurred only when the flies were held in cages of approximately 12 cubic feet or less.

Emergence trap data indicated that mink manure was not a prime breeding area for Fannia canicularis.

Mink manure would not sustain the adult flies in the laboratory and granulated white sugar was required.

A swarming male to female population ratio of 11:1 and a resting population ratio of 1:2 was observed during the day at the mink farm. The total day population was estimated at twice that of the night, there being three times as many males present during the day.

Fannia canicularis is more sensitive to changing air currents than Musca domestica which may account for the erratic flight of the former when swarming.

ATTRACTANT, BEHAVIORAL, AND TOXICOLOGICAL STUDIES OF FANNIA CANICULARIS L. (DIPTERA:MUSCIDAE) IN ASSOCIATION WITH A MINK FUR FARM

by

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INTRODUCTION

The development of man and animals into larger more concentrated populations with more confined habitats has resulted in a parallel increase of populations of medically important arthopods. The best known fly in this group is the housefly, Musca domestica L., whose biology and toxicology has been extensively investigated. Less work has been done on other medically important Diptera including the ubiquitous subfamily Fanniinae (Muscidae). While over 200 species of Fanniinae are found in the Nearctic region (4, p. 5), Fannia canicularis L. predominates in the Northwest and is the subject of this paper.

Fannia canicularis is nearly as cosmopolitan as M. domestica and is found primarily in the Holarctic region of the world. Its range extends north beyond the range of the housefly into Alaska and Iceland. In the Nearctic region, it extends south from Alaska to central Mexico (4, p. 190).

Limited investigations have been conducted on the genus Fannia consisting predominantly of life history studies. Some early biological work was completed by British entomologists (12;13), and a comprehensive study of Nearctic species of the subfamily Fanniinae was completed recently by Chillcott (4). Species within the subfamily were found to be carriers of typhoid bacillus and intermediate hosts of the eye worm, Thelazia californiensis Price (27;4, p. 36).

Fannia canicularis larvae cause 75 percent of human intestinal myiasis and are involved in aural and urinary myiasis (4, p. 192).

The most common problem with F. canicularis is the presence of large populations in areas where animal husbandry is practiced. Swarms gather inside barns, chicken houses, under sheds, and beneath tree canopies. Although they may not associate as intimately with man as does the housefly, the presence of these large populations is irritating and often gives the impression that good husbandry practices are lacking. As a result of the inadequate control measures practiced in many of the animal raising areas, the flies disperse and invade the ever-increasing suburban communities. Suburban expansion will continue to encircle the rural areas in the future, and control of F. canicularis will become increasingly critical.

Various control methods have been utilized in controlling this species. Toxicological investigations have included the use of cords impregnated with a diazinon-parathion mixture (27), various organophosphate and chlorinated hydrocarbon compounds (16), and a variety of poison baits (21). Based on housefly control information, malathion sprays have been commonly used because of low mammalian toxicity. Ronnel, diazinon, and other organophosphates have been employed where husbandry practices permit.

A more complete knowledge of the habits of F. canicularis and of toxic materials is necessary to obtain more efficient control. The object of this study was to add to the limited quantity of biological and toxicological information available concerning F. canicularis and provide a better definition of the problem.

The area chosen for a fly source was the Oregon State University experimental mink fur farm at Corvallis, Oregon. A portion of the toxicological and behavioral studies was conducted there and the remainder in the laboratory. The study was divided into five sections.

The first toxicological study dealt with the use of mink as test animals for the selection of organophosphate insecticides that were relatively low in mammalian toxicity. The method used simulated conditions that might be encountered by extreme exposure to drifting spray from a fly control operation. Observations for acute and chronic toxicity were made. Three promising compounds were selected for testing against F. canicularis. Relative toxicities were determined by holding flies caught at the mink fur farm in cages and exposing them to insecticide-coated wood strips having varying deposit ages.

The responses of male F. canicularis and both sexes of M. domestica to various organic and inorganic materials were studied using a McIndoo olfactometer. Additional observations were made upon the responses of F. canicularis to ultraviolet light.

Field studies within the environment of the mink fur farm were made on the distribution of adults in the habitat, their association with potential larval media, and the adult emergence rates.

Many aspects of the Fannia problem were found to differ markedly from those of the housefly. This study attempts to contribute to a greater understanding of the rather neglected Lesser Housefly by simulating conditions as might be found in a fly control program

where insecticides and mink are involved, and providing a more accurate definition of the bionomics of F. canicularis.

ORGANOPHOSPHATE TOXICITY TO MINK

A review of the literature concerned with laboratory and field tests of insecticides for fly control resulted in a list of compounds of varying toxicity and residue. Results of many of the trials were conflicting particularly where a long-lasting residue was involved. This conflict was due to different climatic areas, the condition of a sprayed surface, insecticidal history of the flies in question, and other local variables. In most cases the flies tested were Musca domestica, all of the other species being members of the family Calliphoridae.

The organophosphates were chosen on the basis of consistent efficiency in knockdown and long-term residual activity. All were emulsifiable concentrates. Their formulas are as follows:

1. Malathion - 0,0 dimethyl dithiophosphate of diethyl mercaptosuccinate. 57% active ingredient - 5 lb./gal.
2. Dimethoate - 0,0 dimethyl S-(N-methylcarbamoylmethyl) phosphorodithioate. 25.7% active ingredient - 2 lb./gal.
3. Co-Ral - 0,0 diethyl 0-3 chloro-4 methyl-2 oxo-2H-1-benzopyran-7-yl phosphorothioate. 11.6% active ingredient - 1 lb./gal.
4. Baytex - 0,0 dimethyl 0-4-(methylthio)-m-tolyl phosphorothioate. 46.1% active ingredient - 4 lb./gal.
5. Ronnel - 0,0 dimethyl 0-2,4,5 trichlorophenol phosphorothioate. 24.5% active ingredient - 2 lb./gal.

Acute Toxicity

Mink were tested to determine their tolerance to the selected organophosphates. The Oregon State University experimental fur farm has fly problems typical of the Willamette Valley during the summer months although management of the sanitary problems is better than that in many other mink farms. These animals were selected because owners consider them to have a low tolerance to insecticides.

Observations were made of the reaction of mink when exposed to sprays of varying concentrations and volumes in excess of that which would ordinarily be encountered during a routine fly control operation. A De Vilbiss spray gun with a #394 nozzle was used for spray application. Output varied from 40 to 45 ml./min. depending on the viscosity of the solution. An electric pump supplied pressure at 17 psi. Distance from the cage containing the animal under treatment to the spray gun was two feet, resulting in utilization of approximately 75 percent of the area covered by the spray pattern.

A phonograph turntable with a cage placed on top rotated the animal at 30 rpm. The cage was about one and one-half times the length of the mink and slightly larger in width and height. It was constructed of 3/4 in. hardware cloth with a sheet metal door, and was placed at the same height as the spray gun (Figure 1).

Eighteen adult female animals were treated, their ages ranging from one and one-half to six and one-half years. Pelt color was standard dark. All were healthy and vigorous with no past record of any unusual habits or sicknesses.

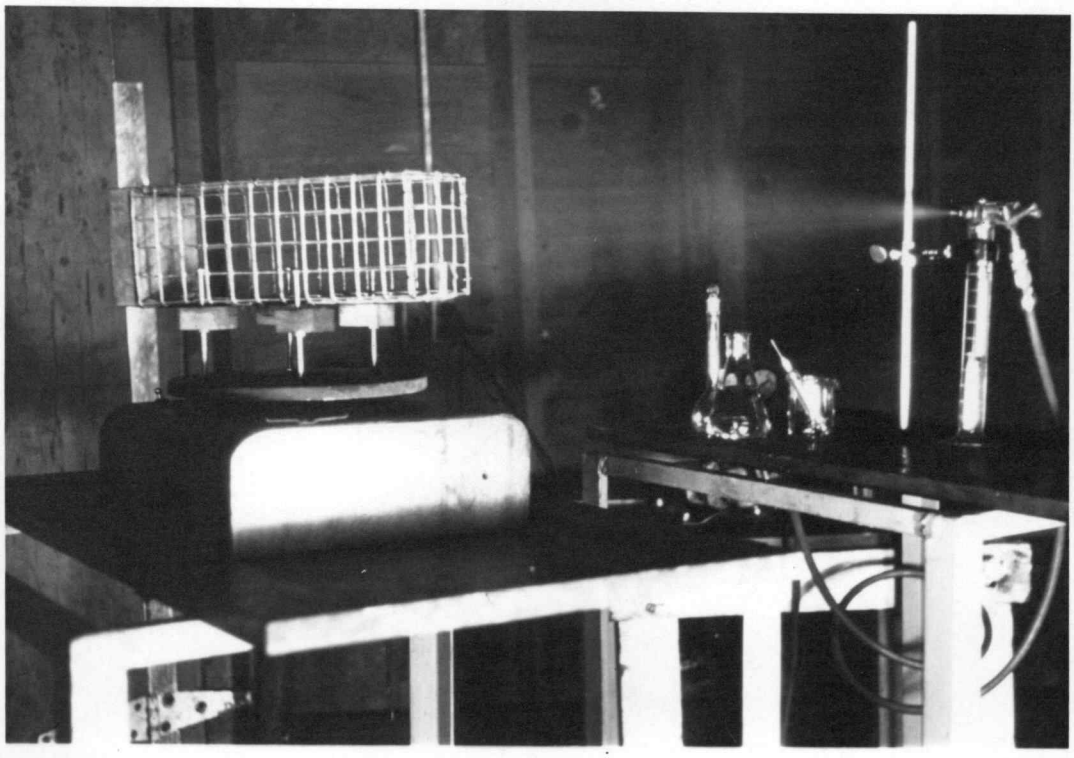


Figure 1. Apparatus used to spray mink with insecticide

One and five percent finished spray formulations were used. They represented a concentration likely to be found on a label recommendation, plus one that was much higher and likely to occur only by miscalculation or careless preparation.

Three rates of application, light, medium, and heavy were chosen to supplement the concentrations. The light rate contained 20 ml. of solution. The tips of the guard hairs clung together and many small droplets were visible. No liquid reached the inner, more downy portion of the pelt. Due to a lesser density, the pelt on the head was wetted closer to the skin. The medium rate contained 50 ml. of material. The skin on the head and part of the neck was soaked. The downy portion of the pelt on the rest of the body became damp but the skin was not wet. The longer, outer guard hairs were matted together in small groups for almost their complete length. The heavy rate of application at 100 ml. nearly drenched the animals and the liquid reached the skin in several areas in addition to the head and neck.

The temperature varied between 40° F. and 55° F. during the trials. This resulted in a minimum evaporation rate from the coats of the animals.

Each mink was placed into a cage, sprayed, and then placed back into its regular cage. They required about one-half hour to return to normal behavior after being handled, rotated, sprayed, and then replaced. No appreciable amount of preening was noticed and the coats were dry in one to two hours, depending upon the rate

of application. Many mink rubbed against the sides of their cages and some rolled in a thin layer of sawdust in their nesting boxes.

The changes looked for following treatment included any difference in appetite, general activity levels, weight gain or loss, and pelt condition.

Light Application Rate

One and five percent finished sprays were applied using two animals at one percent and one at five percent. In the case of Baytex, two animals were exposed to the five percent concentration. Twenty ml. of solution were used and the mink were observed for six days.

None of the pesticides produced any unusual reactions indicative of organophosphate poisoning. Food consumption varied considerably whether the animals were treated or sprayed with water as a control. Although some loss of appetite could be associated with the treatments, the animals remained active and appeared to be in good health. Weight changes were variable with each organophosphate compound (Table I). At least one animal always lost weight after exposure to an insecticide and weight loss ranged up to 130 g. at the end of the six-day period with an average loss of 58 g. for nine treated animals. Three mink showed no change and four gained weight, with an average increase of 22 g. and a maximum increase of 50 g. One control lost weight and the other did not change. The excitement generated by handling and spraying may have been a primary cause of weight loss.

Medium and Heavy Application Rates

The day following the termination of the light application rate, a new program was put into effect using the same animals. Each animal was exposed to the same insecticide. Concentrations of one and five percent were used again and the substitution of a medium application of 50 ml. and a heavy application of 100 ml. were used and the mink were observed for nine days. The additional animal was sprayed again with Baytex and involved the only insecticide where a five percent concentration was applied at a 100 ml. rate.

The insecticide applications resulted in data that clearly indicated their relative toxicity to mink (Table 2). All of the Baytex-treated animals died within four days after exposure. Two of the three animals treated with Co-Ral also died within four days after exposure. The third animal was not affected. One of the three animals treated with ronnel died nine days later with the other showing no effect. None of the malathion, dimethoate, or control animals died or showed any unnatural response.

The symptoms of organophosphate poisoning were similar in all animals and resulted in terminal poisoning. The first symptom to occur was a mild depression. The animal tended to remain in one area of the cage or inside its nesting box. Next, a minor incoordination in the hind legs appeared. Depression and incoordination increased gradually over a 24 hour period. During this time urinary incontinence began and the hindquarters became wet with urine. During the

later stages of the syndrome, depression deepened, the eyes became sunken, and often voice loss occurred. Feeding ceased shortly after onset of the symptoms. Any animal reaching the state of moderate depression and incoordination did not recover. Death occurred between two and nine days depending on the concentration of the insecticide. The effects of urinary incontinence were not unlike the common "wet belly" of mink. Two of the dead animals were necropsied and found to have hemorrhagic gastroenteritis.

The earliest poisoning response came six hours after exposure using Baytex at five percent with a medium and heavy rate of application, and Co-Ral at five percent with a medium volume applied. Otherwise, the symptoms appeared approximately 24 hours after application except in the case of ronnel at one percent and a medium rate of application where it took three days before any difference was noted. This particular animal was sluggish from the start possibly due to being a relatively aged animal of six years.

