INVESTIGATIONS ON THE CONTROL OF THE COMMON BITING FLIES ON DAIRY CATTLE BY MEANS OF SOME NEW FLY SPRAY FORMULAE

by

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INTRODUCTION

The control of flies on domestic animals and around barns constitutes an annual problem wherever livestock are kept. Flies are a nuisance to livestock causing the animals to fight them which interferes with the animals feeding and resting. Sometimes the animals may cause injury to themselves or their handlers through their fly fighting activities. The result is a monetary loss for the producer. Livestock are difficult to handle when they are fighting flies. It appears reasonable that these strenuous efforts to dislodge and escape flies would directly affect milk production of dairy cattle and normal gain of weight of grazing animals. The public, each year, buys enormous quantities of fly sprays, repellents, and fly screens to combat flies. At the present time, there are over two hundred kinds of fly sprays on the market and there is an insistent demand for more efficient fly sprays and more successful fly control.

The Hercules Powder Company, Wilmington, Delaware is a manufacturer of fly spray materials. Among the products they have developed is a new one known as thanite which they believe to be superior to any now being used in fly sprays. After extensive laboratory tests in Delaware, the Company desired to have some large scale practical tests conducted under mid-western climatic conditions. It was for this reason that the Hercules Company sponsored such a project at Kansas State

College and because of its location, place in the dairy industry and the excellent dairy facilities available. When the Company was assured of cooperation between the Departments of Dairy Husbandry and of Entomology, it agreed to finance such a project.

There are three species of flies commonly found around dairies and on dairy animals, in the United States, which constitutes the fly problem of dairymen. They are the housefly (Musca domestica Linn.), the stable fly (Stomoxys calcitrans Linn.), and the horn fly (Haematobia irritans Linn.).

Since the house fly has sponging mouthparts, it cannot bite the animal nor suck blood from it. This fly, however, may be responsible for the spread of mastitis, among the cows in the dairy herd, as reported from Florida but unconfirmed. These flies are of no consequence in the field and so were not given consideration in the field experiments. They are the predominand fly around the stable and stable spraying and fly screens are effective means of control.

The stable fly, which closely resembles the housefly, has piercing-sucking mouthparts and is often called the "biting house fly." At rest, the stable fly can be distinguished from the housefly by the position it assumes. The stable fly sits with the proboscis projecting in front of its head, suggesting a bayonet, and the tips of the wings touching the surface on which it is resting. The housefly has a vertical proboscis and holds its wings approximately parallel to the surface on which it is resting.

The horn fly is much smaller than the stable fly. It has piercing-sucking mouthparts and is found at times in quite large numbers on the animals.

The objectives of these investigations were:

1. To observe the insecticidal and repellent effect of one to five percent thanite in base oil of 50 Saybolt viscosity to stable and horn flies and to compare it with oil sprays of similar weight using pyrethrum extract of the same percentages.
2. To determine whether protection from flies by a petroleum oil spray resulted in an increase in the milk production of the cows.
3. To determine the effect of petroleum oil spray on the animals, particularly the body temperatures.
4. To make observations of fly behavior, their reaction to cows of different color and breed; and to different types of weather conditions.

REVIEW OF LITERATURE

Considerable work of various kinds has been done on the repellent value of fly sprays and their effect on the animals. There has been no uniform or accepted way of conducting these investigations. The conclusions from experimental work have been conflicting and in some cases even controversial.

Beach and Clark (1904) reported that they found no increase in milk production or butter fat from cows sprayed with proprie-

tary fly sprays over cows that were not sprayed. Cory (1917) reported an average increase of three pounds of milk for ten days for each cow sprayed with a pine tar-creosote emulsion. He stated that his conclusions were subject to experimental error because the experimental cows were selected at random with no regard to lactation stage or fly susceptibility.

Lush and Cave (1925) conducted a number of tests on the Kansas State College dairy herd. Five commercial fly sprays were used. Their results showed increases in milk flow for the sprayed lots from 0.22 to 4.07 percent over their production before the tests were conducted. The unsprayed check group showed a 0.41 percent increase in their production over what it was before the tests began. They reported significant decreases in the number of flies.

Freeborn, Regan, and Folger (1925) reported from their work in California that during one month's confinement in a stable with large numbers of horn flies, the experimental cows dropped 1.4 percent in their milk production. When confined with house flies the drop was 3.33 percent and with stable flies 9.26 percent. When confined with a large population of stable flies and sprayed daily with a bland, non-toxic oil type spray, the cattle lost 21.0 percent in their milk production. With horn flies the loss was 13.1 percent when sprayed with a combination of bland, non-toxic oil and a pyrethrum extract spray, while the controls without flies lost 4.3 percent in milk production and the cattle infested with stable flies lost 12.4 percent.

Cleveland (1926) reported that the horn fly was easily killed with any type of fly spray and also very easily repelled.

Lush and Cave (1928) conducted a second series of fly spray tests on the Kansas State College dairy herd using two commercial sprays. They found that the sprays repelled the flies for only one half hour to an hour. They reported that the sprayed lot lost 1.06 percent more in milk production than the unsprayed lot.

Freeborn, Regan, and Folger (1928) found that cows sprayed with 250 c. c. of white oil showed consistently higher body temperatures sometimes 3° F. higher than the unsprayed controls. The respiration rate of the oil sprayed group averaged 40 percent higher than the unsprayed controls. They found that sponging the cows with water in the absence of flies had no effect on milk production. Spraying with water caused 5.4 percent loss, with pine tar-creosote a loss of 6.9 percent and with white oil a loss of 9.7 percent.

Hadwen (1928) stated that several observers had reported the horn fly to come to rest on the darker animals in preference to the lighter animals. He reported that his observations in the stable showed that the horn flies have a tendency to rest on the white spots on the animals and usually avoided the dark spots or the shade of buildings.

Gnadinger and Corl (1931) reported that a 5 percent solution of rotenone was less toxic to flies than a 5 percent solution of pyrethrum.

Melvin (1932) found that all the petroleum oil sprays used in his experiments caused a measurable rise in the body temperatures of the experimental animals when the air temperature was above 80 - 85° F. He reported that when oil sprayed animals were exposed to direct rays of the sun, there was a greater rise in the body temperature of the dark colored animals than in the light colored ones.

Pearson, Wilson, and Richardson (1933) reported that some methods which have been used for testing fly sprays for repellent efficiency on the stable fly are unsatisfactory. They showed, by their results, that close observation of relative few cows of known fly susceptibility gave more consistent and dependable results than less accurate observations on a large number of cows.

Redding (1934) found from tests at the Dairy Department of Kansas State College that black cows had nearly twice as many flies on them as white cows of approximately the same size. He found that a solution of palustrex which was a water soluble tar derivation in tap water, a commercial pyrethrum extract oil spray and a home made spray of oil of tar in used crank case oil gave good protection against flies for one to two hours. He obtained no appreciable increase in body temperature from any of the sprays. A slight though not significant increase in milk production resulted in the sprayed group. He pointed out that the easier handling of sprayed cattle was an item of importance.

