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EFFECT OF SEVERAL INSECTICIDES ON THE TOTAL ARTHROPOD POPULATION IN ALFALFA

by

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The Effect of Several Insecticides on the Total Arthropod Population in Alfalfa[1]

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ABSTRACT

Sprays containing parathion, malathion, demeton, endrin or toxaphene applied to alfalfa caused marked reductions of the total arthropod populations. Reductions were greater for the phytophagous species as a group than for the entomophagous species. The toxic effects of some of the insecticides to certain insect predators created favorable conditions for their prey which became more numerous later on in the sprayed plots than in the untreated checks. The specificity of certain of the insecticides caused profound changes in the components of the populations. The residual effects of all of the above were quite limited due to migration into or between plots. At the dosages used, namely 3 pounds toxaphene, ½ pound malathion, and ¼ pound each of parathion, endrin or demeton,—toxaphene was generally less effective than the others. Parathion was the most toxic to some of the beneficial species and endrin was the least toxic.

Considerable work has been done in the past few years on the effects of insecticides on beneficial insects, but so far as is known, no work has been published on the effects of insecticides on the total arthropod population in alfalfa. This paper reports results of a two-year study, 1954 and 1955, on the effect of insecticide spray applications on the total arthropod population in alfalfa. Gaines (1954), van den Bosch *et al.* (1956), Ahmen (1954) and Wene (1953, 1954), studied the effects of a number of compounds on the beneficial species present in various crops including alfalfa.

The data reported in this paper are based on a study of the effects of toxaphene, parathion, endrin, and demeton (Systox) applied to small replicated plots, each 1/40 acre in size, and in one large scale field test where malathion was the insecticide used. The untreated checks in the small plot tests were replicated the same as the sprayed plots but in the large scale test there were no replications and the check was a ⅝-acre plot of alfalfa in the same field. The insecticides were applied to the small plots at the rate of 40 gallons per acre April 26 and June 10, 1954; and July 8, 1955, at the following amounts of actual toxicants per acre: toxaphene, 3 pounds, parathion, endrin, and demeton, ¼-pound each. In the large scale test, malathion was applied at the rate of ½-pound in 8 gallons of spray per acre, May 3, 1955.

Populations were determined by sweeping with an insect net at the rate of 25 to 50 sweeps per plot or sampling area, depending upon a pilot sample estimate of the numbers of arthropods present. In the small plot tests each plot replicated was sampled; in the large scale field test, there were five sampling areas staked out in the sprayed part of the field and five in the check area. Samples were taken before treatment, immediately after and subsequently at various intervals, usually weekly, weather permitting. The procedure used has been reported by Fenton & Howell (1957). Determinations were made by specialists.[2]

Due to the enormous numbers of insects and spiders collected it is impossible to present all of the data by species, nor is this necessary. However, it is well to point out that a total of 396 species of insects, 15 species of spiders, and several species of mites were collected. Most of these were not taken in sufficient numbers to be included in a statistical analysis of the data. Instead, with the exceptions noted later in this report, they were grouped together for one part of the study, into four

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Table 4.—Effect of four insecticides applied July 6 to alfalfa on the populations of the most common arthropods, 1955.

Arthropods and Stage of Development	Number Collected per 125 Sweeps on Dates[a] Shown (July)														
	Untreated			Toxaphene			Parathion			Demeton			Endrin		
	6	8	15	6	8	15	6	8	15	6	8	15	6	8	15
Hippodamia convergens, A	8	13	19	15	3	14	8	1	1	20	0	1	10	1	2
H. convergens, L	9	6	49	12	7	34	3	4	1	7	0	1	9	4	3
Collops quadrimaculatus	0	1	45	0	1	21	0	0	22	0	0	15	0	0	19
Acrididae, N	13	17	28	13	2	8	17	1	29	15	1	16	8	0	1
Lygus lineolaris, A	17	10	13	34	2	13	48	0	19	39	1	9	33	1	10
L. lineolaris, N	11	7	24	14	2	1	14	1	23	29	0	10	14	1	6
Nabis alternatus, A	8	9	8	7	5	5	5	0	3	6	1	1	5	3	0
N. alternatus, N	3	2	4	3	2	3	2	0	1	5	0	7	3	3	5
Orius insidiosus, A	14	5	91	14	0	202	24	1	202	28	3	179	18	3	213
O. insidiosus, N	61	14	33	46	4	2	66	4	4	53	7	5	58	4	1
Geocoris sp., A	1	1	9	1	0	1	2	0	2	0	0	2	1	0	5
Geocoris sp., N	0	0	20	0	0	0	0	0	2	1	0	3	0	0	1
Macrosiphum pisi	29	10	0	19	3	1	27	1	0	62	3	0	52	2	0
Therioaphis maculata	866	628	2,162	1,079	394	1,198	888	46	566	868	45	306	764	76	661
Aceratagallia uhleri, A	15	35	87	29	47	46	17	1	22	24	5	15	23	18	42
A. uhleri, N	7	9	51	7	16	21	5	0	0	5	1	1	10	7	6
Empoasca fabae, A	39	16	49	39	12	42	51	1	28	70	2	28	29	1	28
E. fabae, N	98	15	31	110	23	9	75	25	15	130	44	19	115	7	7
Chrysopa plorabunda, A	14	9	1	12	2	3	13	1	0	9	0	0	6	1	0
C. plorabunda, L	0	4	14	1	1	15	3	0	6	2	0	5	0	2	11
Frankliniella occidentalis	19	6	78	35	5	72	45	7	235	39	5	178	33	6	92
Araneida	44	46	221	—	14	123	—	19	185	—	22	176	—	10	112
Other species	225	84	399	8	80	808	58	51	463	13	69	465	17	47	404
Totals	1,501	947	3,436	1,482	625	2,442	1,332	164	1,829	1,425	209	1,442	1,208	197	1,629