Weight gains and losses were irregular. One control animal gained slightly and the other remained the same. The Baytex-treated animals which died lost up to 180 g. during the four-day period before death. The Co-Ral-treated animals lost weight in a similar fashion. One of the malathion-treated animals lost 270 g. although its activity did not change. Decreased food consumption did not always result in a loss of weight or correspond to a heavier insecticide application, and in general no correlation could be made.

During pelting, no unusual skin or pelt conditions were noticed on any of the trial animals. Upon being inspected and graded with pelts from other mink on the farm, no noticeable decrease in color or quality was observed. The animals having the pseudo "wet belly" symptoms due to the insecticide received a lower grade as did untreated animals with a true "wet belly" problem.

Baytex and Co-Ral appeared most toxic to mink. Malathion, dimethoate, and ronnel produced no adverse reactions except in the case of one animal treated with ronnel.

Chronic Toxicity

The knowledge of mink tolerance to repeated insecticide applications is needed in order to develop adequate fly control recommendations. In this trial, 12 applications were made on four day intervals using malathion, dimethoate, and ronnel.

Eight male mink were available for use. Two were used for each compound and two for the control. Their color was dark and they were ten months old when the trial began. All were in good health but their pelt condition was poor due to the habit of chewing their fur. Individual mink were housed in a wire cage 2 ft. x 2 ft. x 3 ft., and all were kept in a closed shed illuminated by indirect sunlight coming through windows.

The methods and equipment used in the acute toxicity tests were repeated. Fifty ml. of two percent finished spray was applied to each animal which was far in excess of that caused by drift in a

normal field operation. At this volume, all of the pelt surface became wet, the guard hairs clung together, and the skin on the face was soaked. However, the inner portion of the rest of the pelt remained dry.

During the seven weeks, no animals showed any organophosphate poisoning symptoms or other abnormalities. Weight gains became excessive due to overfeeding and during the fourth week the daily ration was reduced (Table 3).

Summary

A preliminary light application rate of five organophosphate insecticides at concentrations of one and five percent resulted in no toxicity symptoms in any of the test animals.

This test was immediately followed by a medium and heavy rate of application to the same animals using identical concentrations. Dimethoate and malathion did not produce organophosphate toxicity symptoms, and ronnel was non-toxic to two of three mink tested. All of the Baytex, two of three Co-Ral, and one of the ronnel-treated mink died within nine days. The surviving animals remained in good condition; they were active and healthy from all appearances. The majority of the surviving animals lost weight, the average loss being 60 g.

Selecting dimethoate, malathion, and ronnel, these were applied to additional mink to gain knowledge of chronic toxicity symptoms. Medium-rate spray applications were used every four days for seven weeks. No toxic symptoms or weight loss occurred during this period.

The acute and chronic toxicity tests indicated that dimethoate, malathion, and ronnel were safe for controlling flies at a mink fur farm when extremely heavy sprays were applied to the mink. Further testing for toxicity to Fannia canicularis was conducted using these compounds.

TABLE 1. WEIGHT CHANGE AND TOXICITY TO MINK FOLLOWING A LIGHT APPLICATION RATE OF INSECTICIDES

	Liquid Volume Applied (ml.)	Pretreatment Weight (grams)	Weight Gain or Loss (grams)	Toxicity
Baytex				
1%	20	1430	-20	none
1%	20	1160	0	none
5%	20	1080	-130	none
5%	20	1220	0	none
Co-Ral				
1%	20	1110	-50	none
1%	20	950	-50	none
5%	20	1060	-80	none
Ronnel				
1%	20	840	0	none
1%	20	1060	-90	none
5%	20	1330	50	none
Dimethoate				
1%	20	1350	-30	none
1%	20	820	20	none
5%	20	1140	10	none
Malathion				
1%	20	1150	10	none
1%	20	1150	-30	none
5%	20	810	-40	none
Control				
#1	20	1200	-10	none
#2	20	1230	0	none

TABLE 2. WEIGHT CHANGE AND TOXICITY TO MINK FOLLOWING A MEDIUM AND HEAVY APPLICATION RATE OF INSECTICIDES

	Liquid Volume Applied (ml.)	Pretreatment Weight (grams)	Weight Gain or Loss (grams)	Toxicity
Baytex				
1%	50	1410	-180	Terminal Poisoning
1%	100	1160	-100	Terminal Poisoning
5%	50	1220	-170	Terminal Poisoning
5%	100	950	-60	Terminal Poisoning
Co-Ral				
1%	50	1060	-30	none
1%	100	900	-90	Terminal Poisoning
5%	50	980	-140	Terminal Poisoning
Ronnel				
1%	50	970	-270	Terminal Poisoning
1%	100	840	20	none
5%	50	1380	-50	none
Dimethoate				
1%	50	840	-10	none
1%	100	1320	-30	none
5%	50	1150	50	none
Malathion				
1%	50	1120	-270	none
1%	100	1160	-10	none
5%	50	770	-20	none
Control				
#1	50	1190	50	none
#2	100	1230	0	none

TABLE 3. WEIGHT CHANGE AND TOXICITY TO MINK FOLLOWING A MEDIUM APPLICATION RATE OF INSECTICIDES DURING A TIME INTERVAL OF SEVEN WEEKS

	Liquid Volume Applied (ml.)	Pretreatment Weight (grams)	Weight Gain or Loss (grams)	Toxicity
Ronnel				
2%	50	1470	150	none
2%	50	1470	260	none
Dimethoate				
2%	50	1390	350	none
2%	50	1440	480	none
Malathion				
2%	50	1480	330	none
2%	50	1460	310	none
Control				
#1	50	1490	140	none
#2	50	1530	180	none

ORGANOPHOSPHATE TOXICITY TO *FANNIA CANICULARIS*

The objective of these tests was to determine the relative toxicity of three organophosphates to *F. canicularis* held in large cages. These cages supported insecticide-coated wood strips to simulate structures recently sprayed with one of the candidate insecticides. These tests were considered an intermediate step between laboratory toxicity studies and practical field trials. They were undertaken to provide preliminary information on the effectiveness of malathion, dimethoate, and ronnel under conditions resembling those encountered in the field.

Each insecticide was formulated at one percent and one-half percent from commercial emulsifiable concentrates containing 24.5 percent ronnel, 57 percent malathion, or 43.5 percent dimethoate.

Six wooden cages were constructed using cheesecloth on the top and sides (Figure 2). Ample room was available for the flies to hover and fly in an apparently normal manner. Each cage was placed on heavy paper which was changed regularly. Granulated white sugar and a paper water-wick were available on the floor for the flies. Four strips of 3/8 x 1 x 12 inch plywood were suspended vertically from a horizontal bar in the top of the cage. Two of the strips were adjacent to opposite sides of the cage, and the remaining two divided the horizontal bar into thirds. The strips were placed inside the cages through slits in the cheesecloth which were then taped closed. They offered a resting place for the flies in addition to the sides of the cage. This

Figure 2. Cage containing wooden strips coated with insecticide

was an attempt to make use of the habit of resting on linear surfaces found commonly in F. canicularis and other fly species.

Four strips of wood were sprayed with each insecticide at each concentration. A DeVilbiss spray gun was used and all sides of the strips were sprayed until run-off occurred. Those strips being tested for toxicity at a deposit age of zero days were placed in the cages within half an hour. The strips to be exposed to the flies after an interval of 1 to 14 days were taken to the Oregon State University mink fur farm where they were strung up inside the sheds to be exposed to actual field conditions. Presumably any residue changes would be similar to those that would occur upon spraying the inside of the sheds themselves. Two replications were made of each insecticide concentration and deposit age.

Insecticide-free specimens of F. canicularis, consisting of approximately 90 percent males, were caught with a net at the mink farm and placed in gallon jars. Each jar was placed inside a cage, the top removed, and shaken until the stronger, more healthy flies had escaped leaving the weaker ones inside the jar. At least 100 flies were always released into each cage. Carbon dioxide was not used to make an accurate count of the flies placed in a cage because of variable recovery from this gas. Mortality counts, which included moribund flies, were made after intervals of 1, 2, 4, 8, 24, and in a number of cases, 48 hours.

When unsatisfactory results with malathion occurred, additional tests were conducted with this material using flies that were

considered relatively free from a history of association with organophosphate insecticides. Unfortunately, a population of flies with a known history of pesticide exposure was not available. The additional flies were used both for cage trials with malathion and a more standard method for testing for resistance of flies to insecticides. This method involved using wide-mouth pint jars coated with an acetone solution of the technical grade insecticide. The concentrations used were 1.0, .5, .1, and .05 ppm, with two ml. placed in jars which were rotated until dry. After half an hour, 20 F. canicularis were placed in each jar, the screen tops replaced, and a piece of cotton soaked in sugar-water placed on top of the screen for food. Carbon dioxide was used to anesthetize the flies. F. canicularis are very sensitive to carbon dioxide and extra care was necessary to insure complete recovery. The temperature varied between 76° and 82° F., and the relative humidity remained at 50 percent. An overhead incandescent light remained on during the first three hours of each trial.

An additional test was conducted, using malathion and ronnel, to observe the mortality rate of a malathion resistant strain and a susceptible strain of male and female M. domestica. Each strain was placed separately in the large cages containing wooden strips with insecticide concentrations of one percent and a zero-day deposit age. The purpose was to make a comparison of their mortality to that of F. canicularis when the latter was exposed to the same insecticides from previous tests.

All tests involving the cages were conducted inside a building with lighting from sunlit windows and incandescent lights. The flies were kept in darkness during the night and the temperature never dropped below 50° F.

All results were corrected for control mortality by using Abbott's formula resulting in the use of the term "adjusted percent mortality" on graphs (24, p. 86).

Results

Ronnel and dimethoate, at a concentration of one percent, produced a greater kill of F. canicularis through the 14-day deposit age than was found in the control cages (Figure 3). Ronnel killed at least 90 percent of all flies except in the case of the deposit age of two to three days, where the mortality rate fell to 85 percent. The time length before the final mortality count was made was extended to 48 hours after the deposit age of four to five days was reached. Only in the case of the 14 to 16-day deposit age was this extension needed for the mortality to reach 90 percent. It took several hours longer for a high mortality level to be reached after the seven to nine-day deposit age as shown by the shift of the curve to the right. Ronnel always resulted in a higher and more rapid mortality of flies than dimethoate or malathion.

Dimethoate killed 45 percent to 90 percent of F. canicularis at one percent concentration. The mortality rate was variable and did not decrease proportionately as the interval between spraying

and exposure increased. It always took a longer period of time for dimethoate to achieve the same mortality as ronnel at the same concentration.

Results of tests with pesticides at concentrations of one-half percent indicated that although the last mortality count was extended to 48 hours after the two-day interval, 65 percent or more of the flies were always killed by the 24-hour count and more than 80 percent by the 48-hour count using ronnel (Figure 4). After the seven-day trial, the curves shifted to the right indicating a greater length of time needed for obtaining a given mortality rate as the deposit age increased. Dimethoate did not produce the large mortality levels as rapidly as did ronnel in all but the ten-day deposit age. In most cases, the difference in mortality levels between ronnel and dimethoate was greater at the one-half percent concentration than at the one percent concentration. The mortality rate varied from 50 percent to 90 percent. In general, the mortality difference between the one-half percent and one percent dimethoate concentration was greater than that of ronnel at each deposit age.

The exposure time required for 50 percent mortality at each deposit age was estimated for both ronnel and dimethoate at concentrations of one and one-half percent (Figures 5 and 6). At each deposit age dimethoate required at least twice the time of ronnel to reach 50 percent mortality except in the 14 to 16-day deposit

age where they were equal. Dimethoate did not kill 50 percent of the flies in the 10 to 12 day deposit age trial.

At one-half percent concentration, dimethoate again took longer to produce a 50 percent mortality and the differences were greater than the one percent concentration.

One percent malathion did not achieve better than a 25 percent kill at zero to one or one to two-day deposit age. For this reason, further testing of malathion along with ronnel and dimethoate at one percent and one-half percent concentrations was terminated. Instead, tests were conducted separately using the same facilities and an additional malathion concentration level of two percent. Malathion at zero to one-day deposit age and one-half, one, and two percent concentrations resulted in a kill slightly over 30 percent after 24 hours exposure to a zero to one-day deposit age (Figure 7). An alternate fly source, comprised of F. canicularis from an area where organophosphate insecticides had never been used, resulted in an average kill of 50 percent which was still very low.

The ronnel-treated strips of wood that were protected with a wire screen killed 75 percent of F. canicularis in 24 hours (Figure 8). The wire screen alone resulted in approximately the same amount of mortality as the control, and treated strips without protection killed 95 percent of the flies. This illustrates the fumigant action of ronnel when placed in close proximity to the flies.

When F. canicularis was placed in jars coated with insecticide, both ronnel and dimethoate produced a 90 percent or better kill at

1 ppm and .5 ppm (Figure 9). The mortality rate dropped considerably at lower concentrations. Ronnel also produced a greater mortality rate per unit of time than dimethoate. However, the malathion mortality level remained at approximately 33 percent at 1 ppm and .5 ppm, agreeing with low mortality levels as found by using the cages.

When placed in the large cages, the M. domestica strain resistant to malathion reached a mortality of 40 percent in 48 hours when exposed to malathion, and a 95 percent level when using ronnel (Figure 10). The susceptible strain was killed up to a 95 percent level using both insecticides and the mortality per unit of time was higher (Figure 11).

M. domestica rested on the wood strips in much greater numbers and for longer periods of time than F. canicularis. In the latter, about 10 percent of the population might be resting on the strips while the others were flying or resting on the cage sides. With M. domestica, as high as 60 percent of the flies remained on the wood during the night.

Summary

Ronnel appears to produce high mortality levels at both a one percent and one-half percent concentration. There was no large decrease in kill over a 14-day interval between spraying and exposing the flies, although as the deposit age increased it took longer to reach the previous mortality levels. Ronnel was superior to dimethoate in rate of mortality, total mortality, and in toxicity of both the one and the one-half percent concentrations.