GENERAL PLAN OF THE EXPERIMENT

These experiments were performed at the Kansas State College Dairy farm. Sixteen cows were selected from the college herd for use in the experiments. Four cows were selected from each of the four breeds represented at the farm - namely, Jersey, Guernsey, Ayrshire, and Holstein.

The materials compared in each of the four test series conducted during the summer are given in Table 1.

Table 1. Spray materials compared in the experimental trials.

Preliminary Trials June 18 - June 21	:	No spray materials used
	:	Check (no spray)
Series A	:	Tap water
June 25 - July 13	:	Base oil
	:	Thanite 3 percent in base oil
	:	Check (no spray)
Series B	:	Thanite 1 percent in base oil
July 17 - August 3	:	Thanite 2 percent in base oil
	:	Thanite 4 percent in base oil
	:	Check (no spray)
Series C	:	Base oil
August 5 - Sept. 9	:	Thanite 5 percent in base oil
	:	Insecticide No. 1 (5 percent 20/1 pyrethrum)

Preliminary Trials

As a basis for later experimental procedure, one week was spent making preliminary tests with the 16 cows in an attempt to determine the variation in the fly numbers during different hours of the day, and to determine the relative fly suscept-

ibility of the individual cows to be used in the test.

Fly counts were made on each cow at hourly intervals from 6:00 to 10:00 in the morning and 1:30 to 4:30 in the afternoon. All fly counts were made by the same person. Fly counts were not made during the three and one-half hour period, between the 10:00 a.m. count and the 1:30 p.m. count. This was unfortunate but unavoidable because the cows were in the barn being milked at that time, due to the fact that the experimental cows were milked three times daily.

The periods when the fly population averaged the greatest were from 8:00 a.m. to 9:00 a.m. and 2:30 p.m. to 3:30 p.m. Table 2. Since the peak of fly numbers was the second and third reading in both the morning and afternoon, it might be assumed that sufficient time had not elapsed for the flies to be attracted to the cows in maximum numbers after the cows were taken from the barn to the pasture.

It can be noted from the explanation of the preliminary table that the breed showing a tendency to be the least susceptible was the Ayrshire. Two of these cows were white with the exception of red markings about the head. They are represented in test by numbers 1 and 2A. Cow number 1 was a large animal, almost as large as numbers 5A and 6A which were the Holsteins that had such enormous fly populations. Number 7A, a Jersey, was much lower in susceptibility than the other members of this breed but she was much smaller and of a lighter color.

The Holsteins showed much the greatest susceptibility to total flies and horn flies, but this was not so pronounced with

Table 2. Preliminary period, no spraying - to determine trends in fly numbers, and to balance groups according to fly susceptibility.
(Fly counts on individual cows, and groups, at hourly intervals)

	Group 1												Group 2											
Cow No.	7A			4			8A			5A			1A			2A			5			3A		
Name	Madrigal			Blanche			Lilac			Hulda			Tidbit			Buttercup			Dewdrop			Ivalee		
Breed	Jersey			Ayrshire			Guernsey			Holstein			Jersey			Ayrshire			Guernsey			Holstein		
	S*	H**	T***	S	H	T	S	H	T	S	H	T	S	H	T	S	H	T	S	H	T	S	H	T
6:00 a.m.	51	49	100	34	105	139	51	107	158	131	245	376	46	69	115	51	41	92	108	44	152	70	104	174
7:00 a.m.	80	41	121	63	90	153	120	78	198	197	515	712	61	66	127	58	44	102	119	46	165	121	188	309
8:00 a.m.	88	34	122	83	57	140	141	75	216	271	235	506	102	59	161	55	34	89	127	53	180	123	140	263
9:00 a.m.	77	20	97	58	37	95	116	55	171	194	169	363	89	42	131	53	20	73	92	55	147	109	96	205
10:00 a.m.	60	11	71	62	15	77	71	43	114	157	171	328	106	40	146	41	20	61	83	68	151	89	76	165
1:30 p.m.	57	20	77	41	46	87	81	42	103	136	230	366	65	32	97	39	13	52	68	47	115	91	79	170
2:30 p.m.	54	26	80	77	46	123	84	71	155	152	245	397	75	48	123	59	45	104	122	86	208	141	86	227
3:30 p.m.	49	19	68	45	46	91	91	43	134	182	277	459	69	50	119	47	37	84	79	68	147	110	106	216
4:30 p.m.	41	28	69	65	20	85	73	38	111	183	192	375	77	55	132	34	31	66	79	70	149	130	80	210

	Group 3												Group 4											
Cow No.	7			6			4A			3			2			1			8			6A		
Name	Duckling			B. Girl			Catnip			Ima			Formality			Prim			Aster			Edith		
Breed	Jersey			Ayrshire			Guernsey			Holstein			Jersey			Ayrshire			Guernsey			Holstein		
	S*	H**	T***	S	H	T	S	H	T	S	H	T	S	H	T	S	H	T	S	H	T	S	H	T
6:00 a.m.	73	70	143	51	118	169	91	60	151	79	135	214	72	38	110	48	71	119	35	64	99	125	376	501
7:00 a.m.	71	83	154	97	77	174	165	92	257	99	182	281	118	51	169	67	59	126	99	59	158	121	331	452
8:00 a.m.	82	74	156	87	76	163	117	86	203	99	138	237	90	50	140	69	54	123	129	23	152	218	400	618
9:00 a.m.	78	52	130	85	46	131	129	73	202	107	120	227	57	26	80	95	39	134	86	19	105	196	262	458
10:00 a.m.	73	37	110	64	38	102	104	63	167	101	125	226	77	22	99	86	27	113	77	12	89	177	241	418
1:30 p.m.	90	51	141	43	77	120	72	47	119	107	134	241	48	24	72	69	29	98	52	36	88	167	187	354
2:30 p.m.	71	52	123	102	80	182	109	58	167	116	183	299	102	30	132	91	24	115	63	57	120	376	371	747
3:30 p.m.	49	50	99	83	55	138	79	77	156	111	87	198	80	55	135	71	39	110	92	58	150	276	340	616
4:30 p.m.	64	51	115	95	41	136	116	40	156	103	92	195	56	48	104	79	30	109	77	47	124	228	263	616

* stable flies
** horn flies
*** total flies

respect to stable flies in cows numbered 3 and 3A as in cows 5A and 6A. Cows numbered 3 and 3A were smaller than 5A and 6A and their color was approximately fifty percent white, whereas numbers 5A and 6A were almost wholly black.

Two steps were taken to offset this variability in fly susceptibility between cows. First an attempt was made to group the cows so that the susceptibility of the groups was as nearly equal as possible. Each group had in it one Jersey, one Ayrshire, one Guernsey, and one Holstein. A statistical analysis of the data taken for the morning counts showed that there were no significant differences between the groups (Table 3).