[a] The temperature was 87, 88, and 92° F., respectively, at the time the collections were made. Three was no wind.

taken. Toxaphene and endrin were every effective and residual. Other materials failed to reduce populations because of continued hatching of the eggs in the various plots.

Lygus lineolaris (P. deB.): Malathion was effective against nymphs and adults in the large scale test. No significant changes were noted in the small plots.

Nabis alternatus Parshley: Parathion and malathion were the only toxic materials against this species.

Orius insidiosus (Say): Endrin, toxaphene, parathion and demeton were very toxic.

Therioaphis maculatus: Parathion, demeton and endrin caused marked reductions; toxaphene was less effective in one test. There is evidence that this species increased in the large scale experiment because malathion killed great numbers of the convergent lady beetle.

Macrosiphum pisi: Biological control masked the direct effect of the insecticides on this species, but population increases were recorded in plots sprayed with parathion, toxaphene and demeton. Populations remained lower in the plots sprayed with endrin than in the checks.

Aceratagallia uhleri: Parathion, demeton and endrin were very effective; toxaphene less so.

Empoasca fabae (Harris): Parathion, demeton, and endrin were quite effective.

Chrysopa sp.: Population differences between treated plots and checks were not statistically significant.

EFFECT ON THE DIPTERA, HYMENOPTERA, AND ARANEIDA.—No evidence was found that any of the materials reduced fly populations. None of the insecticides had any measurable effect upon the populations of entomophagous Hymenoptera. There was also no relation between the numbers of spiders collected and spray treatments.

PARASITE-PREDATOR-APHID RATIOS IN SPRAYED AND CHECK PLOTS.—Since the population of aphids was greater in the plots sprayed with certain of the insecticides, notably parathion and malathion, than in the checks, there was the possibility that these materials had made conditions more favorable for the aphids by killing their natural enemies. Comparable parasite-predator-host ratios were studied for all of the plots sprayed with parathion or malathion in 1954 and 1955 to determine this point. The data are shown in table 5. The natural enemy complex consisted of the convergent lady beetle, the *Aphidius* parasite (a Braconid that did not parasitize *Therioaphis maculata*) and *Chrysopa* species. In 1954 the aphid was *M. pisi* and in 1955 *M. pisi* and *T. maculatus*. It is seen that for 1954 (table 5) and for the large scale test in 1955 (table 5) following spraying there were more natural enemies per aphid in the checks whereas the reverse was true in the sprayed plots. June 4, 1954, these differences had disappeared possibly due to the greater attraction of the natural enemies to the heavier aphid populations in the sprayed plots. In the small plot tests in 1955, (table 5) the ratio was also more favorable in the check plots than in the parathion plots and increased slightly July 15 in the check plots. On the other hand, it

Table 5.—Parasite-predator-aphid population[a] ratios in alfalfa sprayed with malathion and parathion. 1954–1955.

Date	Numbers of Aphids per 125 Sweeps		Number of Enemies to Aphid	
	Untreated	Treated	Untreated	Treated
		Parathion, 1954		
Apr. 28	50	91	4.5– 1	1 – 1.2
May 5	5	32	12.4– 1	1.5– 1
May 22	13	38	1 – 1	1 –12.7
May 28	46	148	1 – 4	1 –29.6
June 4	413	940	1 –23	1 –16
June 9	290	553	1 – 9	1 –12.6
		Parathion, 1955		
July 6	895	915	1 –28	1 –34
July 8	639	47	1 –20	1 – 7.8
July 15	2162	566	1 –26	1 –70
		Malathion, 1955		
May 10	138	428	2.4– 1	1 – 3.6
May 17	56	197	1.1– 1	1 – 5.2
May 24	22	73	1.7– 1	1 – 2.4
May 31	38	145	1 – 2	1 – 6.3

[a] Aphids were primarily the pea aphid in 1954 and in 1955 the pea aphid and the spotted alfalfa aphid were involved.

Table 1.—Effect of four insecticides applied April 26 to alfalfa on the populations of the most common arthropods, 1954.