Malathion was relatively non-toxic to F. canicularis from the mink fur farm and from an alternate source. Increasing the concentration to two percent made no difference in the total mortality.

A fumigation effect occurs and accounts for much of the fly kill during a zero to one-day deposit age trial using ronnel. How important this factor is when spraying is done in the field and when considering the hovering characteristic of F. canicularis males is not known.

M. domestica were attracted to the wooden strips in large numbers and this accounts for much of the large and rapid kill with both ronnel and malathion. The ronnel mortality rate was lower in the malathion resistant strain and the total mortality with malathion was less than half that of the susceptible strain. From these results, some similarity may be seen with the lack of kill of F. canicularis using malathion and the large mortality with ronnel and dimethoate (Table 4). Quite possibly malathion has either a low toxicity to F. canicularis or resistance has developed in this population of the species. The mink fur farm has been sprayed with malathion several times each summer during the last five years, and it is possible that resistance has developed in F. canicularis.

The results of these tests are dependent upon the age of the flies, their handling, their general activity, and the contamination of the cages with insecticides. Nevertheless, these cages with their wooden strips do offer a convenient intermediate step between laboratory and field, and enable the investigator to distinguish knock-down effect,

residue activity, fumigant activity, and resistance indications. The relative effectiveness of two or more pesticides can be studied along these lines.

Figure 3. Percent mortality of F. canicularis at insecticide concentrations of one percent with increasing deposit age.

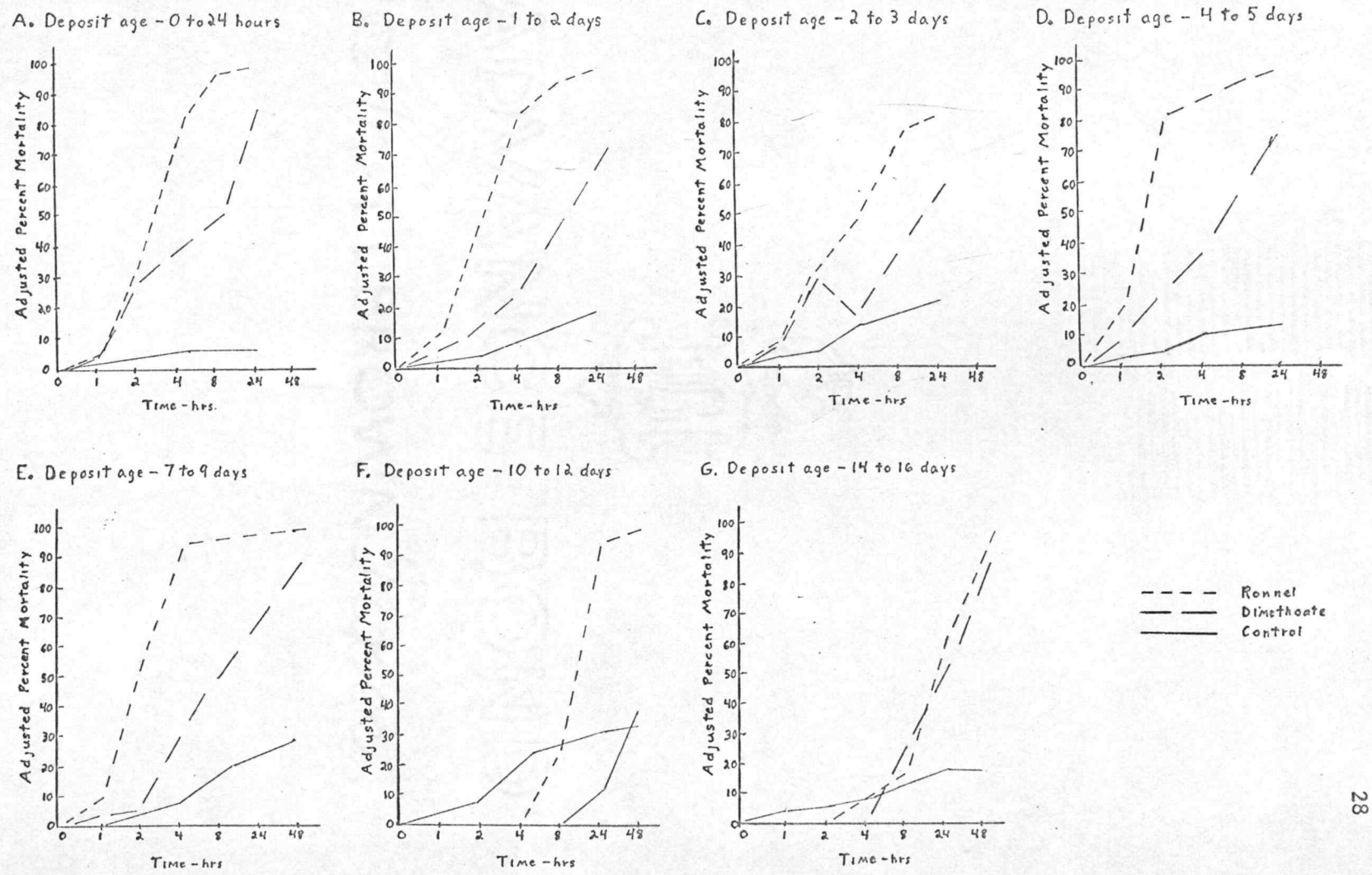


Figure 4. Percent mortality of F. canicularis at insecticide concentrations of one-half percent with increasing deposit age.

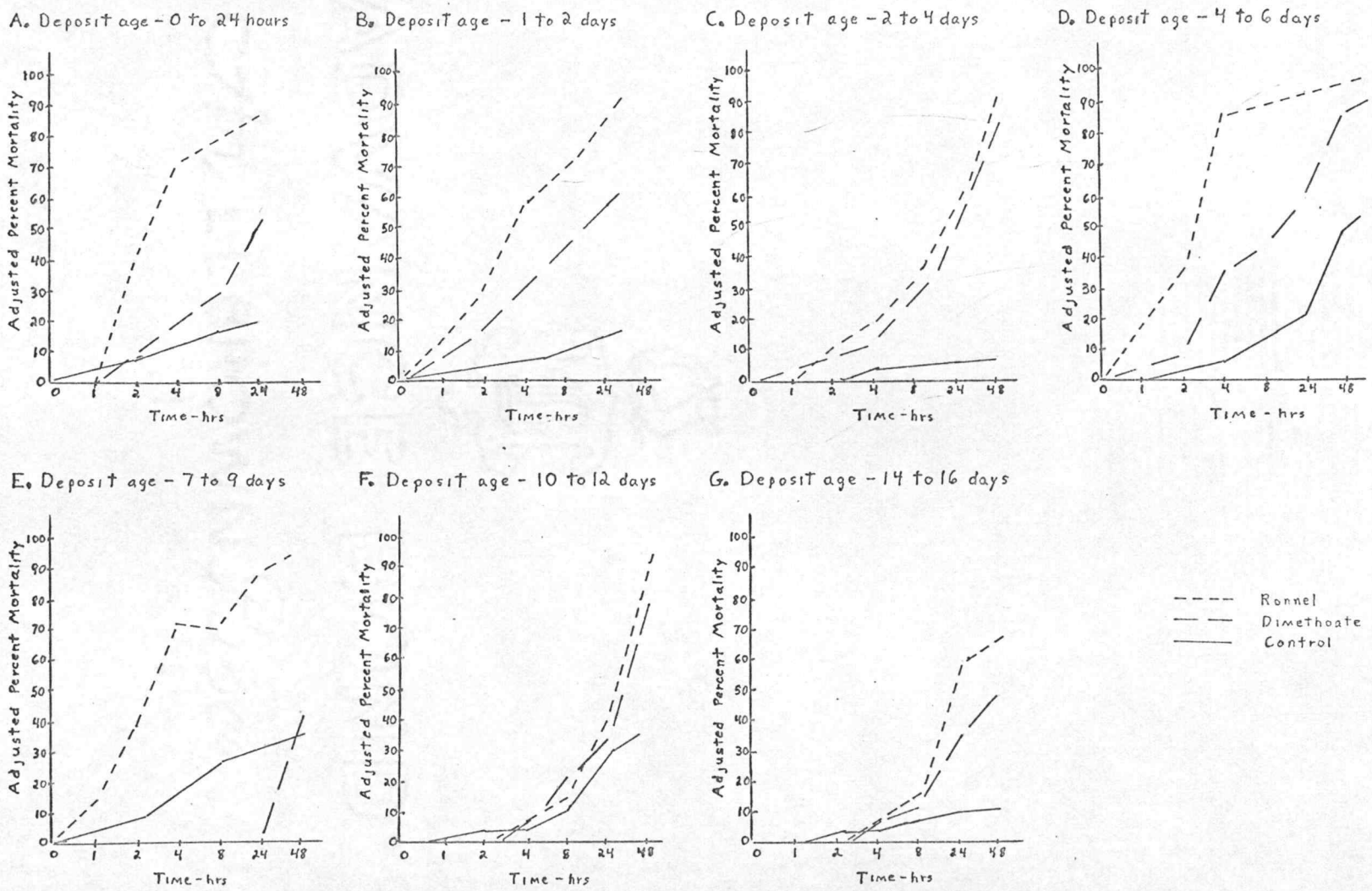


Figure 5. Exposure time for 50 percent mortality of F. canicularis at an insecticide concentration of one percent.

Figure 6. Exposure time for 50 percent mortality of F. canicularis at an insecticide concentration of one-half percent.

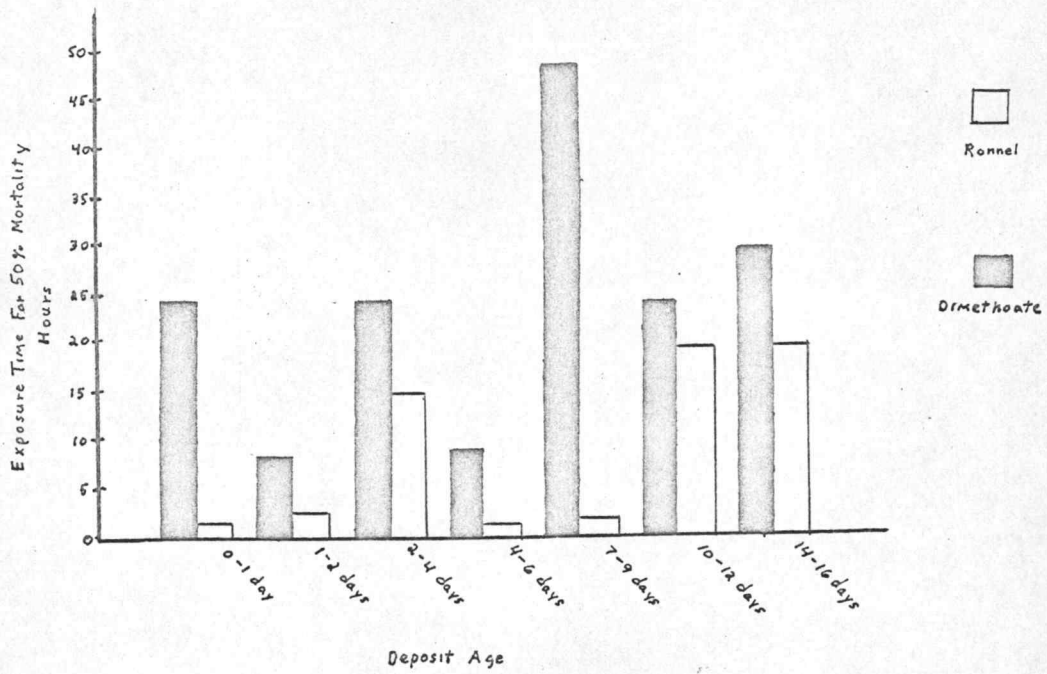


Figure 7. Percent mortality of F. canicularis with various malathion concentrations at zero to one-day deposit age.

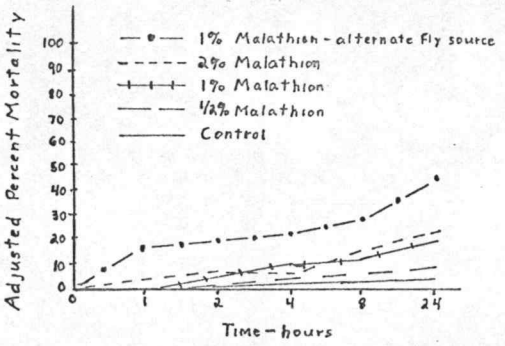


Figure 8. Percent mortality of F. canicularis testing the fumigant characteristic of ronnel concentrations of one percent.

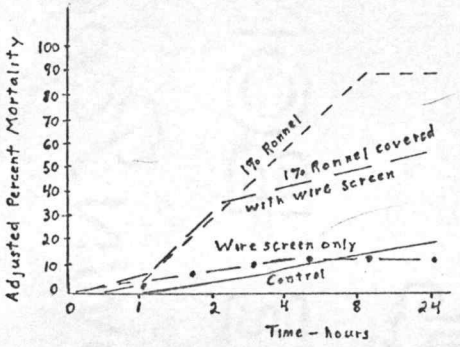


Figure 9. Percent mortality of F. canicularis using jars coated with acetone solutions of insecticides.

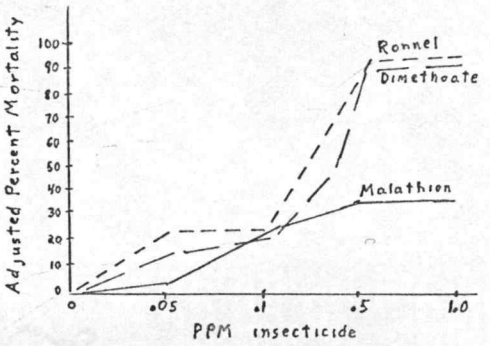


Figure 10. Percent mortality of M. domestica resistant to malathion using ronnel and malathion at a concentration one percent.