Table 3. Analysis of variance of the transformed data taken during the preliminary period to determine whether the groups were properly balanced for fly susceptibility.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Hours	4	48.4	12.1
Groups	3	8.8	2.93
Hours x groups	12	14.0	1.16
Remainder	284	760.4	2.68
Total	303	837.6	

The groups were balanced as to fly susceptibility. This is shown by the fact that the ratio of the mean square for groups and the mean square for the error term is far below the 5 percent level of significance which indicates no differences among the groups.

Second, the experiment was then designed to take out as much variability as possible. To do this, each test was designed to cover a period of 16 days, using four groups of four cows each.

In each test, one group was used as an unsprayed check and three other groups were sprayed with different materials. The groups were designated as 1, 2, 3, and 4. By this procedure, each cow was exposed to the conditions of each of the four groups for four of the 16 days. By rotating the order of the cows by groups, and by averaging the results of four different groups of cows for four different four day periods, the environmental factors are minimized in comparing results (Table 4).

Table 4. The arrangement of groups in the series.

Period	Check	Spray I	Spray II	Spray III
First 4 days	Group 1	Group 2	Group 3	Group 4
Second 4 days	Group 2	Group 3	Group 4	Group 1
Third 4 days	Group 3	Group 4	Group 1	Group 2
Fourth 4 days	Group 4	Group 1	Group 2	Group 3

Time of Spraying and Fly Counting

The cows were sprayed twice daily, after which four counts were made at hourly intervals. The first spraying was begun at 6:30 a.m. and the first counts were begun approximately at 7:00 a.m. Further counts were made at 8:00, 9:00, and 10:00 a.m. It took from 40 to 50 minutes to make the counts and the cows

were brought in for milking at 10:30 a. m. They were sprayed again at 1:00 p.m. and counts were made at 1:30, 2:30, 3:30, and 4:30 p.m. The method of counting has previously been described. All counts were made by the same person throughout all the experiments. All counts were made in the field where the cows were staked out to pasture with no shade. The spraying was all done in the pavilion at the dairy barn with a small electric sprayer. Only one group was allowed in the pavilion at a time in order to prevent spray drift from one group to another. Approximately 30 cc. of spray was used for each animal. This varied some with the size of the animal. The objective was to get the animal well covered.

Arrangement of Cows in Pasture

The cows were led to pasture after they had been sprayed. Each group was led separately to prevent contact with other sprayed animals. They were staked individually at sufficient distances apart to prevent the cows from rubbing against one another.

The cows were staked to chains approximately 25 feet long and the stakes were moved each day to provide the animal with ample pasture.

Analysis of the Accuracy of Counting

There was a question raised at the beginning of the experiment about how accurately a person could count the flies on

the cows. A test was conducted to determine whether two persons counting at the same time could count, within a reasonable degree of accuracy, the number of flies on 64 cows. Both people counted on the same cow at the same time. One counted the right side and the other one the left after which they changed sides and counted. Each man kept a record of his own counts and they were compared when the counting was completed. The results of these counts are shown in Table 5. To further determine the accuracy of the counting, counts were made at five minute intervals to see if the numbers of the flies counted by one individual could be duplicated. An examination of these data shows that the counts were not significantly different. This is sufficient evidence to show that the fly counts by a single individual are reliable.

Table 5. Analysis of the accuracy of two persons counting flies on cows.

A	B	Total
41	41	82
35	36	71
45	44	89
177	178	355
46	48	94
55	66	123
25	27	52
62	62	124
53	56	109
20	22	42
32	32	64
55	56	111
17	17	34
15	12	27
29	31	60
39	36	75
31	29	60

Table 5. (cont.)

A	B	Total
46	45	91
28	28	56
49	48	97
36	35	71
27	27	54
51	50	101
40	41	81
23	31	54
15	15	30
35	35	70
61	71	132
39	39	78
25	23	48
58	66	124
158	160	318
2	2	4
3	3	6
5	5	10
39	41	80
17	17	34
15	14	29
10	10	20
93	92	185
5	5	10
10	10	20
22	18	40
9	9	18
4	4	8
4	4	8
6	5	11
22	22	44
9	9	18
4	4	8
17	17	34
88	98	186
16	18	34
5	5	10
17	20	37
66	71	137
11	10	21
6	7	13
19	19	38
29	29	58
11	10	21
10	7	17
35	39	74
Total 2077	2133	4210

Table 5. (concl.)

Source of variation	Degrees of freedom	Sum of squares	Mean square
Between cows counted	63	133,559	2120.6
Between men counting	1	25	25.0
Error	63	1,293	20.52
Total	127	134,877	

There was a highly significant difference in the number of flies counted on the various animals, but the difference between the counts of the two men was not significant. Therefore, the counts of one man can be considered accurate and reliable within a reasonable degree of error.

COMPARATIVE TESTS OF FLY REPELLENT MATERIALS

Series A

The series was conducted from June 25 until July 13. The materials used for spraying were tap water, base oil, and 3 percent thanite in base oil. One group was used as a control upon which no spray was applied. The supply of base oil was depleted on the sixth day of the series and none was obtained to continue it in the series so the series was completed with only three groups. The summary of the hourly fly counts is shown in Table 6.

Table 6. Series A to test the repellent eff ect of tap water, base oil, and 3 percent thanite in base oil to stable flies and horn flies. (June 25 - July 13, 1940)

Spray	Species of fly		Average number of flies per cow per count							
			Hour of day a.m.				p.m.			
			7:00	8:00	9:00	10:00	1:30	2:30	3:30	4:30
Check: no spray	Stable fly	Mean	34.2	43.1	45.2	41.7	33.1	41.5	40.8	37.6
		S.dev.	21.8	24.3	24.2	23.1	18.6	18.8	23.4	22.9
	Horn fly	Mean	24.9	26.5	23.6	21.2	20.0	23.3	19.6	19.7
		S.dev.	19.8	20.1	18.6	19.2	14.3	17.8	17.1	17.8
Tap Water	Stable fly	Mean	31.7	45.9	45.2	39.9	35.1	45.2	42.6	38.9
		S.dev.	19.8	24.6	22.9	17.4	16.4	19.4	20.2	17.4
	Horn fly	Mean	27.1	27.3	27.9	19.9	22.8	29.2	25.4	22.3
		S.dev.	20.1	21.4	20.9	18.6	14.4	16.8	11.4	10.4
Base oil (inc.	Stable fly	Mean	24.0	34.0	38.4	39.1	27.6	35.0	42.0	42.9
		S.dev.	12.2	16.4	18.6	19.9	11.4	12.6	16.3	14.8
	Horn fly	Mean	13.7	16.9	14.6	17.6	11.2	15.9	14.4	14.0
		S.dev.								
Thanite 3%	Stable fly	Mean	9.8	18.3	27.3	29.7	11.0	17.2	22.2	25.9
		S.dev.	7.8	12.4	18.6	19.4	6.5	8.2	9.4	9.6
	Horn fly	Mean	0.5	2.1	3.2	4.5	0.3	1.6	2.4	4.5

It will be noted that the group mean for the no spray group and tap water group followed each other very closely and this was noted throughout the daily counts. There was never very much difference between the counts of these two groups. The base oil counts were about 30 percent lower than the check for the stable fly and 50 percent lower for the horn fly during the first hour but they increased steadily. At the fourth hour after spraying there was no significant difference between the base oil count, the unsprayed counts, or the tap water check counts. The group sprayed with thanite 3 percent was definitely below the others in all counts. The population mean on the thanite 3 percent group in the morning counts was only 25 percent of the unsprayed group during the first hour, 35 percent during the second hour, 60 percent the third hour, and 70 percent the third hour for the stable flies. The horn fly population on the thanite 3 percent group were negligible (Table 6). Table 7 contains the statistical analysis of this series.