	Number Collected per 100 Sweeps										
	Untreated			Toxaphene		Parathion		Demeton		Endrin	
	April		June	April	June	April	June	April	June	April	June
Arthropods[a]	24	28	9	28	9	28	9	28	9	28	9
Hippodamis convergens, A	906	79	1	26	2	19	10	53	11	46	1
H. convergens, L	238	54	16	53	15	19	17	27	18	53	12
Lygus lineolaris, A	220	15	38	21	17	24	28	22	32	7	11
L. lineolaris, N	78	16	89	7	32	4	55	12	31	0	18
Nabis alternatus, A	62	10	5	4	4	1	11	8	9	6	2
N. alternatus, N	0	24	43	10	19	4	19	26	28	24	30
Orius insidiosus, A	1	0	10	1	16	1	49	0	37	0	13
O. insidiosus, N	0	0	149	0	110	0	169	0	126	0	127
Nysius raphanus	672	35	0	24	0	30	1	68	0	28	0
Aphidius sp.	454	1	11	9	8	9	14	3	24	4	2
Macrosiphum pisi	8,296	50	290	52	379	91	553	56	438	44	114
Aceratagallia uhleri, A	338	170	62	85	32	57	8	36	64	35	31
A. uhleri, N	2,880	1,549	67	706	116	382	69	116	47	196	107
Chrysopa plorabunda, A	4	4	0	1	0	2	0	1	1	2	0
C. plorabunda, L	108	73	4	48	5	24	3	85	6	54	1
Frankliniella occidentalis	0	2	229	4	220	3	340	5	295	1	196
Araneida sp.	58	38	55	35	70	37	82	43	84	18	48
Other species	498	148	150	161	309	139	347	139	365	138	255
Totals	14,813	2,268	1,219	1,247	1,354	846	1,775	700	1,616	655	968

[a] A, denotes adults; L, larvae; N, nymphs.

classes; phytophagous, entomophagous, pollen and nectar feeders, and scavengers. The first two classes comprised most of the species collected and it is for these that the data have been compiled and analyzed.

TESTS IN 1954.—The effects of the four insecticides on the total spider-insect population are shown in tables 1 and 2. The first application of the insecticides caused a greater reduction in the plant feeders April 28 than it did in the entomophagous species. By June 9, however, there was little difference between the populations of these groups and the checks indicating that a recovery had taken place (table 1).

The second sprays were applied June 10 and their effects upon the arthropod populations June 14 and 29 are shown in table 2. When these data were analyzed for the entomophagous totals they showed that June 14 reductions were lower than in the checks with the least differences shown in the toxaphene plots and the least reductions and therefore greatest differences in the demeton plots. For the phytophagous species only parathion and demeton had caused greater reductions than in the checks. June 29, toxaphene and demeton had caused a greater reduction in the total entomophagous species than the checks, whereas parathion and endrin reductions were less than in the checks.

During the course of the experiment, the alfalfa leafhopper, *Aceratagallia uhleri* Van D., was by far the most common species, comprising more than 90% of the total population during the first test. Therefore, the effects of the several insecticides on this species determined to a large extent the degree of reduction of the total arthropod population. The pea aphid, *Macrosiphum pisi* (Harris),

Table 2.—Effect of four insecticides applied June 10 to alfalfa on the populations of the most common arthropods, 1954.

	Number Collected per 125 Sweeps on Dates[a] Shown (June)														
	Untreated			Toxaphene			Parathion			Demeton			Endrin		
Arthropods and Stage of Development	9	14	29	9	14	29	9	14	29	9	14	29	9	14	29
Hippodamia convergens, A	1	7	2	2	7	0	10	5	1	11	4	2	1	6	2
H. convergens, L	16	3	0	15	3	0	17	3	0	18	0	1	12	0	0
Lygus lineolaris, A	38	6	0	17	5	1	28	15	0	32	8	0	11	8	2
L. lineolaris, N	89	18	0	32	2	0	55	1	2	31	5	0	18	0	2
Nabis alternatus, A	5	0	1	4	1	1	11	0	0	9	2	0	2	3	0
N. alternatus, N	43	22	0	19	14	0	19	6	1	28	10	2	30	19	1
Orius insidiosus, A	10	11	1	16	9	2	49	25	0	37	24	1	13	10	13
O. insidiosus, N	149	12	4	110	3	6	169	9	12	126	19	16	127	19	23
Aphidius sp.	11	4	0	8	0	0	14	4	5	24	4	1	2	3	0
Macrosiphum pisi	290	8	0	379	6	0	553	10	1	438	16	4	114	4	0
Aceratagallia uhleri, A	62	104	645	32	57	869	8	5	224	64	33	440	31	50	698
A. uhleri, N	67	149	301	116	219	273	69	9	35	47	43	177	107	112	148
Empoasca fabae, A	12	13	6	22	9	7	31	6	6	33	8	6	5	6	6
E. fabae, N	?	3	0	0	2	3	3	1	3	3	1	1	4	0	3
Spissistilus festinus	0	4	16	2	7	40	1	3	46	0	5	64	0	4	17
Frankliniella occidentalis	229	50	20	220	47	10	340	64	25	295	55	67	196	66	56
Araneida	55	122	180	70	133	354	82	242	427	84	265	531	48	144	305
Other species	142	201	217	290	175	303	316	205	413	336	231	478	247	168	259
Totals	1,219	737	1,393	1,354	699	1,869	1,775	613	1,201	1,616	733	1,791	968	622	1,537

[a] The temperature was 81, 84, and 81° F., respectively, and the wind velocity was 4, 3, and 0 m.p.h., respectively, at the time the collections were made.