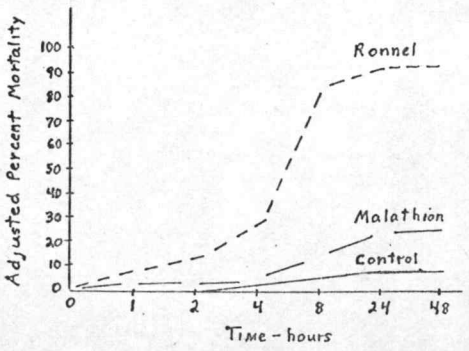


Figure 11. Percent mortality of M. domestica susceptible to organophosphates using ronnel and malathion at a concentration of one percent.

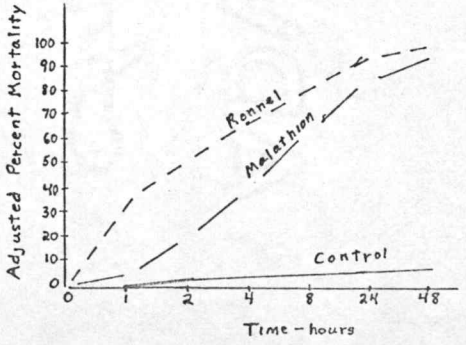


TABLE 4. PERCENT MORTALITY OF *F. CANICULARIS* AND MALATHION RESISTANT AND SUSCEPTIBLE STRAINS OF *M. DOMESTICA* USING ONE PERCENT CONCENTRATIONS OF RONNEL AND MALATHION[1]

Organism	Malathion 1%	Ronnel 1%	Control
F. canicularis			
From Mink Fur Farm	6	100	10
From Mink Fur Farm	27	97	14
Alternate Source	50	99	14
M. domestica			
Resistant Strain	32	98	11
Susceptible Strain	91	99	10

1. Deposit age was zero to 24 hours and percentages represent readings taken at the 24 hour period.

FLY ATTRACTANTS

Experiments were conducted to test selected materials for possible attractant properties when exposed to Fannia canicularis. As a comparison, Musca domestica, the common housefly, was subjected to the same test conditions. Considerable work has been done with housefly attractants and many were chosen for testing. The substances known to invoke positive responses in the housefly and substances whose ability to stimulate was unknown, were then exposed to both M. domestica and F. canicularis.

Two methods of exposing the flies to candidate materials were chosen. The main emphasis was placed upon the use of a McIndoo olfactometer and all of the compounds were presented to the flies in this manner (8;18). The second method involved the placement of animal and plant materials in the olfactometer cage allowing the flies to come in direct contact with the materials in addition to the usual exposure to air that has been passed over the candidate materials.

The McIndoo olfactometer consists of a plywood cage two feet square and one foot high supported on four short legs (Figure 12). Two small holes, for 1/4 in. diameter rubber tubing, were drilled through the bottom of the cage and positioned eight inches apart and equidistant from opposite sides. A thin metal disk 1 1/2 in. in diameter and elevated 1/8 in. off the cage bottom was placed above each hole to provide a uniform air stream dispersion. A

wire screen covered the top of the box. An air compressor with a variable output control pumped air through a bottle containing water. From there, part of this humidified air flowed through a bottle containing the candidate material and the remainder through another bottle containing water used as the control so that the flies are offered a choice. Each was connected to one of the holes in the bottom of the cage by a combination of glass and rubber tubing. Flies were introduced through a side door.

Light was supplied from above by an incandescent bulb and varied from 3 to 20 foot candles, the central areas being at high intensity and decreasing as measurements were made in peripheral regions of the olfactometer cage.

Temperature in the cage remained between 75° F. and 80° F. and relative humidity remained near 55 percent during the tests.

Candidate materials were samples of different chemical groups of inorganic and organic nature. Some were chosen because they were protein and fat decomposition products common around animal habitats. Others were chosen as representative plant products. Due to the number of substances in these categories, it was difficult to pick a limited number to be tested, the choice often depending upon the availability of the substances.

Varying amounts of each compound were diluted with either 30 ml. or 100 ml. of water, a humidified air stream bubbled through, and the resulting gaseous mixture pumped into the cage. There was always one concentration considerably below that which could be detected by

the operator, and at least one concentration that was detectable. A few solids with no apparent odor to the operator were placed inside the cage where visual and physical contact would be possible. Animal and plant materials were exposed both for odor and visual and physical contact as explained earlier. At least one hour was allowed between exposure to different candidate materials, and 15 minutes separated each of four exposures to a given material. A container of granulated sugar and a jar of water with a paper wick were always available for the flies.

A swarming population of F. canicularis at the Oregon State University mink fur farm was used as the source of experimental material. These flies consisted of 90 percent or more males of unknown age. The same population of 150 were used in each of four exposures to a material and several materials were used during a given day. A new population was utilized each day.

A similar number of five-day old M. domestica was also employed. They were a susceptible strain obtained from the toxicology laboratory of the Department of Entomology at Oregon State University.

A lack of response implied that either no flies came near the opening corresponding to the candidate material, or if they did none stopped longer than ten seconds. A positive reaction indicated that varying numbers congregated around the opening, and although many may not have remained much longer than ten seconds, there was always a constant group present. For example, .1 g. of Skatole in 30 ml. of water resulted in a range of from three to five M. domestica out of

Figure 12. McIndoo olfactometer

150 congregating around the metal disk over the odor-producing outlet. This means that after four exposures were made, the minimum to be attracted was three flies and the maximum was six during the two minutes of each exposure.

Results

The resulting response ranges in the candidate substances are tabulated in table five. A dash under the control column indicates that no control was present as an alternate choice when a material was placed inside the cage.

I. Protein and Fat Decomposition Products

A. Protein

1. Skatole - An odor of putrefaction is produced from this heterocyclic compound. It has been found to attract sheep blowflies and species of Sarcophaga (8, p. 111), among others. Skatole was found to produce a positive reaction only in houseflies, and in this case it was with .1 g. in 30 ml. of water. Three to five flies were attracted.

2. Casein - A protein found in milk, this compound is attractive to fruit flies and some moths (8, p. 181). When several drops of hot water were deposited on this solid and

the container placed inside the olfactometer cage; there was no reaction.

3. Ammonium Phosphate Hydrolysate - A common lure for fruit flies (8, p. 118), this product produced no reaction.

B. Fatty Acids

1. Butyric Acid - This is a product found in sweat and barnyard manure. It is known to be an attractant for several fly families including Muscidae, Sarcophagidae, Calliphoridae, and Anthomyiidae (8, p. 115). Butyric acid did not attract F. canicularis but it did produce a positive reaction in M. domestica. The concentrations of .05 ml. and .1 ml. in 30 ml. of water resulted in a consistent attraction of three to five houseflies.

2. Valeric Acid - A material found in manure, this acid is known to have attractant qualities for several fly families including Muscidae (8, p. 115). No positive reactions were obtained in this study.

3. Oleic Acid - A known attractant for certain moths (8, p. 181), this compound did not produce a reaction.

4. Lactic Acid - A product of milk fermentation and other common substances, it has been found to attract Calliphoridae in particular (8, p. 115; 19). There were no positive reactions in either M. domestica or F. canicularis in this study.

5. Acetic Acid - A commonly occurring acid found attractive to fruit flies and certain moths (8, p. 114), this compound did not produce any response.

II. Essential Oils

A. Camphor - A well-known oil of certain plants, this compound is also known to be a repellent (8, p. 207). No positive responses were produced.

B. Geraniol - This distillate of oil of citronella is well known for its specific attracting ability for the Japanese Beetle (8, p. 176). No positive responses were produced in testing with flies.

C. Cymene - A component of caraway oil, this compound did not produce any reaction.

D. Furaldehyde - Similar in odor to benzaldehyde, which is a common compound eminating from certain

crushed plants, this oil did not produce any reaction.

E. Amyl Salicylate - An experimental repellent to M. domestica (8, p. 223), this oil did not have any attractive properties.

F. Limonene - An attractant for the codling moth (8, p. 91), this oil did not produce any positive reaction.

III. Inorganic Compounds

A. Hydrogen Sulfide - A decomposition constituent in habitats such as manure and stagnant ponds, this common gas has been found to attract a variety of flies usually when in combination with other products of animal decomposition (8, p. 106; 25). A positive response was not obtained with hydrogen sulfide under the conditions of this experiment.

B. Carbon Dioxide - Conflicting reports as to the attractant capabilities of this gas to Muscidae and Calliphoridae had been reported by researchers, and later work showed CO_2 as being almost completely unattractive (29; 8, p. 117). Positive reactions were not found with the flies tested in the olfactometer.

C. Ammonium Carbonate - This is perhaps the best known attractant for insects associated with decaying plant and animal materials. It is commonly used

to induce oviposition by M. domestica and tests conducted in this study produced the same results. An ammonia odor forced into the olfactometer gave very apparent positive reactions at all concentrations when using M. domestica. The maximum amount of these flies that congregated around the outlet numbered between 35 and 40. Curiously enough, from two to five houseflies were also attracted to the air flow used as the control. F. canicularis was not attracted to ammonia in any case.

D. Ammonium Sulfate - A considerably reduced attractive response as compared to ammonium carbonate was produced, with two to five M. domestica congregating around the air outlet. Concentrations of .1 g. and .5 g. in 30 ml. of water were the only mixtures to produce these results. F. canicularis was not attracted.

E. Sodium Hydroxide - Found to be attractive to a Calliphoridae species (8, p. 113), this compound did not produce any positive results.

F. Hydroxylamine Hydrochloride - No response was recorded for this compound.

IV. Sugars

A. Molasses - Commonly used in bait mixtures, only M. domestica responded to molasses. A solution of 15 ml. molasses diluted with 15 ml. of water resulted in a positive response to the material whereas a more dilute concentration did not. When this mixture was made available by placement inside the olfactometer, it gave a positive response in that three to four flies were attracted compared to four to eight when only the odor was forced into the cage. A two-week old fermented mixture consisting of 15 ml. molasses, 30 ml. water, and 2 g. yeast, also was placed inside the cage. It produced a positive reaction drawing three to five flies, but the number was not greater than that due to a nonfermented mixture.

B. Granulated White Sugar - When dissolved in water and exposed to the air stream, no reaction occurred in either fly species. Sugar granules placed inside the cage attracted both M. domestica and F. canicularis in

numbers of 15 to 20 and seven to ten, respectively. However, a solution of 10 g. of sugar and 30 ml. of water attracted only M. domestica and then in reduced numbers of three to four.

C. Granulated Brown Sugar - Exposure to F. canicularis did not produce a response. 10 g. placed inside the cage gave a positive reaction of three to four M. domestica, but when diluted with water no response occurred. A fermented mixture of 10 g. brown sugar, 30 ml. water, and 2 g. yeast, resulted in a positive reaction consisting of two to three houseflies.

D. Lactose - When several drops of water were placed on a portion of this sugar and placed inside the cage, only M. domestica responded positively. From two to four flies congregated around the container primarily where the water was located. Possibly the contrast of the solid and liquid or the water itself was the main attracting stimulus, although water was available adjacent to the lactose.

E. Peptose - No reaction occurred when placed in the olfactometer cage.

V. Plant Materials

A. Fescue (*Festuca* sp.) - This common range grass was chopped while in a green and growing condition. The volatile components were forced into the olfactometer, and both *F. canicularis* and *M. domestica* responded. The former gathered in numbers of four to six and the houseflies from three to five. When the fescue was placed inside the cage, similar reactions occurred in both fly species. Silage, made by the addition of molasses to pint jars of chopped fescue and allowed to ferment for one month, did not result in a reaction for either species.

B. Pigweed (*Amaranthus retroflexus*) - Pigweed did not produce any response when the odor of the freshly chopped green plant or ensiled material was introduced. The same results occurred when these materials were placed inside the cage.

C. Cabbage - Air stream exposure and actual contact with the freshly chopped leaves produced no response.

D. Peach - Fresh peach exposed to the air stream and placed inside the cage did not cause a positive fly response.

E. Banana - Freshly mashed banana caused a positive response only in M. domestica and then only when placed inside the cage. A small number of houseflies, two to three, were always present on the banana.

F. Celery - Freshly chopped celery produced no response from either fly species.

G. Carrot - Freshly chopped carrot produced no response from either fly species.

VI. Animal Materials

A. Ground Beef - F. canicularis did not respond to ground beef. However, M. domestica reacted to both the volatile components and the presence of meat inside the olfactometer. The greatest numbers of flies, seven to eight, accumulated on fresh rather than on spoiled meat. The fresh meat also attracted slightly more houseflies.

B. Tuna Fish - Canned tuna fish odors mixed with the air stream and the presence of tuna fish in the cage did not produce a positive fly response.

C. Human Urine - No reactions were observed when the two fly species were exposed to an air stream passed through urine.

D. Mink Manure - The odor of fresh manure produced a small positive response in M. domestica but not in F. canicularis. When placed inside the cage, both species were attracted and 15 to 20 M. domestica and five to six F. canicularis were found on the manure. When the manure was allowed to age for one day, nearly identical numbers of both species were attracted. When allowed to age in the open air for one week, the numbers of flies attracted were reduced to five to six M. domestica and two to three F. canicularis.

E. Aphid Honeydew - A report of Fannia being attracted to aphid honeydew (4, p. 33) prompted the collecting of maple leaves covered with heavy amounts of honeydew. Sections of leaves were placed in the cage but no responses were observed in the case of F. canicularis or M. domestica.

F. Flies - Whole males and females of both species were crushed separately and placed inside the olfactometer cage. Male F. canicularis and M. domestica were exposed to the crushed flies of their corresponding species.

A. F. canicularis, male, crushed - No positive reaction occurred.

B. F. canicularis, female, crushed - No positive reaction occurred.

C. M. domestica, male, crushed - Positive responses occurred and three to six male houseflies were attracted.

D. M. domestica, female, crushed - Positive responses occurred and six to seven male houseflies were attracted, a larger number being attracted than to crushed males.