The petroleum oil spray apparently had no significant effect on the milk production either favorable or unfavorably (Table 8).

The object of spraying one group with tap water was to try to determine the effect of the mechanics of spraying upon the milk production of a dairy cow. From the results, as shown in Table 8, no significant effect was demonstrated. In no group was the group average for the tap water treatment below the group average for the unsprayed controls.

The test was conducted to determine if there would be an increase in milk production by cows protected from the flies but the results gave no evidence of this during the test.

Table 7. Analysis of variance. The transformed data for the the stable fly counts and the analysis of variance for Series A to compare the fly population on cows when sprayed with 3 percent thanite in base oil and when unsprayed.

(Each number is the total of the transformed data for that hour)

Spray	Hour of day				
	7:00	8:00	9:00	10:00	Total
Check	364.0	403.0	426.6	407.3	1600.9
Tap water	338.5	401.9	408.0	392.3	1540.7
Thanite 3%	179.2	268.1	211.6	342.7	1101.6
Total	881.7	1073.0	1146.2	1142.3	4243.2

Source of variation	Degrees of freedom	Sum of squares	Mean square
Hours	3	240.40	80.13
Sprays	2	580.40	290.20
Hours x sprays	6	75.79	12.63
Remainder	756	1899.64	2.51
Total	767	2796.32	

Table 7. (cont.)

(Each number is the total of the transformed data for that hour)

Spray	Hour of day				
	1:30	2:30	3:30	4:30	Total
Check	290.9	325.6	324.6	314.3	1255.4
Tap water	282.3	322.8	323.5	313.0	1241.6
Thanite 3 %	178.7	216.4	247.7	264.6	907.4
Total	751.9	864.8	895.8	891.9	3404.4

Source of variation	Degrees of freedom	Sum of squares	Mean square
Hours	3	373.37	186.69
Sprays	2	73.71	36.86
Hours x sprays	6	45.33	7.56
Remainder	612	1872.97	3.06
Total	623	2365.38	

The conclusion that the fly population is different at different hours of counting is proved by the fact that the ratio between the mean square for hours and the mean square for error term exceeds 5.14 which is necessary for the 5 percent level of significance.

Table 8. Summary of the daily milk production for Series A. (June 25 - July 13, 1940)

Spray	Average daily production of milk in pounds					
	Group 1	Group 2	Group 3	Group 4	Total	Mean
Check (no spray)	31.73	19.83	32.93	37.08	121.57	30.39
	29.93	19.90	34.43	33.05	117.31	29.33
	30.10	19.95	29.01	33.65	112.80	28.30
	29.88	20.33	36.33	35.00	121.54	30.38
Total	121.54	80.01	132.79	138.78	473.22	118.30
Mean	30.38	20.00	33.20	34.70	118.30	29.58
Tap water	31.63	26.98	32.85	35.53	126.99	31.75
	32.88	30.33	24.68	35.88	123.77	30.94
	30.50	27.43	28.13	35.07	121.13	30.28
	31.23	28.25	35.53	33.40	128.41	32.01
Total	126.24	112.99	121.19	139.88	493.67	123.42
Mean	31.56	28.25	30.30	34.97	123.42	30.85
Thanite 3%	33.33	22.73	29.03	32.73	117.82	29.46
	33.78	24.88	36.70	36.68	122.04	30.51
	31.00	22.83	28.65	35.63	118.11	29.55
	31.00	25.35	30.30	36.25	122.90	30.75
Total	129.11	95.81	114.68	141.29	480.87	120.22
Mean	32.38	23.95	28.67	35.32	120.22	30.05

Table 8 summarizes the test on the effect of oil sprays and fly protection on milk production. The numbers in the columns headed by the different treatments are the average daily production for each cow for the four days that she was on that treatment. Each of the four numbers represents a single cow of the group. The order of tabulating the cows, from top to bottom of each cell, is Jersey, Ayrshire, Guernsey, and Holstein. The rows termed "total" are the average daily product-

ion for each group. The column termed "mean" is the average daily production for each breed for each treatment. There are only three treatments represented here because the base oil group was discontinued after six days for lack of material and no production comparisons could be made with this treatment.

In summing up Series A, the following conclusions may be drawn:

1. The act of spraying had no apparent effect on milk production.

2. Base oil showed effectiveness against flies for the first two hours.

3. Thanite 3 percent gave a marked decrease in fly population throughout the entire test period of four hours.

Series B

Series B tests were conducted from July 17 to August 3, 1940. The experimental plan followed in this series was the same as for Series A. The sprays used in this series were 1, 2, and 4 percent thanite solutions in a petroleum oil base. There was also an unsprayed control group.

The weather was unusually dry during this period. Little rain had fallen since June 15 and the pastures were becoming poor. The fly population was low. A significant difference in fly populations between the unsprayed cows and the ones that had been sprayed could be noted by causal observation without making accurate counts but differences among the sprays

were less apparent.

The results of the fly counts for this series are given in Table 9. The horn fly population was almost too small to be considered in this test but the stable fly population was large enough to provide a basis for study and conclusions (Table 10).

If Table 9 in Series B is checked against Table 6 in Series A, it will be noted that the morning stable fly counts resembled each other very closely. This provides a comparison of 3 percent thanite spray, used in Series A, with the 1 percent, 2 percent, and 4 percent thanite sprays used in this series. From this comparison, it may be said that as the percentage of thanite in the spray is increased the repellent property of the spray is increased.