Table 3.—Effect of malathion applied May 3 to alfalfa on the populations of the most common arthropods, 1955.

Arthropods and Stage of Development	Number Collected per 125 Sweeps on Dates Shown								
	May 3	May 10		May 17		May 24		May 31	
	Check	Check	Treated	Check	Treated	Check	Treated	Check	Treated
Hippodamis convergens, A	50	223	77	48	32	33	24	14	19
H. convergens, L	46	46	3	1	0	1	0	0	0
Hylemya cilicrura	3	10	11	2	5	6	7	6	4
Lyneches sp.	41	25	92	70	140	46	33	62	33
Thaumatomya glabra	2	13	52	10	25	60	21	15	29
Lygus lineolaris, A	174	78	18	46	17	37	16	23	25
L. lineolaris, N	105	3	0	17	7	27	3	19	3
Nabis alternatus, A	7	21	11	15	20	11	12	7	2
N. alternatus, N	63	63	2	0	1	3	0	1	0
Orius insidiosus, A	42	42	125	94	138	228	111	220	132
O. insidiosus, N	4	15	1	3	2	4	10	8	11
Macrosiphum pisi	15	22	39	7	37	18	63	27	116
Theriophis maculata	18,948	116	389	49	160	7	25	11	29
Ceratagallia uhleri, A	7	253	9	53	4	98	19	14	6
C. uhleri, N	0	356	1	73	7	57	0	10	2
Empoasca fabae	0	2	3	27	23	164	181	60	53
Macrosteles fascifrons	0	36	17	115	154	129	94	4	0
Chrysopa plorabunda, A	71	48	35	13	3	1	4	3	4
C. plorabunda, L	20	20	5	1	3	2	2	2	0
Araneida	50	90	99	42	73	68	52	31	18
Other species	390	564	558	566	662	1,493	1,327	505	462
Totals	20,038	2,046	2,547	1,252	1,513	2,493	2,004	1,042	948
Temperature ° F.	79	83.5		95		79		84	
Wind, m. p. h.	3	0		4.5		0		4	

nd three of its most important enemies namely, *Hippo-damia convergens* G.-M., *Chrysopa plorabunda* Fitch, and *Aphidius* sp., reached their peak of abundance prior to the irst spray application. As will be shown later, the toxic ffects of parathion on the lady beetle and to a lesser ex-ent that of demeton and toxaphene, created favorable onditions for the multiplication of *M. pisi*.

Tests in 1955.—Table 3 shows the effects of the mala-hion spray on the arthropods present in the large scale est. The spotted alfalfa aphid (*Therioaphis maculata* Buckton)) reached the peak of its abundance on the late of the spraying. The first postspraying count showed hat remarkable reduction had taken place in both the prayed and check plots. This situation was very similar o that in 1954 when the first spray application was made o control the pea aphid except that in the former year he pea aphid population had been going down steadily or some time before spraying. The reductions in the otal plant insect feeding populations in both check and prayed plots found May 10, seven days after treatment, were 95 and 97%, so were not significantly different. There continued to be very little difference in the total populations of phytophagous species up to and including May 31. On the other hand by May 10, increases were found in the entomophagus populations in the checks whereas in the sprayed alfalfa on this date only a slight increase was found. From this date on, reductions were recorded except for the checks May 24. These reductions were much lower for the entomophagous populations for the four dates than for the phytophagous populations.

The effects of the four insecticides, applied to the small plots, on the total populations of phytophagous species are shown in table 4. July 8 there was very little difference in per cent reductions caused by demeton and parathion. Endrin and toxaphene were less effective. July 15, increases had taken place in all plots, were greatest in the checks and toxaphene plots, with the smallest increase shown in the demeton plots.

For the phytophagous species parathion and demeton were most effective, endrin somewhat less so and toxaphene least effective, but all materials caused reductions over the checks. By July 15 the total population of phytophagous species, as listed in table 4, had increased by 125.6% in the checks. The increase was only 2.3% in the toxaphene plots and decreases were recorded for the other materials—21% for the parathion and endrin plots and 54.6% for the demeton plots. In these tests the spider population was not included in the calculations.

Effects of All Insecticides on Certain Species.—When it was possible to identify a species, and it was sufficiently numerous, the effects of the insecticides on it were evaluated by population changes. Here, it must be pointed out that migration into or out of the plots, the effects of unfavorable weather conditions and the interaction between a host and its natural enemies all cause population changes. Thus the best chance of determining the effects of insecticides on the species present came within a few days after the plots had been treated.