VII. Miscellaneous Materials

A. Coumarin - An organic compound with the odor of freshly cut hay, this material did not produce any positive reaction when placed inside the cage.

B. 8-Quinolinol - No responses resulted from this compound when placed inside the cage.

C. Commercial Fertilizer (6-16-0) - No positive responses were observed when the fly species were exposed to this material.

D. Iso Amyl Alcohol (99%) - No responses were observed when the fly species were exposed to this alcohol at different concentrations. This compound, at a concentration of four percent,

has been found to attract species of *Calliphora* and *Sarcophaga* (22).

E. Ethyl Alcohol (75%) - Positive responses were not observed using this alcohol in the olfactometer.

F. Soya Bean Oil - One ml. of this oil, when used as a coating on the inside of the test bottle, produced positive responses in *M. domestica* but not *F. canicularis*. From 4 to 20 houseflies were attracted. The control outlet of humid air attracted an inconsistent number of houseflies, varying from one to six.

VIII. Flavor Compounds

A. Fritzsche Brothers - Aromatic extracts #36693, #39172, and #39173 did not produce any responses.

B. Vico 400 Fermentation Flavor - A positive response resulted only with *M. domestica* when 1 g. and 30 ml. of water were mixed. Two to five houseflies responded.

C. Vico 55-11 Pet Food Appetizer - No positive responses were observed.

Summary

A variety of selected materials were tested as attractants for F. canicularis using a McIndoo olfactometer and responses were generally lacking. The materials causing positive responses were manure of varying ages, chopped fescue, and granulated white sugar. In these cases, the flies were only attracted to a limited extent. Granulated sugar is a standard food for flies when kept under artificial conditions, and appeared to be attractive only when placed inside the cage in its solid form. Freshly chopped fescue attracted F. canicularis both from its odor and from visual and odor contact, with small numbers being drawn in each case. Mink manure drew these flies when placed inside the cage in a fresh and day-old condition. Again, the number of flies was small. Manure that was one week old drew fewer numbers.

M. domestica responded in many more cases but the number of houseflies was still low in all but one compound, ammonium carbonate. The materials that produced some measure of attractive response were banana, crushed houseflies, soya bean oil, Vico 400 fermentation flavor, skatole, butyric acid, granulated brown sugar, granulated white sugar, lactose, mink manure, fescue, ground beef, molasses, ammonium sulfate, and ammonium carbonate. As with F. canicularis, granulated white sugar is commonly used as food for houseflies in captivity. The largest number of houseflies to be attracted resulted when ammonium carbonate was used. From 35 to 40 houseflies congregated

which was considerably greater than the second best attractant, mink manure, and far greater than the other attractive materials. This fact also shows that the McIndoo olfactometer will draw large numbers of flies to its odor producing outlet when a strongly attractive substance is present.

Apparently the small number of houseflies drawn by the other materials was due as much to their being weak attractants as it was to the questionable olfactometer design. The McIndoo olfactometer characteristically has small population responses rather than large, and this has been a common criticism of it. It was noticed that the incandescent light above the cage acted as an external stimulus for F. canicularis and M. domestica. Both species tended to remain on the screen covering the top of the olfactometer through which this light filtered. In addition they were not effectively exposed to the odor eminating from the bottom of the cage and any gradient was too unstable. To reduce external variables such as light and loss of odor gradient to the air surrounding the cage, a closed system of lighting and forced ventilation would be desirable.

The fact that F. canicularis did not respond to some extent to a variety of animal material or products of protein decomposition as did M. domestica seems to imply that these materials may play more of a minimum role in its biology than has previously been believed. An example is the lack of response to ammonium carbonate or ground beef as compared to the housefly's attraction. Mink manure was

attractive as was expected when considering that the larval environment involves this material to a limited extent.

Essential oils derived from plant metabolism had no apparent attraction for either fly species, and F. canicularis does not seem to be oriented toward the plant materials included in this study.

The search for materials of greater attractive power for F. canicularis, such as that which ammonium carbonate produces for M. domestica, is desirable in order to better understand the behavior of F. canicularis and to utilize the attractants in control methods. The tests performed in this study seem to indicate either a specificity of response, a minimum development of olfactory or gustatory receptors, or an extremely critical and sensitive threshold stimulation probably coupled with specific substance response. Olfactory equipment with improved control of the flies, air flow, and concentration, and less external environmental influence, would be necessary to pursue this further.

TABLE 5. RESPONSES OF F. CANICULARIS AND M. DOMESTICA TO CANDIDATE ATTRACTANTS[1]

Candidate Materials	Range in Number of Flies During Four Two-Minute Exposures			
	Test		Control	
	M. domestica	F. canicularis	M. domestica	F. canicularis
Protein and Fat Decomposition				
Skatole				
.05 g. + 30 ml. H_2O	0	0	0	0
.1 g. + 30 ml. H_2O	3-5	0	0	0
.5 g. + 30 ml. H_2O	0	0	0	0
1.0 g. + 30 ml. H_2O	0	0	0	0
Casein				
5.0 g. + 3 drops H_2O placed inside cage	0	0	-	-
Ammonium Phosphate Hydrolysate				
.5 ml. + 30 ml. H_2O	0	0	0	0
5.0 ml. + 30 ml. H_2O	0	0	0	0
Butyric Acid				
.05 ml. + 30 ml. H_2O	3-4	0	0	0
.1 ml. + 30 ml. H_2O	3-5	0	0	0
.5 ml. + 30 ml. H_2O	0	0	0	0
1.0 ml. + 30 ml. H_2O	0	0	0	0

1. Flies were exposed to the candidate materials by means of an air stream which passed over the material and terminated at the "odor" producing outlet. Materials not introduced in this way are so stated as in the case of casein.

TABLE 5. (CONTINUED)

Candidate Materials	Range in Number of Flies During Four Two-Minute Exposures			
	Test		Control	
	M. domestica	F. canicularis	M. domestica	F. canicularis
Protein and Fat Decomposition				
Valeric Acid				
.05 ml. + 30 ml. H_2O	0	0	0	0
.1 ml. + 30 ml. H_2O	0	0	0	0
.5 ml. + 30 ml. H_2O	0	0	0	0
1.0 ml. + 30 ml. H_2O	0	0	0	0
Oleic Acid				
.05 ml. + 30 ml. H_2O	0	0	0	0
.1 ml. + 30 ml. H_2O	0	0	0	0
.5 ml. + 30 ml. H_2O	0	0	0	0
1.0 ml. + 30 ml. H_2O	0	0	0	0
Lactic Acid				
.05 ml. + 30 ml. H_2O	0	0	0	0
.1 ml. + 30 ml. H_2O	0	0	0	0
1.0 ml. + 30 ml. H_2O	0	0	0	0
Acetic Acid				
.01 N	0	0	0	0
.1 N	0	0	0	0
.5 N	0	0	0	0
1.0 N	0	0	0	0

TABLE 5. (CONTINUED)

Candidate Materials	Range in Number of Flies During Four Two-Minute Exposures			
	Test		Control	
	M. domestica	F. canicularis	M. domestica	F. canicularis
Essential Oils				
Camphor				
.05 g. + 30 ml. H_2O	0	0	0	0
.1 g. + 30 ml. H_2O	0	0	0	0
.5 g. + 30 ml. H_2O	0	0	0	0
Geraniol				
.05 ml. + 100 ml. H_2O	0	0	0	0
.1 ml. + 100 ml. H_2O	0	0	0	0
.5 ml. + 100 ml. H_2O	0	0	0	0
Cymene				
.05 ml. + 200 ml. H_2O	0	0	0	0
.05 ml. + 100 ml. H_2O	0	0	0	0
.05 ml. + 30 ml. H_2O	0	0	0	0
Furaldehyde				
.05 ml. + 100 ml. H_2O	0	0	0	0
.05 ml. + 30 ml. H_2O	0	0	0	0
.1 ml. + 30 ml. H_2O	0	0	0	0
.5 ml. + 30 ml. H_2O	0	0	0	0
Amyl Salicylate				
.05 ml. + 30 ml. H_2O	0	0	0	0
.1 ml. + 30 ml. H_2O	0	0	0	0
.5 ml. + 30 ml. H_2O	0	0	0	0
1.0 ml. + 30 ml. H_2O	0	0	0	0

TABLE 5. (CONTINUED)

Candidate Materials	Range in Number of Flies During Four Two-Minute Exposures			
	Test		Control	
	M. domestica	F. canicularis	M. domestica	F. canicularis
Essential Oils				
Limonene				
.05 ml. + 30 ml. H_2O	0	0	0	0
.1 ml. + 30 ml. H_2O	0	0	0	0
.5 ml. + 30 ml. H_2O	0	0	0	0
Inorganic Compounds				
Hydrogen Sulfide				
Undetectable	0	0	0	0
Slightly detectable	0	0	0	0
Detectable	0	0	0	0
Carbon Dioxide				
Undetectable	0	0	0	0
Slightly detectable	0	0	0	0
Detectable	0	0	0	0
Ammonium Carbonate				
.1 g. + 30 ml. H_2O	10-30	0	5	0
.5 g. + 30 ml. H_2O	10-30	0	3	0
1.0 g. + 30 ml. H_2O	35-40	0	3	0
2.0 g. + 30 ml. H_2O	35-40	0	2-5	0
5.0 g. + 30 ml. H_2O	5-10	0	3	0
Ammonium Sulfate				
.1 g. + 30 ml. H_2O	2-5	0	0	0

TABLE 5. (CONTINUED)

Candidate Materials	Range in Number of Flies During Four Two-Minute Exposures			
	Test		Control	
	M. domestica	F. canicularis	M. domestica	F. canicularis
Inorganic Compounds				
Ammonium Sulfate				
.5 g. + 30 ml. H_2O	2-5	0	0	0
1.0 g. + 30 ml. H_2O	0	0	0	0
Sodium Hydroxide				
.1 N	0	0	0	0
.5 N	0	0	0	0
1.0 N	0	0	0	0
Hydroxylamine Hydrochloride				
.5 g. + 30 ml. H_2O	0	0	0	0
1.0 g. + 30 ml. H_2O	0	0	0	0
2.0 g. + 30 ml. H_2O	0	0	0	0
Sugars				
Molasses				
10 ml. + 30 ml. H_2O	0	0	0	0
30 ml. + 30 ml. H_2O	4-8	0	0	0
30 ml. + 30 ml. H_2O placed inside cage	3-4	0	-	-
Fermented mixture placed inside cage	3-5	0	-	-
Granulated White Sugar				
5.0 g. + 30 ml. H_2O	0	0	0	0
10.0 g. + 30 ml. H_2O	0	0	0	0
10.0 g. placed inside cage	15-20	7-10	-	-
10.0 g. + 30 ml. H_2O	3-4	0	-	-

TABLE 5. (CONTINUED)

Candidate Materials	Range in Number of Flies During Four Two-Minute Exposures			
	Test		Control	
	M. domestica	F. canicularis	M. domestica	F. canicularis
Sugars				
Granulated Brown Sugar				
5.0 g. + 30 ml. H_2O	0	0	0	0
10.0 g. + 30 ml. H_2O	0	0	0	0
10.0 g. placed inside cage	3-4	0	-	-
10.0 g. + 30 ml. H_2O placed inside cage	0	0	-	-
Fermented mixture placed inside cage	2-3	0	-	-
Lactose				
5 g. + 3 drops H_2O placed inside cage	2-4	0	-	-
Peptose				
5 g. + 3 drops H_2O placed inside cage	0	0	-	-
Plant Materials				
Fescue				
Freshly chopped	3-5	4-6	0	1-2
Freshly chopped and placed inside cage	3-5	3-5	-	-
Silage - 3 wks. old	0	0	0	0
Silage - 3 wks. old and placed inside cage	0	0	-	-
Pigweed				
Freshly chopped	0	0	0	0
Freshly chopped and placed inside cage	0	0	-	-
Silage - 3 wks. old	0	0	0	0
Silage - 3 wks. old and placed inside cage	0	0	-	-

TABLE 5. (CONTINUED)

Candidate Materials	Range in Number of Flies During Four Two-Minute Exposures			
	Test		Control	
	M. domestica	F. canicularis	M. domestica	F. canicularis
Plant Materials				
Cabbage				
Freshly chopped	0	0	0	0
Freshly chopped and placed inside cage	0	0	-	-
Peach				
Fresh	0	0	0	0
Fresh and placed inside cage	0	0	-	-
Banana				
Freshly mashed	0	0	0	0
Fresh and placed inside cage	2-3	0	-	-
Celery				
Freshly chopped	0	0	0	0
Carrot				
Freshly chopped	0	0	0	0
Animal Materials				
Human Urine	0	0	0	0
Mink Manure				
Fresh	2-3	0	0	0
Fresh and placed inside cage	15-20	5-6	-	-

TABLE 5. (CONTINUED)

Candidate Materials	Range in Number of Flies During Four Two-Minute Exposures			
	Test		Control	
	M. domestica	F. canicularis	M. domestica	F. canicularis
Animal Materials				
Mink Manure				
One day old and placed inside cage	15-20	5-6	-	-
One week old and placed inside cage	5-6	2-3	-	-
Aphid Honeydew				
Maple leaf with honeydew deposit placed inside cage	0	0	-	-
Ground Beef				
Fresh	3-4	0	0	0
Spoiled	2-4	0	1	0
Fresh and placed inside cage	7-8	0	-	-
Spoiled and placed inside cage	3-4	0	-	-
Tuna Fish				
Canned	0	0	0	0
Canned and placed inside cage	0	0	-	-
Flies				
Crushed and placed inside cage				
Male F. canicularis	0	0	-	-
Female F. canicularis	0	0	-	-
Male M. domestica	3-6	0	-	-
Female M. domestica	6-7	0	-	-

TABLE 5. (CONTINUED)