Table 9. Series B to test the repellent effect of thanite 1 percent, 2 percent, and 4 percent in base oil to stable flies and horn flies. (July 17 - August 3, 1940)

Spray	Species of fly		Average number of flies per cow per count: Hour of day a.m. 7:00	8:00	9:00	10:00	p.m. 1:30	2:30	3:30	4:30
Check no spray	Stable fly	Mean	34.9	44.0	48.0	45.5	17.0	28.4	30.7	32.3
		S.dev.	18.6	24.5	24.2	22.9	11.4	14.6	16.4	16.5
	Horn fly	Mean	8.4	8.0	8.5	7.0	3.6	4.6	5.6	5.6
Thanite 3%	Stable fly	Mean	13.9	23.1	31.3	31.3	5.4	11.7	19.8	23.2
		S.dev.	11.4	13.3	17.6	18.0	5.9	9.4	18.2	21.1
	Horn fly	Mean	0.7	1.9	3.1	3.3	0.5	1.7	2.7	2.7
Thanite 2%	Stable fly	Mean	9.0	18.4	26.7	30.7	3.7	8.5	15.2	21.2
		S.dev.	6.2	13.1	17.1	18.2	8.4	11.6	16.2	21.8
	Horn fly	Mean	0.3	0.8	1.7	2.5	0.1	0.6	0.9	2.1
Thanite 4%	Stable fly	Mean	7.5	14.1	22.6	26.1	1.6	4.9	11.3	16.3
		S.dev.	7.2	12.8	16.1	17.3	3.1	6.2	12.4	15.9
	Horn fly	Mean	0.1	0.4	1.4	1.7	0.1	0.4	0.7	1.1

Table 10. Analysis of variance. The transformed data for the stable fly counts and the analysis of variance for Series B to compare 1 percent, 2 percent, and 4 percent thanite in base oil as repellents to stable flies and horn flies.

(Each number is the total of the transformed data for that hour)

Spray	Hour of day				
	7:00	8:00	9:00	10:00	Total
Check	331.2	376.7	369.0	389.6	149.35
Thanite 1%	213.9	277.4	322.8	331.6	1145.7
Thanite 2%	167.8	246.6	310.1	323.5	1048.0
Thanite 4%	150.9	216.3	272.8	295.4	935.4
Total	863.8	1117.0	1301.7	1340.1	4622.6

Source of variation	Degrees of freedom	Sum of squares	Mean square
Sprays	3	726.42	242.14
Hours	3	591.76	197.25
Hours x sprays	9	57.75	6.42
Remainder	944	2225.29	2.35
Total	959	3601.22	448.16

Table 10. (concl.)

(Each number is the total of the transformed data for that hour)

Spray	Hour of day				
	1:30	2:30	3:30	4:30	Total
Check	229.1	279.7	296.3	305.6	1110.7
Thanite 1%	125.9	186.4	253.5	280.7	846.5
Thanite 2%	103.1	159.1	221.1	263.9	747.2
Thanite 4%	73.9	119.7	182.5	225.3	601.4
Total	532.0	744.9	953.4	1075.5	3305.8

Source of variation	Degrees of freedom	Sum of squares	Mean square
Sprays	3	575.53	191.84
Hours	3	714.55	238.18
Hours x sprays	9	57.61	6.41
Remainder	944	1814.65	1.92
Total	959	3162.34	

The estimate of variance for sprays and hours are both much higher than the one percent level of significance above the mean square for the hour x spray interaction. When the single degrees of freedom were taken out, the F. for 1 percent thanite against 2 percent thanite for the afternoon was 3.2 which does not reach the 5 percent level of significance for one and none

degrees of freedom. The F. for 2 percent thanite against 4 percent thanite was 6.9 which is between the 5 percent and the 1 percent level of significance. The F. for the unsprayed check against the sprayed was 79.8 which is highly significant.

The conclusions from this analysis are:

1. The sprayed cows had less flies than the unsprayed cows.

2. Thanite 2 percent is not a better spray than thanite 1 percent.

3. Thanite 4 percent is a better spray than either 1 percent or 2 percent thanite.

As in Series A, there was no increase or decrease in milk production during the period a petroleum oil spray was used to protect the cows from flies (Table 11).

Table 11. Summary of daily milk production for Series B.

Spray	Average daily production of milk in pounds					
	Group 1	Group 2	Group 3	Group 4	Total	Mean
Check (no spray)	33.58	21.65	27.08	29.08	111.39	27.85
	30.38	20.60	27.00	28.98	106.96	26.74
	32.33	19.78	27.75	29.05	108.91	27.23
	31.58	17.63	26.70	28.26	104.17	26.04
Total	127.87	79.66	108.53	115.37	431.43	107.86
Mean	31.97	19.92	27.13	28.84	107.86	26.97
Thanite 1%	29.93	19.05	26.93	34.70	110.61	27.65
	32.38	20.05	25.58	33.85	111.86	27.97
	31.00	21.00	25.83	31.65	109.48	27.37
	29.50	19.03	27.95	31.33	107.81	26.95
Total	122.81	79.13	106.29	131.53	439.76	109.94
Mean	30.70	19.78	26.57	32.88	109.94	27.49
Thanite 2%	29.83	19.73	28.03	31.03	108.62	27.16
	27.85	16.95	29.33	31.55	105.68	26.42
	30.43	15.53	27.88	30.13	103.97	25.99
	29.68	16.45	25.95	29.83	101.91	25.48
Total	117.79	68.66	111.19	122.54	420.18	105.05
Mean	29.45	17.17	27.80	30.64	105.05	26.26
Thanite 4%	29.98	20.48	27.45	30.00	107.89	26.97
	28.75	21.30	28.55	29.68	108.28	27.07
	27.88	21.60	27.20	31.73	108.41	27.10
	25.93	20.50	24.13	28.50	99.06	24.77
Total	112.54	83.88	107.31	119.91	423.64	105.91
Mean	28.14	20.97	36.83	29.99	105.91	26.48

This table summarizes the tests on the effect of oil sprays and fly protection on milk production. In the explanation, the vertical columns of numbers under the headings of different groups will be spoken of as "columns". The horizontal rows of

numbers under each treatment will be spoken of a "rows". The term "cells" represents any of the squares containing four numbers.

The numbers in the rows headed by the different treatments are the average daily production in pounds of milk for each cow for the four days she was on that treatment. Each of the four numbers represents a single cow of the group. The order of tabulating the cows from top to bottom of each cell is Jersey, Ayrshire, Guernsey, and Holstein.

The rows termed "total" are the average daily production for each group on each treatment. The numbers in the columns headed by group numbers give the milk production of that group while on all the treatments. The column termed "mean" is the average daily production for each breed for each treatment.

To compare the productions of the different groups on the treatment, read horizontally. To compare the production of the same group while on different treatments, read vertically.

In Series B, a test was conducted to determine whether there was any effect on the body temperature of the cows from the sprays which were being used. The body temperature of the cows was taken approximately two hours after spraying every day of the series. The results showed no significant differences in the body temperatures of the sprayed and unsprayed cows (Table 12). There was, however, a definite rise in the body temperatures of the cows from the morning readings until the afternoon readings. This probably can be attributed to

Table 12. Summary of the experiment to determine the effect of petroleum oil sprays on the body temperature of dairy cows.