Hippodamia convergans: All insecticides reduced adult populations over the checks, parathion causing the greatest reduction. Demeton and endrin were less toxic than either parathion or toxaphene. No effects were observed on the larval populations.

Collops quadrimaculatus (Fab.): All materials reduced populations when this species was present in sufficient numbers to analyze the data.

Melanoplus bilituratus (Walker): Because of the strong flight powers of the adults, only data on the nymphs were

Table 3.—Effect of malathion applied May 3 to alfalfa on the populations of the most common arthropods, 1955.

Anthropods and Stage of Development	Number Collected per 125 Sweeps on Dates Shown								
	May 3	May 10		May 17		May 24		May 31	
	Check	Check	Treated	Check	Treated	Check	Treated	Check	Treated
Hippodamis convergens, A	50	223	77	48	32	33	24	14	19
H. convergens, L	46	46	3	1	0	1	0	0	0
Hylemya cilicrura	3	10	11	2	5	6	7	6	4
Syneches sp.	41	25	92	70	140	46	33	62	33
Thaumatomya glabra	2	13	52	10	25	60	21	15	29
Lygus lineolaris, A	174	78	18	46	17	37	16	23	25
L. lineolaris, N	105	3	0	17	7	27	3	19	3
Nabis alternatus, A	7	21	11	15	20	11	12	7	2
N. alternatus, N	63	63	2	0	1	3	0	1	0
Orius insidiosus, A	42	42	125	94	138	228	111	220	132
O. insidiosus, N	4	15	1	3	2	4	10	8	11
Macrosiphum pisi	15	22	39	7	37	18	63	27	116
Theriophis maculata	18,948	116	389	49	160	7	25	11	29
Aceratagallia uhleri, A	7	253	9	53	4	98	19	14	6
A. uhleri, N	0	356	1	73	7	57	0	10	2
Empoasca fabae	0	2	3	27	23	164	181	60	53
Macrosteles fascifrons	0	36	17	115	154	129	94	4	0
Chrysopa plorabunda, A	71	48	35	13	3	1	4	3	4
C. plorabunda, L	20	20	5	1	3	2	2	2	0
Araneida	50	90	99	42	73	68	52	31	18
Other species	390	564	558	566	662	1,493	1,327	505	462
Totals	20,038	2,046	2,547	1,252	1,513	2,493	2,004	1,042	948
Temperature ° F.	79	83.5		95		79		84	
Wind, m. p. h.	3	0		4.5		0		4	

and three of its most important enemies namely, *Hippodamia convergens* G.-M., *Chrysopa plorabunda* Fitch, and *Aphidius* sp., reached their peak of abundance prior to the first spray application. As will be shown later, the toxic effects of parathion on the lady beetle and to a lesser extent that of demeton and toxaphene, created favorable conditions for the multiplication of *M. pisi*.

Tests in 1955.—Table 3 shows the effects of the malathion spray on the arthropods present in the large scale test. The spotted alfalfa aphid (*Therioaphis maculata* (Buckton)) reached the peak of its abundance on the date of the spraying. The first postspraying count showed that remarkable reduction had taken place in both the sprayed and check plots. This situation was very similar to that in 1954 when the first spray application was made to control the pea aphid except that in the former year the pea aphid population had been going down steadily for some time before spraying. The reductions in the total plant insect feeding populations in both check and sprayed plots found May 10, seven days after treatment, were 95 and 97%, so were not significantly different. There continued to be very little difference in the total populations of phytophagous species up to and including May 31. On the other hand by May 10, increases were found in the entomophagus populations in the checks whereas in the sprayed alfalfa on this date only a slight increase was found. From this date on, reductions were recorded except for the checks May 24. These reductions were much lower for the entomophagous populations for the four dates than for the phytophagous populations.

The effects of the four insecticides, applied to the small plots, on the total populations of phytophagous species are shown in table 4. July 8 there was very little difference in per cent reductions caused by demeton and parathion. Endrin and toxaphene were less effective. July 15, increases had taken place in all plots, were greatest in the checks and toxaphene plots, with the smallest increase shown in the demeton plots.

For the phytophagous species parathion and demeton were most effective, endrin somewhat less so and toxaphene least effective, but all materials caused reductions over the checks. By July 15 the total population of phytophagous species, as listed in table 4, had increased by 125.6% in the checks. The increase was only 2.3% in the toxaphene plots and decreases were recorded for the other materials—21% for the parathion and endrin plots and 54.6% for the demeton plots. In these tests the spider population was not included in the calculations.

Effects of All Insecticides on Certain Species.—When it was possible to identify a species, and it was sufficiently numerous, the effects of the insecticides on it were evaluated by population changes. Here, it must be pointed out that migration into or out of the plots, the effects of unfavorable weather conditions and the interaction between a host and its natural enemies all cause population changes. Thus the best chance of determining the effects of insecticides on the species present came within a few days after the plots had been treated.