Candidate Materials	Range in Number of Flies During Four Two-Minute Exposures			
	Test		Control	
	M. domestica	F. canicularis	M. domestica	F. canicularis
Miscellaneous Materials				
Coumarin				
5 g. placed inside cage	0	0	-	-
8-Quinolinol				
5 g. placed inside cage	0	0	-	-
Commercial Fertilizer (6-16-0)				
5 g. + 30 ml. H_2O	0	0	0	0
10 g. + 30 ml. H_2O	0	0	0	0
Iso Amyl Alcohol (99%)				
.1 ml. + 30 ml. H_2O	0	0	0	0
.5 ml. + 30 ml. H_2O	0	0	0	0
1.0 ml. + 30 ml. H_2O	0	0	0	0
Ethyl Alcohol (75%)				
1.0 ml. + 30 ml. H_2O	0	0	0	0
5.0 ml. + 30 ml. H_2O	0	0	0	0
15.0 ml. + 15 ml. H_2O	0	0	0	0
Soya Bean Oil				
1.0 ml.	4-20	0	1-6	0

TABLE 5. (CONTINUED)

Candidate Materials	Range in Number of Flies During Four Two-Minute Exposures			
	Test		Control	
	M. domestica	F. canicularis	M. domestica	F. canicularis
Flavor Compounds				
Fritzsche Brothers Aromatic Compounds				
#36693 - 1 ml. + 30 ml. H_2O	0	0	0	0
#39172 - 1 ml. + 30 ml. H_2O	0	0	0	0
#39173 - 1 ml. + 30 ml. H_2O	0	0	0	0
Vico 400 Fermentation Flavor				
1 g. + 30 ml. H_2O	2-5	0	0	0
Vico 55-11 Pet Food Appetizer				
.5 g. + 30 ml. H_2O	0	0	0	0

ULTRAVIOLET LIGHT AS AN ATTRACTANT

Two blacklights which emitted light in the blue and ultraviolet portion of the spectrum were obtained to discover if they produced an attractive stimulus to F. canicularis. Filtered and unfiltered blacklights were used to test the responses of this fly to shorter wavelengths, and any difference in fly response was noted.

The flies were caught at the Oregon State University mink fur farm and placed inside a white cage two feet square and three feet high. Fine-mesh plastic screening formed the sides and top of the cage. The two lamps were placed on the outside of the cage with one on each opposing side and at a position equidistant from the top and bottom of a side. The lamps were approximately one inch from the screen resulting in a small diffusion of light upon the screen.

The ultraviolet sources were General Electric 15 watt blacklights one foot in length. The unfiltered lamp produced an intense and bright light ranging between 3200 and 4200 Angstroms, and the filtered lamp emitted more light concentrated between 3200 and 3600 Angstroms.

Granulated sugar and water were available to the flies. Incandescent light bulbs were turned on after each trial was completed. The flies were never kept in the dark except as part of a particular test. There were always flies feeding on the sugar, resting on the other sides of the cage, and in the air, although the majority were found on the sides adjacent to the blacklight when the latter was in operation.

The room temperature was 75° F. and the relative humidity remained at 55 percent.

The series of tests conducted are indicated by the following outline:

I. Laboratory - Fixed Cage Size
   A. Attraction to blacklights operating separately
      1. Filtered
      2. Unfiltered
      3. Reoccurrence of attraction to a specific blacklight by individual flies
   B. Attraction to filtered and unfiltered blacklights operating simultaneously
   C. Attraction to blacklights at various distances in competition with indirect natural lighting
      1. Filtered
      2. Unfiltered

II. Field Conditions
   A. Attraction to blacklights at a mink fur farm

III. Attraction to blacklights in relation to cage size

Attraction to Blacklights Operating Separately

The first series of tests determined the degree of attractiveness of each blacklight. Approximately 175 male F. canicularis were placed inside the cage. The filtered blacklight was placed on the left side of the cage, the number of flies counted on that side, and the blacklight

was turned on for one minute. At the end of this interval, the number of flies attracted to the screen was noted. After five exposures the light was moved to the right side of the cage and the routine was repeated. These trials were then performed using the unfiltered blacklight.

The use of blacklights increased the number of F. canicularis found on the adjacent screen by a factor of from 4 to 17 with an average of eight and one-half (Figure 13). The filtered blacklight drew an average of 99 flies per trial as against 94 flies attracted to the unfiltered light. Less flies were drawn to the right side of the cage, as compared to the left side, when using the filtered blacklight. The number of flies on either screen before the light was turned on did not have any direct correlation with the number found on this screen after the light had been on for the one-minute interval. Neither type of light drew a consistently large number of flies away from the slightly fluorescent sugar located on the cage bottom. The maximum number leaving the sugar was 20 percent of the total feeding, and in most cases only four or five percent left the food. In some trials the number feeding increased by several percentage points when the blacklights were on.

Attraction to Filtered and Unfiltered Blacklights Operating Simultaneously

The second series of tests involved the exposure of F. canicularis to the simultaneous operation of filtered and unfiltered blacklights.

The flies were kept in darkness for approximately ten seconds and then both lights were turned on simultaneously for one minute. One was centered on the left side of the cage and the other on the right at about one inch from the screen. After each test, the positions of the lights were reversed so that orientation to a particular side did not occur as a result of one light always being located on that side. There were approximately 150 male F. canicularis in the cage.

The difference in degree of attraction between lamps was small (Figure 14). The largest and most consistent difference was observed when the filtered blacklight was placed on the right side of the cage. An average of 17 percent more flies were found when this light was competing with the unfiltered lamp on the opposite side. The filtered lamp increased the number of flies on the adjacent screen by a factor range of two to seven and one-half. The unfiltered lamp produced a similar range of two to eight. Again there was no correlation between the numbers of flies on the screen before the tests and the numbers found as a result of using the lamps. The total number attracted did not depend on the number present before the test was begun.

While conducting the above tests, there was an opportunity to observe whether a reoccurrence of attraction to a specific blacklight was present. A fluorescent powder was used to dust the flies. Specimens of F. canicularis that were attracted to the filtered blacklight while both types of lights were on were captured, anesthesized with carbon dioxide, placed in a bag containing the dust, and the bag

was swirled gently for several seconds. All other flies were removed from the cage, the dusted Fannia were released once more into the same cage, and four one-minute exposures were conducted turning both lights on and off simultaneously. Of the 25 male flies used, an average of 80 percent returned to the filtered blacklight and the remaining flew to the unfiltered blacklight. The identical procedure was conducted with F. canicularis that were found on the screen adjacent to the unfiltered blacklight. Similarly, an average of 65 percent returned to this light.

Larger populations, many replicates, and a narrower and larger number of spectral ranges are needed to substantiate these tests before any results can be accurately recorded. However, there are indications that some individual Fannia are more responsive to large amounts of short wavelength light and others appear to be stimulated more by longer wavelengths.

Attraction to Blacklights at Various Distances in Competition with Indirect Natural Lighting

The third test concerned itself with comparing the influence of blacklights in attracting F. canicularis when indirect natural lighting was present. The filtered and unfiltered lamps were used separately and placed in the same positions as in the previous trials. Flies were caught at the mink farm and 75 males were placed in the cage.

The flies on the three screens opposing the blacklight were counted and totaled before turning on the lamp as were the flies found

on the adjacent screen. After the lamp had been on for one minute, the four screens were counted again for flies.

The cage was placed in indirect light coming through several windows. The side adjacent to the blacklight was situated so as to receive slightly less sunlight than the others. Fewer flies landed on this side as a result, and a greater difference in fly numbers between this side and the other three sides could be observed when the lamp was in operation. The light meter reading inside the cage was 300 to 400 ft. cd., and the reading was 300 ft. cd. on the screen next to the blacklight. The room temperature was 75° F.

Five exposures were made at each of six distances from the cage. These separations between the cage and blacklight were one inch and one to five feet in increments of one foot.

The results indicate that both filtered and unfiltered blacklights will attract male F. canicularis inside a cage in competition with subdued light (Table 6). When placed one inch from the cage screen, the lamps drew the most flies and the number decreased as the lamp distance from the cage increased. The unfiltered blacklight drew a greater average of flies at each distance when compared to the filtered blacklight. When the latter was placed three feet from the screen, numbers of flies were so small that further observations were unnecessary. For this reason, the counts with the filtered blacklight were discontinued after a distance of two feet was reached. In most cases, the number of flies on the three opposing screens was reduced while a lamp was in

operation, but this did not directly correspond to the increased number of flies attracted to the test screen. This is due to flies that were attracted while hovering in the air inside the cage, and they account for much of the increase when a lamp was turned on. Flies that were feeding were not attracted to the blacklights.

The difference between the number of flies on the screen adjacent to the blacklight before and after the test was averaged at each light distance (Figure 15). Both lights decreased in attractiveness as the distance increased except in the case of the unfiltered lamp at the three-foot distance, where a slight increase in the number of attracted flies was noted.

These results show that subdued light decreased the attractive stimulus of ultraviolet light probably by competition or by reducing the insect's ability to detect shorter wavelengths by decreasing the light to dark intensity ratio. The filtered lamp produced less total light than the unfiltered lamp which accounts for the lesser number of flies attracted under background light competition. Both blacklights are so intense when in a dark situation that their intensity differences are not as much of a factor.

Attraction to Blacklights at a Mink Fur Farm

The fourth test involved the attachment of each blacklight to the ceiling of a mink shed at the Oregon State University mink fur farm. Each light was suspended in the center of swarms of F. canicularis inside the shed. White sheets were used as a background in

several tests, and were placed about one inch behind the light. Both lights were operated separately at 6:00 p.m., 7:00 p.m., and 8:00 p.m. Daylight Saving Time during the first two weeks of July. At these times flies were still out in large numbers although the background light was low as darkness approached.

Specimens of F. canicularis were not attracted in any significant numbers. None swarmed around the light and only a few landed on the sheet when it was placed behind the light. Their speed of flight was not increased as was typical of stimulation due to a blacklight being placed next to a cage. The same results occurred at 9:30 p.m., when completely dark, and at 1:30 p.m. in the afternoon. These results were so unlike previous trials using these lamps and caged F. canicularis that a series of tests involving cages of larger sizes seemed necessary.

Attraction to Blacklights in Relation to Cage Size

The fifth test considered the observation that F. canicularis was attracted to blacklights when caged but not under field conditions. A dark room was divided into four sections using sheets of non-fluorescent cloth. The first section was equivalent in volume to the cage used in all the tests involving these lights, being 2 ft. x 2 ft. x 3 ft. in size. Each lamp was placed inside the dark section in front of one of the sides and compared separately. Fifty male flies were released inside the section and the numbers attracted to the blacklight were counted and averaged with and without a wire screen being placed in front of the light. The results using each lamp were combined and

averaged since the difference between the filtered and unfiltered lamps was small. The section was then doubled in size making it 4 ft. x 2 ft. x 3 ft. and the same procedure followed. The following sections were 4 ft. x 4 ft. x 8 ft. and 5 ft. x 6 ft. x 8 ft.

The small sections with dimensions the same as the cage drew a similar number of flies, this being an average of 60 percent of the 50 flies in the section (Figure 16). The 4 ft. x 2 ft. x 3 ft. section resulted in a considerable decrease with 40 percent of the flies responding. The 4 ft. x 4 ft. x 8 ft. and 5 ft. x 6 ft. x 8 ft. sections drew approximately 14 percent of the total which meant an average of seven flies were found on the white cloth, on the lamp itself, or on the wire screen around the lamp. Most of the flies that remained flying did so at one foot to three foot heights although they could go as high as eight feet in the two larger sections. Ten to 20 percent preferred the darker corners, and if disturbed they would often return to the same or similar dark area giving the impression that they were attempting to avoid the light. Most of the flies settled on the lower levels of the cloth comprising the sides of the sections involved. It is apparent that the size of the airspace containing F. canicularis has a direct effect upon the attraction of these flies to blacklights, and this size must remain at or below 12 cu. ft. to insure a response of 50 percent or more of the population under the test conditions.

Summary

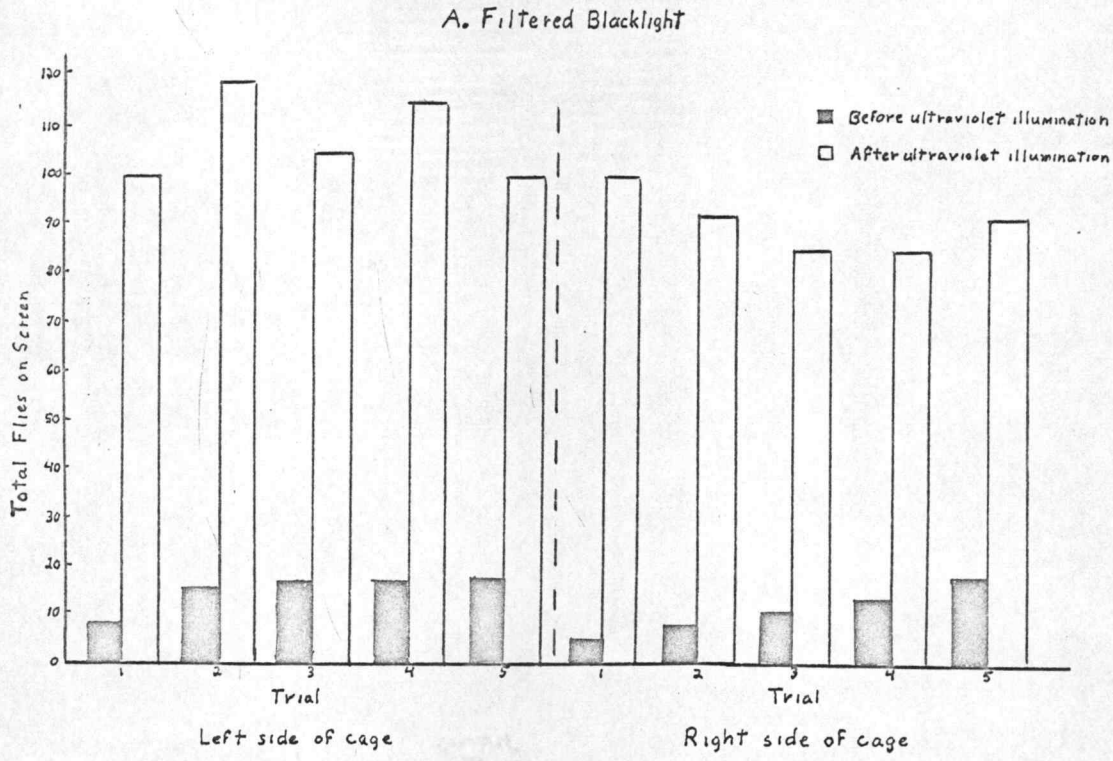
F. canicularis is attracted to light of short wavelengths as produced by a blacklight. For a maximum response, certain conditions are necessary and include a relatively small area in which to swarm and a minimum of background light interference.