Group No.	Cow No.	Sprays: Check (no spray) a.m. B.T.*	Check (no spray) a.m. A.T.**	Check (no spray) p.m. B.T.	Check (no spray) p.m. A.T.	Thanite 1% a.m. B.T.	Thanite 1% a.m. A.T.	Thanite 1% p.m. B.T.	Thanite 1% p.m. A.T.	Thanite 2% a.m. B.T.	Thanite 2% a.m. A.T.	Thanite 2% p.m. B.T.	Thanite 2% p.m. A.T.	Thanite 4% a.m. B.T.	Thanite 4% a.m. A.T.	Thanite 4% p.m. B.T.	Thanite 4% p.m. A.T.
		Degrees F.															
1	7A	101.4		102.4		101.5		103.2		101.0		103.5		101.3		103.0	
	4	101.2	87	101.4	106	100.7	87	103.3	103	101.2	83	103.7	99	101.8	86	102.8	104.5
	8A	101.2		103.1		101.5		103.7		101.9		103.9		101.5		104.5	
	5A	101.6		102.3		101.6		104.1		101.5		103.2		100.6		103.2	
Total		405.4		409.3		405.3		414.3		405.6		414.1		405.2		413.5	
Mean		101.4		102.3		101.3		103.6		101.4		103.5		101.6		103.4	
2	1A	102.0		103.9		101.1		102.5		101.6		102.9		101.2		101.4	
	2A	101.3	87	103.9	103	101.6	83	102.5	99	102.0	86	103.0	104.5	100.7	87	101.9	106
	5	101.3		103.4		101.1		102.2		101.9		103.5		100.9		102.5	
	3A	101.7		102.9		101.8		102.6		100.9		101.0		101.1		101.9	
Total		406.3		414.1		405.6		409.6		406.4		410.4		403.9		407.7	
Mean		101.6		103.5		101.4		102.4		101.6		102.6		101.0		101.9	
3	7	100.9		102.7		101.9		103.2		101.2		102.5		101.4		101.7	
	6	101.7	83	102.7	99	101.6	86	102.7	104.5	100.5	87	102.7	106	100.8	87	102.1	103
	4A	101.6		102.4		101.0		101.4		101.5		102.8		102.2		102.4	
	3	101.4		102.6		100.6		101.7		101.1		102.7		101.4		103.5	
Total		405.6		410.4		405.1		409.0		404.3		410.7		405.8		409.7	
Mean		101.4		102.6		101.3		102.3		101.1		102.7		101.5		102.4	
4	2	101.4		103.6		101.0		102.5		101.3		103.5		100.6		103.5	
	1	101.7		102.8		101.5		102.8		101.9		103.1		101.8		103.4	
	8	101.8	86	103.5	104.5	101.5	87	103.1	106	101.9	87	102.9	103	101.9	83	103.5	99
	6A	100.5		101.9		101.5		102.8		101.7		102.3		101.7		102.3	
Totale		405.4		411.6		405.3		411.2		405.8		411.8		406.2		412.7	
Mean		101.4		102.9		101.4		102.8		101.7		103.9		101.0		103.2	

* Average body temperature for four days.

** Average air temperature, degrees F., for four days for the hour when the body temperature was taken.

the increase in the air temperature. It will be noted from Table 12 that this relationship is evident.

This table summarized the work on the effect of a petroleum oil spray on the body temperature of these experimental animals.

To help clarify the explanation, the following terms will be defined. Columns will be the term applied to the vertical columns of numbers under the headings of groups.

Rows will be the term applied to the horizontal rows of numbers headed by the different treatments used in this series.

Cell is the term applied to any of the individual divisions of the table containing four numbers.

The numbers in the rows are the average body temperature for each cow for the four days she was on that treatment. Each number in each cell represents a single cow in the group. The order of tabulating the cows from top to bottom of each cell is Jersey, Ayrshire, Guernsey, and Holstein. The row termed "mean" is the mean temperature of the four animals for four days.

The columns a.m. are the temperatures taken approximately two hours after spraying in the morning. The columns p.m. are the temperatures taken approximately two hours after spraying in the afternoon.

To compare the reactions of different groups on the same treatment, read horizontally. To compare the reaction of the same group on different treatments, read vertically.

The conclusions indicated by the tests in Series B are that all the sprays had definite repelling properties. The sprays ranked according to their percentage of thanite in the solution. Each increase in percentage of thanite increased the effectiveness of the spray. It will also be noted that the horn fly population had practically disappeared. These flies are very easily killed with any type of spray and it is probable that the continuous use of a good spray might keep them well under control.

The protection from the flies in this test did not show any tendency to increase milk production.

The use of petroleum oil sprays had no apparent effect on the body temperatures of the animals and no evidences of harmful effects to the skin or hair cost were observed after four days of spraying.

Series C

Series C was started August 5 and was completed September 9. The plan of procedure was the same for this series as for the two preceding ones. The materials used for this series were petroleum base oil, insecticide No. 1 (5 percent - 20/1 pyrethrum in base oil), and 5 percent thanite in base oil. The reason for using base oil in this test was to get a complete test with this material, because the earlier test with it in Series A was incomplete since it was only used for six days.

There was a 12 day break in this series due to rain.

This interval came at the end of the first four days. It was too wet to continue until August 20, when the series was started again and carried to completion without a break until September 9. During the rainy period the fly population built up again. Before the rains started, pasturage was poor and the heat was so intense that the cows had to be taken to water. These conditions were much improved when the series was resumed.

This is probably the most valuable series conducted during the summer because the 5 percent thanite spray was in direct comparison in the test with 5 percent - 20/1 pyrethrum. The comparisons were made with a comparatively high fly population. The results of the series are summarized in Tables 13 and 14.

The base oil was effective for the first two hours but by the end of that time the fly population had increased to sufficient numbers to annoy the animals. The pyrethrum spray was fairly effective for two and one-half to three hours but by that time the fly population had increased to large enough numbers to cause distress to the animals.

Table 13. Series C to test the repellent effect of base oil, 5 percent (20/1) pyrethrum in base oil, and 5 percent thanite in base oil to stable flies and horn flies.
(August 6-8; August 20 - September 9, 1940)

Spray	Species of fly		Average number of flies per cow per count							
			Hour of day a.m.				p.m.			
			7:00	8:00	9:00	10:00	1:30	2:30	3:30	4:30
Check (no spray)	Stable fly	Mean	40.1	63.8	68.7	63.9	47.5	63.7	70.6	64.9
		S.dev.	31.4	24.3	25.3	25.4	24.5	35.0	35.2	33.8
	Horn fly	Mean	56.8	70.7	65.9	59.9	39.0	41.2	40.4	46.0
		S.dev.	33.2	41.6	39.2	36.3	20.1	21.2	20.8	24.1
Base oil	Stable fly	Mean	14.8	36.9	55.6	56.4	24.8	41.4	56.6	60.5
		S.dev.	13.2	18.4	26.3	25.4	16.9	21.1	28.1	32.9
	Horn fly	Mean	12.6	20.4	27.3	27.6	6.2	13.4	19.6	27.5
		S.dev.	7.6	13.8	15.4	14.1	4.2	11.4	15.6	13.4
Thanite 5%	Stable fly	Mean	2.3	6.7	13.1	19.3	4.2	11.2	17.4	21.5
		S.dev.	2.9	5.8	7.8	9.1	3.8	5.1	10.1	11.1
	Horn fly	Mean	0.07	0.17	0.4	1.2	0.18	0.7	1.1	2.0
		S.dev.								
Insecticide No. 1	Stable fly	Mean	5.2	13.1	26.2	35.7	8.4	20.5	33.3	36.5
		S.dev.	5.3	7.6	12.3	16.8	17.3	11.6	17.5	18.2
	Horn fly	Mean	0.27	1.23	2.5	4.7	0.4	1.6	3.3	4.5

Table 14. Analysis of variance. The transformed data and analysis of variance of the stable fly counts for Series C to compare the repellency of base oil, 5 percent (20/1) pyrethrum in base oil, and 5 percent thanite in base oil to stable flies and horn flies.