Hippodamia convergans: All insecticides reduced adult populations over the checks, parathion causing the greatest reduction. Demeton and endrin were less toxic than either parathion or toxaphene. No effects were observed on the larval populations.

Collops quadrimaculatus (Fab.): All materials reduced populations when this species was present in sufficient numbers to analyze the data.

Melanoplus bilituratus (Walker): Because of the strong flight powers of the adults, only data on the nymphs were

Table 1.—Effect of four insecticides applied April 26 to alfalfa on the populations of the most common arthropods, 1954.

	Number Collected per 100 Sweeps										
	Untreated			Toxaphene		Parathion		Demeton		Endrin	
	April		June	April	June	April	June	April	June	April	June
Arthropods[a]	24	28	9	28	9	28	9	28	9	28	9
Hippodamis convergens, A	906	79	1	26	2	19	10	53	11	46	1
H. convergens, L	238	54	16	53	15	19	17	27	18	53	12
Lygus lineolaris, A	220	15	38	21	17	24	28	22	32	7	11
L. lineolaris, N	78	16	89	7	32	4	55	12	31	0	18
Nabis alternatus, A	62	10	5	4	4	1	11	8	9	6	2
N. alternatus, N	0	24	43	10	19	4	19	26	28	24	30
Orius insidiosus, A	1	0	10	1	16	1	49	0	37	0	13
O. insidiosus, N	0	0	149	0	110	0	169	0	126	0	127
Nysius raphanus	672	35	0	24	0	30	1	68	0	28	0
Aphidius sp.	454	1	11	9	8	9	14	3	24	4	2
Macrosiphum pisi	8,296	50	290	52	379	91	553	56	438	44	114
Aceratagallia uhleri, A	338	170	62	85	32	57	8	36	64	35	31
A. uhleri, N	2,880	1,549	67	706	116	382	69	116	47	196	107
Chrysopa plorabunda, A	4	4	0	1	0	2	0	1	1	2	0
C. plorabunda, L	108	73	4	48	5	24	3	85	6	54	1
Frankliniella occidentalis	0	2	229	4	220	3	340	5	295	1	196
Araneida sp.	58	38	55	35	70	37	82	43	84	18	48
Other species	498	148	150	161	309	139	347	139	365	138	255
Totals	14,813	2,268	1,219	1,247	1,354	846	1,775	700	1,616	655	968

[a] A, denotes adults; L, larvae; N, nymphs.

classes; phytophagous, entomophagous, pollen and nectar feeders, and scavengers. The first two classes comprised most of the species collected and it is for these that the data have been compiled and analyzed.

TESTS IN 1954.—The effects of the four insecticides on the total spider-insect population are shown in tables 1 and 2. The first application of the insecticides caused a greater reduction in the plant feeders April 28 than it did in the entomophagous species. By June 9, however, there was little difference between the populations of these groups and the checks indicating that a recovery had taken place (table 1).

The second sprays were applied June 10 and their effects upon the arthropod populations June 14 and 29 are shown in table 2. When these data were analyzed for the entomophagous totals they showed that June 14 reductions were lower than in the checks with the least differences shown in the toxaphene plots and the least reductions and therefore greatest differences in the demeton plots. For the phytophagous species only parathion and demeton had caused greater reductions than in the checks. June 29, toxaphene and demeton had caused a greater reduction in the total entomophagous species than the checks, whereas parathion and endrin reductions were less than in the checks.

During the course of the experiment, the alfalfa leafhopper, *Aceratagallia uhleri* Van D., was by far the most common species, comprising more than 90% of the total population during the first test. Therefore, the effects of the several insecticides on this species determined to a large extent the degree of reduction of the total arthropod population. The pea aphid, *Macrosiphum pisi* (Harris),

Table 2.—Effect of four insecticides applied June 10 to alfalfa on the populations of the most common arthropods, 1954.

	Number Collected per 125 Sweeps on Dates[a] Shown (June)														
	Untreated			Toxaphene			Parathion			Demeton			Endrin		
Arthropods and Stage of Development	9	14	29	9	14	29	9	14	29	9	14	29	9	14	29
Hippodamia convergens, A	1	7	2	2	7	0	10	5	1	11	4	2	1	6	2
H. convergens, L	16	3	0	15	3	0	17	3	0	18	0	1	12	0	0
Lygus lineolaris, A	38	6	0	17	5	1	28	15	0	32	8	0	11	8	2
L. lineolaris, N	89	18	0	32	2	0	55	1	2	31	5	0	18	0	2
Nabis alternatus, A	5	0	1	4	1	1	11	0	0	9	2	0	2	3	0
N. alternatus, N	43	22	0	19	14	0	19	6	1	28	10	2	30	19	1
Orius insidiosus, A	10	11	1	16	9	2	49	25	0	37	24	1	13	10	13
O. insidiosus, N	149	12	4	110	3	6	169	9	12	126	19	16	127	19	23
Aphidius sp.	11	4	0	8	0	0	14	4	5	24	4	1	2	3	0
Macrosiphum pisi	290	8	0	379	6	0	553	10	1	438	16	4	114	4	0
Aceratagallia uhleri, A	62	104	645	32	57	869	8	5	224	64	33	440	31	50	698
A. uhleri, N	67	149	301	116	219	273	69	9	35	47	43	177	107	112	148
Empoasca fabae, A	12	13	6	22	9	7	31	6	6	33	8	6	5	6	6
E. fabae, N	?	3	0	0	2	3	3	1	3	3	1	1	4	0	5
Spissistilus festinus	0	4	16	2	7	40	1	3	46	0	5	64	0	4	17
Frankliniella occidentalis	229	50	20	220	47	10	340	64	25	295	55	67	196	66	56
Araneida	55	122	180	70	133	354	82	242	427	84	265	531	48	144	305
Other species	142	201	217	290	175	303	316	205	413	336	231	478	247	168	259
Totals	1,219	737	1,393	1,354	699	1,869	1,775	613	1,201	1,616	733	1,791	968	622	1,537