Light produced by the filtered blacklight under dark conditions caused a greater and more consistent difference between the numbers attracted to the cage screen before and after the test than the unfiltered lamp. When indirect external light was present, the increased intensity of the unfiltered blacklight resulted in a slower stimulation decrease when placed at greater distances from the cage.

There was no attraction when the blacklights were placed outside under sheds containing swarms of F. canicularis. This result led to experimentation using various cage sizes and it was found that a cage should be less than 12 cubic feet in volume to result in an attractive response of over 50 percent.

Limited tests indicated that a majority of the Fannia population tested would return to the type of blacklight at which they were captured. This suggests variable thresholds of stimulation in individual flies conceivably due to specific intensity or wavelength responses. Also the development of a temporary conditioned response may be a factor to consider.

Figure 13. Number of F. canicularis attracted to blacklights operated separately.



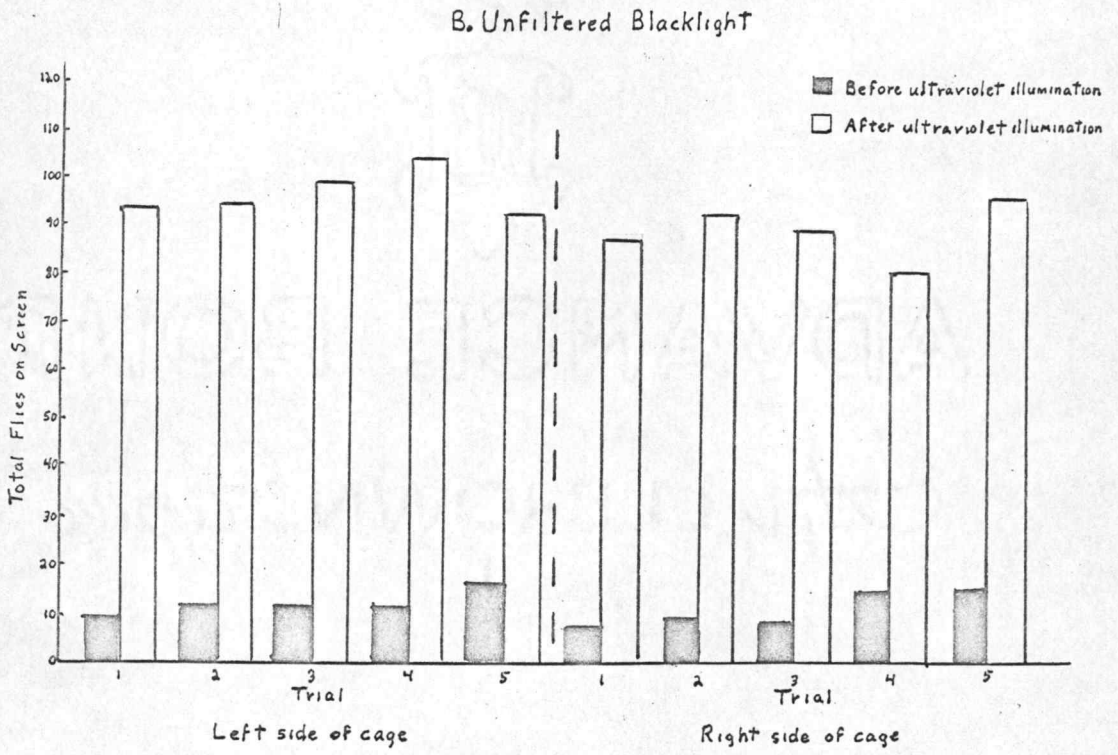
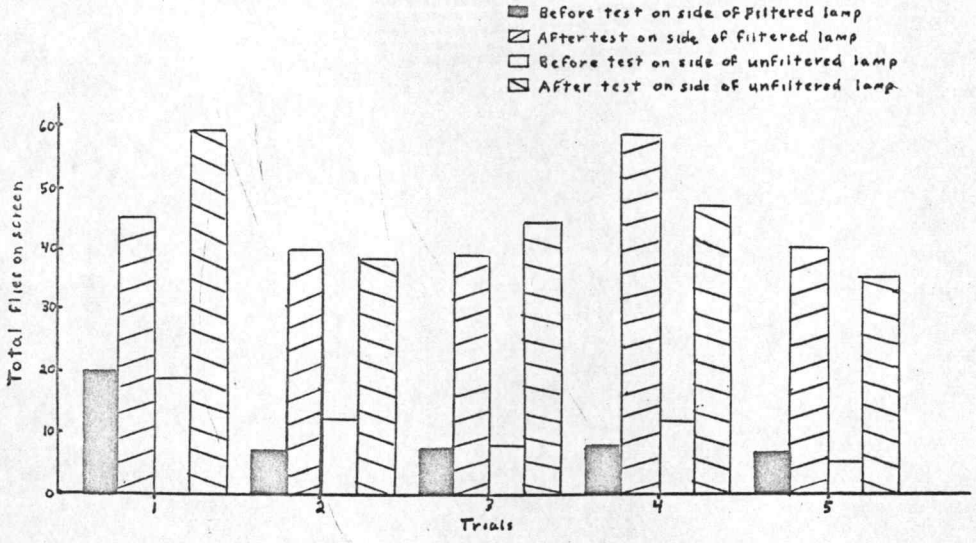


Figure 14. Number of F. canicularis attracted to blacklights operated simultaneously.

A. Filtered blacklight on left side of cage and unfiltered blacklight on right side



B. Unfiltered blacklight on left side of cage and filtered blacklight on right side

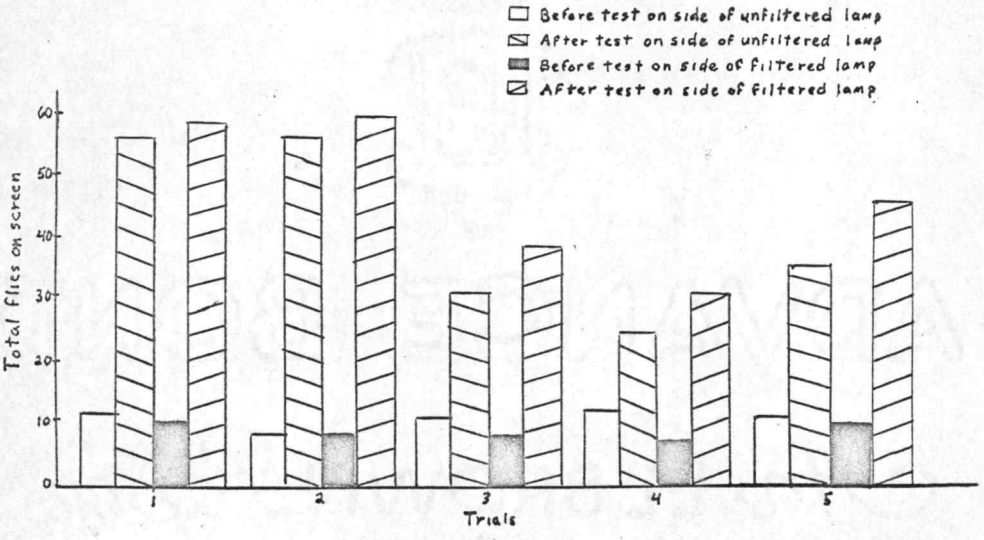


Figure 15. Average number of F. canicularis attracted to blacklights under conditions of indirect natural lighting.

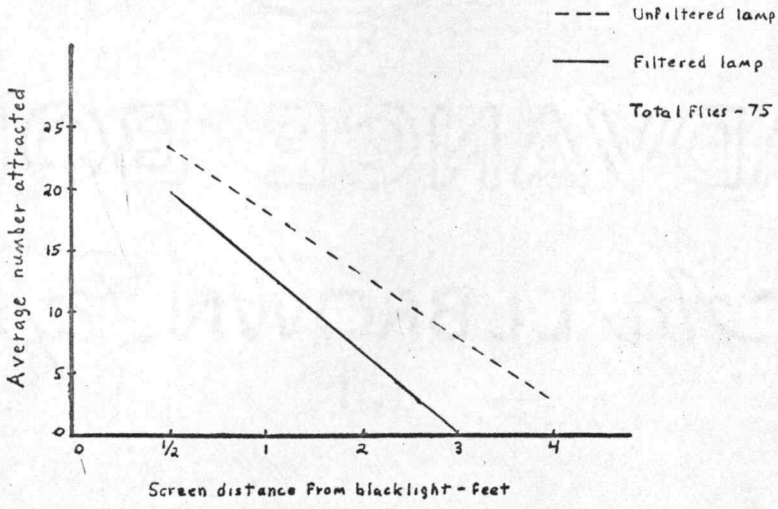


Figure 16. Percent of F. canicularis attracted to blacklights in selected volumes of airspace.

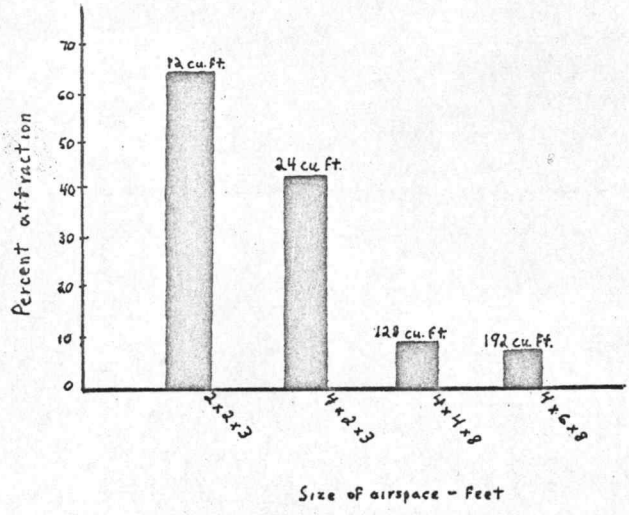


TABLE 6. NUMBER OF F. CANICULARIS ATTRACTED TO BLACKLIGHTS AT VARIOUS DISTANCES IN THE PRESENCE OF INDIRECT NATURAL LIGHTING

A. Blacklight placed one inch from screen

	Unfiltered Exposure					Filtered Exposure				
	1	2	3	4	5	1	2	3	4	5
Flies on 3 opposing screens before test	54	49	46	56	49	46	47	41	50	48
Flies on 3 opposing screens after test	40	36	28	37	38	42	29	34	36	47
Flies on screen next to light before test	4	1	3	2	2	0	3	5	4	3
Flies on screen next to light after test	30	30	25	30	23	20	25	35	21	17

B. Blacklight placed one inch from screen

	Unfiltered Exposure					Filtered Exposure				
	1	2	3	4	5	1	2	3	4	5
Flies on 3 opposing screens before test	53	43	48	48	46	48	42	45	36	47
Flies on 3 opposing screens after test	47	44	43	35	42	48	41	36	42	46
Flies on screen next to light before test	3	2	4	3	6	2	7	8	6	2
Flies on screen next to light after test	26	23	18	25	15	25	16	17	10	13

TABLE 6. (CONTINUED)

C. Blacklight placed two feet from screen

	Unfiltered Exposure					Filtered Exposure				
	1	2	3	4	5	1	2	3	4	5
Flies on 3 opposing screens before test	42	50	49	52	36	62	57	50	39	50
Flies on 3 opposing screens after test	38	48	49	46	36	62	53	56	60	49
Flies on screen next to light before test	3	5	4	12	7	5	7	6	8	7
Flies on screen next to light after test	10	14	17	16	15	11	13	12	11	14

D. Blacklight placed three and four feet from screen

	Unfiltered Exposure					Filtered Exposure				
	1	2	3	4	5	1	2	3	4	5
Flies on 3 opposing screens before test	52	58	64	55	55	50	49	52	53	51
Flies on 3 opposing screens after test	41	51	54	43	48	42	59	50	53	47
Flies on screen next to light before test	5	5	6	9	7	12	5	5	2	4
Flies on screen next to light after test	24	12	12	23	17	15	8	11	7	10

DISTRIBUTION AND OTHER BEHAVIORAL CHARACTERISTICS OF *FANNIA CANICULARIS*

The importance of animal excrement as a component of a fly's food and breeding media could serve as an indicator of a potential disease carrier. Repeated observations of adult *F. canicularis*, near the excrement of mink found below the animals' cages, resulted in finding relatively few numbers of this species. The few that were present were usually females all of which were gravid. Sarcophagid, calliphorid, and muscid larvae, including *Fannia*, were present in varying numbers in the manure. Calliphorid larvae were the most apparent, particularly in the areas receiving more sunlight.

Emergence Traps

In order to check the number and sex ratio of *F. canicularis* adults, emergence traps were placed over the mink manure. These traps were aluminum cones with a base diameter and height of three feet. Eight traps were sunk into the sawdust groundcover to a depth of approximately three inches. Small cardboard cylinders with an inverted cone inside trapped the newly emerged adults. Various ages of manure were chosen ranging from fresh to several days old. Two of the eight locations received sunlight most of the day, and the rest received little or no sunlight. The flies were counted once every three days for 30 days from September to October. Four traps were moved to new locations midway through the 30 day period to increase the number of sites to be sampled.