(Each number is the total per spray per hour of the transformed data)

Spray	Hour of day 7:00	8:00	9:00	10:00	Total
Check (no spray)	365.7	469.2	490.2	471.3	1796.4
Base oil	212.6	353.7	442.0	445.1	1453.4
Insecticide No.1	126.9	207.3	298.6	351.5	984.3
Thanite 5%	88.5	149.9	212.4	261.4	712.2
Total	793.7	1180.1	1443.2	1529.3	4946.3

Source of variation	Degrees of freedom	Sum of squares	Mean square
Hours	3	1389.95	463.32
Sprays	3	2881.97	960.66
Hour x spray	9	158.06	17.56
Remainder	944	1793.30	1.89
Total	959	6223.28	

Table 14. (concl.)

(Each number is the total per spray per hour of the transformed data)

Spray	Hour of day 1:30	2:30	3:30	4:30	Total
Check (no spray)	404.4	465.6	492.1	444.6	1806.7
Base oil	275.3	375.0	443.3	430.7	1524.3
Insecticide No.1	161.8	260.6	336.7	342.4	1101.5
Thanite 5%	122.0	187.1	241.0	254.2	804.3
Total	963.5	1288.3	1513.1	1471.9	5236.8

Source of variation	Degrees of freedom	Sum of squares	Mean square
Hours	3	453.32	151.11
Sprays	3	2507.89	835.90
Hour x spray	9	602.59	66.90
Remainder	928	2209.38	2.38
Total	943	5773.08	

(F. for 5 percent - 5.12 1 percent 10.28)

If the interaction mean square is used for an error term, the only mean square reaching the 5 percent level of significance is the one for sprays. Some comparisons were made using individual degrees of freedom when the unsprayed check group was compared with the three group that were sprayed for the morning counts, the F. was 100.1 for one and nine degrees

of freedom which is above the 1 percent level of significance. When base oil was compared with insecticide No. 1, the F. was 26.1 which for one and nine degrees of freedom is above the 1 percent level of significance when insecticide No. 1 was compared with 5 percent thanite the F. was 8.8 which is between the 5 percent and 1 percent levels of significance. The analysis for the afternoon counts gave approximately the same results except that the F. for the comparison of base oil and insecticide No. 1 was between the 5 and 1 percent levels of significance.

The milk production test gave the same results as in the two preceding series. The summary is given in Table 15. Even with the protection from flies given by the thanite spray, the milk production was not increased over the unsprayed group.

In conclusion, it can be said that in this test 5 percent thanite excelled a good commercial fly spray now on the market. Although the protection from flies gave no measurable effect on milk production, the ease of handling and the comfort of the cattle cannot be overlooked. The number of flies necessary to cause an animal worry depends upon the size and temperament of the animal. The large Holsteins tolerated a population of 40 to 50 stable flies and 60 to 75 horn flies very well, but the smaller cows started their fly fighting activities with a population of half that number.

Table 15. Summary of the dairy milk production for Series C.

Spray	Average daily production of milk in pounds					
	Group 1	Group 2	Group 3	Group 4	Total	Mean
Check (no spray)	28.95	18.70	23.70	31.63	102.98	25.75
	29.35	19.23	24.79	32.90	106.26	26.57
	30.73	19.33	22.00	29.60	101.66	25.42
	29.80	17.75	23.88	27.90	99.33	24.83
Total	120.81	75.01	94.36	122.03	410.23	102.56
Mean	30.20	18.75	23.59	31.51	102.56	25.64
Base oil	31.00	18.65	24.15	30.60	104.30	26.08
	31.60	16.60	25.15	30.10	103.45	25.86
	30.90	16.90	24.70	30.50	103.00	25.75
	31.60	15.10	22.25	30.20	99.75	24.94
Total	125.10	67.25	96.25	121.40	410.50	102.63
Mean	31.28	16.81	24.06	30.35	102.63	25.66
Thanite 5%	30.53	15.25	26.88	31.68	104.39	26.10
	29.03	15.68	25.73	30.28	100.72	25.18
	27.20	16.35	26.68	33.28	103.51	25.88
	27.53	13.33	26.33	33.12	100.31	25.08
Total	114.34	60.61	105.62	128.28	408.93	102.23
Mean	28.39	15.15	26.41	32.07	102.23	25.56
Insecticide No.1	27.43	18.18	27.10	33.78	106.49	26.62
	31.88	18.35	25.33	31.53	107.09	26.77
	29.10	18.70	25.55	29.88	103.23	25.81
	26.85	18.08	25.73	31.30	101.96	25.49
Total	115.26	73.31	103.71	126.49	418.77	104.69
Mean	28.82	18.33	25.93	31.62	104.69	26.17

This summarized the tests on the effect of oil sprays and fly protection on milk production. In the explanation of this table, the columns of numbers under the heading of different groups will be spoken of as "columns". The horizontal rows of numbers reading across from each treatment will be spoken of as "rows". The term "cell" refers to any of the subdivisions of

the table containing four numbers. The numbers in the rows are the average daily production for each cow for the four days she was on that treatment. Each of the four numbers in each cell represents a single cow. The order of tabulating the cows from the top to bottom of each cell is Jersey, Ayrshire, Guernsey, and Holstein. The rows termed "totals" are the average daily production for each group on each treatment. The numbers in each column gives the average milk production of each cow in each group under every treatment. The column termed "mean" is the average daily production for each breed for each treatment.

To compare the production of the different groups on the same treatment, read horizontally. To compare the production of the same group on the different treatments, read vertically.

STUDIES OF FLY SUSCEPTIBILITY OF ANIMALS USED

Susceptibility of Breeds Used

The four breeds used in this experiment were Holstein, Ayrshire, Guernsey, and Jersey.

An analysis of variance test was made to determine the relative fly susceptibility of the breeds used. The results of the tests are shown in Table 17. This analysis shows that the Holstein breed had greater numbers of flies counted on them than did the other breeds and that there were no significant differences among the other breeds. The reason for using the estimate of variance for cows within a breed as the error term was if the variability among breeds is not greater

Table 17. Analysis of variance of the breed susceptibility.