[a] The temperature was 81, 84, and 81° F., respectively, and the wind velocity was 4, 3, and 0 m.p.h., respectively, at the time the collections were made.

Table 4.—Effect of four insecticides applied July 6 to alfalfa on the populations of the most common arthropods, 1955.

Arthropods and Stage of Development	Number Collected per 125 Sweeps on Dates[a] Shown (July)														
	Untreated			Toxaphene			Parathion			Demeton			Endrin		
	6	8	15	6	8	15	6	8	15	6	8	15	6	8	15
Hippodamia convergens, A	8	13	19	15	3	14	8	1	1	20	0	1	10	1	2
H. convergens, L	9	6	49	12	7	34	3	4	1	7	0	1	9	4	3
Collops quadrimaculatus	0	1	45	0	1	21	0	0	22	0	0	15	0	0	19
Acrididae, N	13	17	28	13	2	8	17	1	29	15	1	16	8	0	1
Lygus lineolaris, A	17	10	13	34	2	13	48	0	19	39	1	9	33	1	10
L. lineolaris, N	11	7	24	14	2	1	14	1	23	29	0	10	14	1	6
Nabis alternatus, A	8	9	8	7	5	5	5	0	3	6	1	1	5	3	0
N. alternatus, N	3	2	4	3	2	3	2	0	1	5	0	7	3	3	5
Orius insidiosus, A	14	5	91	14	0	202	24	1	202	28	3	179	18	3	213
O. insidiosus, N	61	14	33	46	4	2	66	4	4	53	7	5	58	4	1
Geocoris sp., A	1	1	9	1	0	1	2	0	2	0	0	2	1	0	5
Geocoris sp., N	0	0	20	0	0	0	0	0	2	1	0	3	0	0	1
Macrosiphum pisi	29	10	0	19	3	1	27	1	0	62	3	0	52	2	0
Therioaphis maculata	866	628	2,162	1,079	394	1,198	888	46	566	868	45	306	764	76	661
Aceratagallia uhleri, A	15	35	87	29	47	46	17	1	22	24	5	15	23	18	42
A. uhleri, N	7	9	51	7	16	21	5	0	0	5	1	1	10	7	6
Empoasca fabae, A	39	16	49	39	12	42	51	1	28	70	2	28	29	1	28
E. fabae, N	98	15	31	110	23	9	75	25	15	130	44	19	115	7	7
Chrysopa plorabunda, A	14	9	1	12	2	3	13	1	0	9	0	0	6	1	0
C. plorabunda, L	0	4	14	1	1	15	3	0	6	2	0	5	0	2	11
Frankliniella occidentalis	19	6	78	35	5	72	45	7	235	39	5	178	33	6	92
Araneida	44	46	221	—	14	123	—	19	185	—	22	176	—	10	112
Other species	225	84	399	8	80	808	58	51	463	13	69	465	17	47	404
Totals	1,501	947	3,436	1,482	825	2,442	1,332	164	1,829	1,425	209	1,442	1,208	197	1,629

[a] The temperature was 87, 88, and 92° F., respectively, at the time the collections were made. Three was no wind.

taken. Toxaphene and endrin were every effective and residual. Other materials failed to reduce populations because of continued hatching of the eggs in the various plots.

Lygus lineolaris (P. deB.): Malathion was effective against nymphs and adults in the large scale test. No significant changes were noted in the small plots.

Nabis alternatus Parshley: Parathion and malathion were the only toxic materials against this species.

Orius insidiosus (Say): Endrin, toxaphene, parathion and demeton were very toxic.

Therioaphis maculatus: Parathion, demeton and endrin caused marked reductions; toxaphene was less effective in one test. There is evidence that this species increased in the large scale experiment because malathion killed great numbers of the convergent lady beetle.

Macrosiphum pisi: Biological control masked the direct effect of the insecticides on this species, but population increases were recorded in plots sprayed with parathion, toxaphene and demeton. Populations remained lower in the plots sprayed with endrin than in the checks.

Aceratagallia uhleri: Parathion, demeton and endrin were very effective; toxaphene less so.