The total number of F. canicularis that had emerged at the end of the trial was very low. A total of 96 adults were captured, 60 of which were males. The majority of the flies caught in the traps represented another Fannia species, F. manicata Meigen. A total of 1,750 specimens of this species were captured. Other Muscidae, Calliphoridae, and Sarcophagidae species also were present. Calliphoridae were especially prevalent in the two traps receiving sunlight, whereas very few Fannia species were present in these traps.

The number of F. manicata and F. canicularis decreased over the period of thirty days in the stationary traps, although the total amount at the last count was approximately one-half that of the beginning count. Apparently the traps were not sunk far enough into the ground and larvae migrated into the traps augmenting the existing population. The emerging population from the traps that were moved once decreased by approximately 25 percent.

The emerging population of F. canicularis was low for several reasons. The major numbers of this species may have emerged previous to September, although observation of the F. canicularis swarms associated with the mink sheds indicated that a noticeable population buildup was still occuring in September. In fact the problem became so acute that it was necessary to spray the fur farm with insecticide before a maximum population could be recorded. A second possibility accounting for the small emerging population might be that the altered external environment, by the placement of traps over the manure, increased the mortality rate in the pupal stage. Light, temperature,

and various gas concentrations in the air were different, the latter being due to the greater confinement of manure-produced gases. However, the fact remains that large numbers of other fly species emerged and apparently were not affected by this altered environment. A third and most likely reason for the decreased emerging population may be the location of larval and/or pupal habitats other than in mink excrement. There is a thick sawdust layer around the manure in addition to a layer beneath it. Although this surrounding medium may offer a drier and more favorable pupation zone, very few larvae or pupae were found upon investigation. It is known that F. canicularis larvae are found in a variety of decaying animal and vegetable matter (4, p. 188). Although only short grass and trees were in the immediate area, a creek surrounded by dense vegetation was located 50 yards from the sheds and this, along with an adjacent pasture for cattle, may supply a likely additional larval environment. A poultry farm is located approximately 300 yards away and it is possible that population exchanges occur between it and the mink farm resulting in the use of this poultry farm as an important larval habitat and source of new flies.

Population Dispersal of F. canicularis

Observations were continued in the area surrounding the mink sheds to learn more of the characteristic of F. canicularis behavior. The object was to compare the day-night population and sex ratios in conjunction with flight and resting habits.

Daytime Sampling

An insect net was used to take samples during the day from swarms inside the mink sheds, underneath a canopy of trees, over the manure, and from short grass growing between the sheds (Figure 17). Samples were taken in the morning and afternoon for one week. When approximately 50 flies were collected, they were killed and counted. A total of 2000 flies were caught during the period of one week. More than 1000 flies found resting on the inside walls of the sheds were checked for the presence of females over a period of one week. Counts were made each day, in the morning and afternoon, without disturbing the resting flies.

The swarms of F. canicularis consisted of an average of 100 males to nine females, or a male to female ratio of 11:1. The location of the swarm sites made little or no difference in this ratio. Random sampling of flies on the shed walls produced a male to female ratio of approximately 1:2. The 1:1.5 male to female ratio from the limited emergence trap population is similar to this ratio, however the large swarms of male F. canicularis found during the day do not correspond in number or ratio.

Night Sampling

In attempting to investigate the reason for the discrepancy in sex ratios of the daytime samples, the flies were observed at night when swarming had ceased. All of the males and females were at rest and it was believed that more accurate information on the population sex ratio could be obtained.

Figure 17. Trees and sheds of the mink fur farm

For night observations, a photoflood lamp was used to illuminate the trees and grasses surrounding the mink sheds. The trees under observation were a locally cultivated eastern oak and were approximately 50 feet in height. Their canopies extended within ten feet of the ground and the lower ten feet of the canopies were searched because the majority of flies were found here. Additional counts were made inside the sheds. The sloping section of the shed roof was constructed using corrugated metal. The roof and sides were divided into equal sections by wooden braces and these sections made convenient units for counting flies per unit area. This unit area was 54 sq. ft. not including the lengths of electrical wiring overhead.

Very few F. canicularis were found on the trees. Some were found on twigs and branches but most were resting on the underside of the leaves. The smaller trees had very few flies. An estimate would place the number of flies at one per 20 to 40 leaves. The male to female ratio was 10:1 indicating that most of these flies were probably from the male swarms. No F. canicularis were found after sweeping the one to three inch grass surrounding the sheds and trees. After sampling the inside of the sheds, the total number of male and female flies per 54 sq. ft. averaged out to be 23 with a male to female ratio of 1:2. At least half of the population was resting on the horizontal wires near the top of the roof. A dozen females were dissected and ten were in a gravid condition. A similar number of gravid females were observed when the resting flies were sampled during the day.

The total number of F. canicularis found resting on the inside of the sheds was greater during the night than during the day. However, the number of female Fannia found resting at night appeared to be far less than the number of males hovering inside and around the outside of the sheds during the day. Some males were resting on the leaves of the surrounding trees and others were resting inside the shed along with the females during the day. Observations of the small resting population of males found during the night gave the impression that many males were "missing" and resting elsewhere. The seemingly few males found on the trees at night did not appear to make up this difference.

Population Estimation

In an attempt to account for the differences in male and female populations and the day-night variance in male numbers, estimates were made of the total flies swarming and resting in the air during the day and those resting on the trees and sheds at night. Estimates were made of the population contained in an applicable unit of area or volume and total populations were extrapolated from these values. Five mink sheds, the areas between them, and the ten foot area surrounding them, contained most of the F. canicularis population. These estimates are contained in table seven.

The total male and female population inside and outside the sheds is very similar during the day. When combined with the small numbers resting in the trees and inside the sheds, a total of 91,200 flies is reached, with the male to female ratio approximately 9.5:1.

TABLE 7. ESTIMATES OF F. CANICULARIS POPULATION DISTRIBUTION

Portion of Total Environment Sampled	Day			Night		
	Unit Sample	Population Estimate	Sex Ratio Male to Female	Unit Sample	Population Estimate	Sex Ratio Male to Female
Swarming in air volume between five sheds 44,000 cu. ft.	1 fly per cu. ft.	44,000	11:1	0	0	0
Swarming in air volume inside five sheds 22,500 cu. ft.	2 flies per cu. ft.	45,000	11:1	0	0	0
Resting in 28 trees 24,000 leaves	50 flies per cu. ft.	1,400	10:1	1 fly per 30 leaves	22,400	10:1
Resting inside five sheds 30,000 sq. ft.	150 flies per cu. ft.	750	1:2	23 flies per 54 sq. ft.	12,778	1:2
Totals						
Flies		91,150	95:1		35,178	
Males		83,106			24,623	
Females		8,044			10,555	

Difference in day-night population

Total	55,972 more flies during the day
Males	58,483 more male flies during the day
Females	2,511 more female flies during the night

During the night hours, part of the fly swarms have moved to the trees with the corresponding tree population increased by a factor of 16. The amount of flies resting inside the sheds has also increased by a factor of 17, reaching a population of 12,800 flies with a male to female ratio of 1:2. Nevertheless, the total population at night is only 35,200 which is 56,000 less flies than are found during the day.

There are 58,500 more males during the daylight hours than are found at night. The location of these "missing" males is the major problem. The fact that there are 2500 more females found at night than during the day may be accounted for by realizing that a certain number are to be found around the mink manure during the day and therefore not present in the sampled areas.

The habits of the female F. canicularis, its closer association with excrement, and its apparent smaller population, are characteristics which distinguish it quite readily from the male. The low emergence trap population and the reduction of the male population found at night seem to indicate that the prime breeding area is not in the mink excrement and is in another area, or more likely, dispersed over many areas. Some of the resting places of males during the night may also be in scattered areas such as beneath wood, rocks, and various debris.

Light Intensity Measurements

Large populations of F. canicularis were found in the relatively subdued natural illumination of the sheds. The sheds that were not

under trees and received a larger amount of indirect sunlight had fewer individuals of this species. The following intensity measurements were made with a lightmeter on a sunny day at 2:30 p.m. in September:

1. Inside the sheds
    a. Dark shed (in shade of trees) - 3 to 15 ft. cd.
    b. Partially shaded shed - 15 to 40 ft. cd.
    c. Sunlit shed (not under shade of trees) - 15 to 60 ft. cd.
2. Underneath the tree canopy
    a. Light measured with lightmeter in horizontal plane - 150 to 200 ft. cd.
    b. Light measured with lightmeter in vertical plane - 400 ft. cd.
3. Sunlight filtering through the leaves and measured with lightmeter in vertical plane - Up to 5,000 ft. cd.
4. Reflected light from manure and litter measured at a two foot distance
    a. In the sun - 200 to 300 ft. cd.
    b. In the shade - 5 to 25 ft. cd.

Food

While male F. canicularis were being held in captivity, mink manure was substituted for the ordinary food of white granulated sugar. After one day 40 of the 50 flies were dead. More flies were brought from the mink fur farm and again the majority died the next day. When granulated sugar was placed in with the manure, only

two flies died by the following day. After repeating this six times it seemed reasonable to assume that mink manure is not a food capable of sustaining life in male F. canicularis when in captivity, and quite possibly not in their normal living conditions. Although they do feed on sugar when captured, a chemically synthesized material such as this is unknown in the field. Calliphorids and other muscids can usually be found exploring and presumably feeding on the manure, but relatively few F. canicularis were observed. Those that were found were gravid females exploring the manure. When sugar was used as bait and placed in an open container in the center of swarms of males at the fur farm, no more than four or five landed on the sugar at any one time.

The food of the male F. canicularis was not determined in the field and it may feed very little. It would seem that the perpetual hovering characteristic would require a constant, external addition of energy-producing food, and this necessity would invoke exploratory habits such as those which are so obvious in M. domestica. But the invariable hovering and occasional bursts of speed of F. canicularis offer no indication as to the reason or energy source that motivates them.

Sensitivity to Air Currents

F. canicularis is more sensitive to changing air currents than M. domestica. The olfactometer cage (Figure 12) was used with about 100 flies resting on the screened top of the cage. When a weak air current was passed over the cage top, F. canicularis would become

stimulated and many would fly inside the cage. No such reaction would occur with M. domestica until stronger air currents were used. This sensitivity may account for the erratic flight observed in swarms of F. canicularis in that they are responding to minute current changes.

SUMMARY AND CONCLUSIONS

High concentrations of Fannia canicularis occur in areas where animal husbandry is practiced and frequently more than 50 percent of the fly population will consist of this species. As suburban growth continues to expand into animal raising areas and is confronted with the pestiferous activities of F. canicularis, the fly population tolerance threshold level decreases and increased fly control becomes necessary. Organophosphate insecticides were investigated as a means of controlling F. canicularis found at a mink fur farm. Studies of population dispersal and attractants also were conducted to provide information for more effective control.

Acute and chronic tests of insecticide toxicity to mink resulted in the selection of ronnel, malathion, and dimethoate as being relatively non-toxic. Use of these chemicals on mink would appear to be quite safe in a recommended fly control operation.

Ronnel and dimethoate at one percent concentrations produced rapid knock-down of F. canicularis held captive in large cages. The residual fly mortality did not decrease rapidly over a two week period and ronnel was consistently more toxic than dimethoate.

Malathion toxicity to F. canicularis was low and resistance indications were present in the mink farm population. Organophosphate resistant and susceptible strains of M. domestica supported this speculation. Malathion did not produce adequate mortality in the F. canicularis population studied, but the toxicity of ronnel and

dimethoate appeared quite satisfactory for further application at a field control level.

F. canicularis was not attracted to any significant degree to a selection of candidate substances using a McIndoo olfactometer. Only three materials out of 47 incited a response as compared to 15 when M. domestica was tested. Further investigations will be required to isolate materials more attractive to F. canicularis.

Ultraviolet and short-wavelength light emitted by filtered and unfiltered blacklights stimulated F. canicularis and caused an attractive response. Light concentrated in the lower spectral region, as produced by a filtered blacklight, produced a greater attraction in complete darkness. Stimulation of F. canicularis occurred only when held in cages of approximately 12 cubic feet or less, and consequently there was no attraction under field conditions.

Emergence trap data indicated that mink manure was not a prime breeding area for F. canicularis. However, large amounts of F. manicata were collected from these traps.

Population dispersal investigations of F. canicularis at the mink farm during the daytime disclosed a large swarming population with a male to female ratio of 11:1 and a male to female ratio of 1:2 in the small population resting in the sheds. Although the male to female ratio of resting F. canicularis was similar during the night, day and night population estimates resulted in a total day population being twice as large as the night population, and over three times as many

males were present during the day than during the night. These data indicate that the male population is larger than the female, and these males rest in scattered areas in proximity to the mink farm, whereas the majority of females appear to rest on the insides of the sheds.

Most male F. canicularis died within 24 hours when provided only mink manure as food. Mink manure does not appear to be a food capable of sustaining life in adult male F. canicularis held in captivity.

Control of F. canicularis was obtained by use of ronnel and dimethoate. The possibility of employing blacklights and various substances as attractants was investigated, but their use was limited since F. canicularis responded only to laboratory conditions with blacklights and insignificant stimulation occurred with the substances. Knowledge of the dispersal habits of F. canicularis indicated that control by spraying killed swarming males and resting females, and spray coverage of trees would contact a major number of flies resting in the area during the night, but a minority when compared to the total population present during the day. Phytotoxicity should be considered if foliage is to be sprayed. Because males do not feed regularly, the use of baits is minimized. However, the swarming habit and night dispersal of F. canicularis does not lend itself to efficient control through the use of residual insecticides, and the development of materials and methods for attracting these flies resulting from additional biological investigations appears necessary.

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