Source of variation		Degrees of freedom	Sum of squares	Mean square
Breeds	(Holsteins vs. other three)	1	1282.52	1282.52
	Remainder	2	78.97	39.49
(Pooled) Cows within breed		12	469.38	39.12

Table 18. An analysis of variance of the variability of the fly susceptibility of cows within a breed.

Source of variation	Degrees of freedom	Sum of squares	Mean squares
Jersey	3	30.69	10.23
Ayrshire	3	30.54	10.18
Guernsey	3	4.41	1.27
Holstein	3	403.74	134.58
(Pooled) (Days within series) (error)	40	1372.21	34.31

than that of cows within a breed, then it would not be safe to say there were differences.

Susceptibility of Cows Within a Breed

To study the variability of cows within a breed, an analysis of variance test was made. The results of these tests are shown in Table 18. From this analysis, it will be noted that only in the Holstein breed was there any significant variability of cows within a breed. From this analysis and the preceding one, the conclusion can be drawn that there were no differences among any of the cows in the Jersey, Ayrshire, and Guernsey breeds. To give further proof of this, the mean for all the counts for the entire experiment on each cow used will be given in Table 19.

This means that the means would have to vary by at least 1.03 to reach the 5 percent level of significance and by 1.36 to be highly significant. None of the cows in the Ayrshire, Jersey, and Guernsey breeds vary from each other by that much. Two of the Holsteins were significantly higher than any of the other 14 cows. All of the Holsteins were higher than the others but the lowest two were not significantly higher than the other breeds.

SUMMARY

The purpose of these experiments was to compare the repellent effect of eight fly sprays against stable flies

Table 19. The mean of transformed counts made on each cow for the entire experiment.

Cow No.	Total	Mean	Breed
6A	1108.2	6.93	Holstein
5A	1075.9	6.72	Holstein
3A	864.2	5.40	Holstein
3	817.9	5.11	Holstein
1A	711.0	4.44	Jersey
2	706.8	4.41	Jersey
8A	703.5	4.40	Guernsey
6	703.0	4.39	Ayrshire
5	701.2	4.38	Guernsey
8	693.0	4.33	Guernsey
4A	669.9	4.19	Guernsey
7	643.0	4.02	Jersey
7A	635.2	3.97	Jersey
2A	625.6	3.91	Ayrshire
1	622.7	3.89	Ayrshire
4	619.1	3.87	Ayrshire

5 percent 1.03 1 percent d 1.56

(Stomoxys calcitrans Linn.), and horn flies (Haematobia irritans Linn.) on dairy animals and to study the effect of the sprays on the animals. Sixteen cows, selected for uniformity in stage of lactation, consisting of four from each of the folloring breeds, Jersey, Ayrshire, Guernsey, and Holstein, were divided into experimental spray test groups containing one of each breed for three sprays and an unsprayed check. These experimental groups were rotated every four days so that each group of cows served for four days in each capacity. The groups were balanced in relative fly susceptibility before the tests were begun. The work was begun with four days of preliminary observation, during which hourly fly counts were made on unsprayed cows. These counts indicated that the greatest fly activity occured from 8:30 to 9:30 a.m. and from 2:30 to 3:30 p.m.

Sprayings were made at 6:30 a.m. and 1:00 p.m. in the dairy barn pavilion. Only one group was admitted at a time to prevent spray drift from one group to another. Approximately 30 c.c. of spray per animal was used at each spraying. After the cows were sprayed, they were staked individually at a sufficient distance from each other to prevent contamination from other sprays by contact. The counting was all done by the same individual. The accuracy of counting was determined by comparing the counts made by two persons. A statistical analysis of the counts showed the differences to be nonsignificant.

The spray materials used in the experiments were tap water, base oil, 1, 2, 3, 4, and 5 percent thanite in base oil,

and 5 percent pyrethrum extract in base oil.

Base oil alone reduced the fly population on the cows such that they caused the animals no distress for the first hour after which it rapidly lost its effectiveness.

Thanite of 1, 2, 3, 4, and 5 percent solutions in the base oil greatly reduced the numbers of flies on the animals compared with the reduction by base oil alone. The reduction in numbers of flies on the animals was in direct proportion with the increase in percentage of thanite.

Fly counts made on animals sprayed with 5 percent thanite in base oil seldom exceeded 50 percent of those counted on cows sprayed with 5 percent pyrethrum extract in the same base oil.

There was no indication that the use of these petroleum oil sprays had any effect on milk production.

There was no measurable rise in the body temperatures of the animals that could be attributed to the use of petroleum oil sprays. No ill effects from oil sprays to the skin or hair coat of the animals were observed.

Counts of flies on black spots and white spots of equal size on the same animal showed that there was approximately twice the number of flies on the black as on the white.

Counts on Holsteins and on cows of similar size but of different color and breed showed a greater number of flies on the Holsteins. Animals of this breed were almost wholly black and had nearly twice as many flies on them as those of the other breeds.

The conclusions made in these tests were all substantiated by accepted methods of statistical analysis of variance.

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LITERATURE CITED

Beach, C. L. and Clark, A. B.
Protecting cows from flies. Storrs Agr. Expt. Sta. Bul. 32:7-14. Dec., 1904.

Cleveland, C. R.
Repellent sprays for flies attacking dairy cattle. Jour. Econ. Ent. 19:529-532. June, 1926.

Cory, E. N.
The protection of dairy cattle from flies. Jour. Econ. Ent. 10:111-113. Feb., 1917.

Freeborn, S. B., Regan, W. M., and Folger, A. H.
The relation of flies and fly spray to milk production. Jour. Econ. Ent. 18:779-790. Dec., 1925.

The relation of flies and fly spray to milk production. Jour. Econ. Ent. 21:494-501. June, 1928.

Gnadinger, Carl and Corl, C. S.
The relative toxicity of pyrethrins and rotenone as fly spray ingredients. Jour. Econ. Ent. 25:1237-1240. Dec., 1931.

Hadwen, S.
Fly attack and animal colouration. Transactions of the Fourth International Congress of Entomology. 2:199-202 August, 1928.

Lush, R. H. and Cave, H. W.
The testing of fly sprays on dairy cattle. Unpublished reports. Kans. State Col. of Agr. and Appl. Sci., Dept. of Dairy Husbandry. 1925, 1928.

Melvin, Roy
Physiological studies on the effect of flies and fly sprays on cattle. Jour. Econ. Ent. 25:1151-1164. Dec., 1932

Pearson, A. M., Wilson, J. L., and Richardson, C. H.
Some methods used in testing cattle fly sprays. Jour. Econ. Ent. 26:269-274. Feb., 1933.

Redding, W. V.
Some comparative tests of fly sprays, fly repellents, and insect electrocutor as a means of control of the common flies on college dairy cattle. Unpublished thesis. Kans. State Col. of Agr. and Appl. Sci. 41 pages. 1934.