Empoasca fabae (Harris): Parathion, demeton, and endrin were quite effective.

Chrysopa sp.: Population differences between treated plots and checks were not statistically significant.

EFFECT ON THE DIPTERA, HYMENOPTERA, AND ARANEIDA.—No evidence was found that any of the materials reduced fly populations. None of the insecticides had any measurable effect upon the populations of entomophagous Hymenoptera. There was also no relation between the numbers of spiders collected and spray treatments.

PARASITE-PREDATOR-APHID RATIOS IN SPRAYED AND CHECK PLOTS.—Since the population of aphids was greater in the plots sprayed with certain of the insecticides, notably parathion and malathion, than in the checks, there was the possibility that these materials had made conditions more favorable for the aphids by killing their natural enemies. Comparable parasite-predator-host ratios were studied for all of the plots sprayed with parathion or malathion in 1954 and 1955 to determine this point. The data are shown in table 5. The natural enemy complex consisted of the convergent lady beetle, the *Aphidius* parasite (a Braconid that did not parasitize *Therioaphis maculata*) and *Chrysopa* species. In 1954 the aphid was *M. pisi* and in 1955 *M. pisi* and *T. maculatus*. It is seen that for 1954 (table 5) and for the large scale test in 1955 (table 5) following spraying there were more natural enemies per aphid in the checks whereas the reverse was true in the sprayed plots. June 4, 1954, these differences had disappeared possibly due to the greater attraction of the natural enemies to the heavier aphid populations in the sprayed plots. In the small plot tests in 1955, (table 5) the ratio was also more favorable in the check plots than in the parathion plots and increased slightly July 15 in the check plots. On the other hand, it

Table 5.—Parasite-predator-aphid population[a] ratios in alfalfa sprayed with malathion and parathion. 1954–1955.

Date	Numbers of Aphids per 125 Sweeps		Number of Enemies to Aphid	
	Untreated	Treated	Untreated	Treated
		Parathion, 1954		
Apr. 28	50	91	4.5– 1	1 – 1.2
May 5	5	32	12.4– 1	1.5– 1
May 22	13	38	1 – 1	1 –12.7
May 28	46	148	1 – 4	1 –29.6
June 4	413	940	1 –23	1 –16
June 9	290	553	1 – 9	1 –12.6
		Parathion, 1955		
July 6	895	915	1 –28	1 –34
July 8	639	47	1 –20	1 – 7.8
July 15	2162	566	1 –26	1 –70
		Malathion, 1955		
May 10	138	428	2.4– 1	1 – 3.6
May 17	56	197	1.1– 1	1 – 5.2
May 24	22	73	1.7– 1	1 – 2.4
May 31	38	145	1 – 2	1 – 6.3

[a] Aphids were primarily the pea aphid in 1954 and in 1955 the pea aphid and the spotted alfalfa aphid were involved.

The Effect of Several Insecticides on the Total Arthropod Population in Alfalfa[1]

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ABSTRACT

Sprays containing parathion, malathion, demeton, endrin or toxaphene applied to alfalfa caused marked reductions of the total arthropod populations. Reductions were greater for the phytophagous species as a group than for the entomophagous species. The toxic effects of some of the insecticides to certain insect predators created favorable conditions for their prey which became more numerous later on in the sprayed plots than in the untreated checks. The specificity of certain of the insecticides caused profound changes in the components of the populations. The residual effects of all of the above were quite limited due to migration into or between plots. At the dosages used, namely 3 pounds toxaphene, ½ pound malathion, and ¼ pound each of parathion, endrin or demeton,—toxaphene was generally less effective than the others. Parathion was the most toxic to some of the beneficial species and endrin was the least toxic.

Considerable work has been done in the past few years on the effects of insecticides on beneficial insects, but so far as is known, no work has been published on the effects of insecticides on the total arthropod population in alfalfa. This paper reports results of a two-year study, 1954 and 1955, on the effect of insecticide spray applications on the total arthropod population in alfalfa. Gaines (1954), van den Bosch *et al.* (1956), Ahmen (1954) and Wene (1953, 1954), studied the effects of a number of compounds on the beneficial species present in various crops including alfalfa.

The data reported in this paper are based on a study of the effects of toxaphene, parathion, endrin, and demeton (Systox) applied to small replicated plots, each 1/40 acre in size, and in one large scale field test where malathion was the insecticide used. The untreated checks in the small plot tests were replicated the same as the sprayed plots but in the large scale test there were no replications and the check was a ⅝-acre plot of alfalfa in the same field. The insecticides were applied to the small plots at the rate of 40 gallons per acre April 26 and June 10, 1954; and July 8, 1955, at the following amounts of actual toxicants per acre: toxaphene, 3 pounds, parathion, endrin, and demeton, ¼-pound each. In the large scale test, malathion was applied at the rate of ½-pound in 8 gallons of spray per acre, May 3, 1955.

Populations were determined by sweeping with an insect net at the rate of 25 to 50 sweeps per plot or sampling area, depending upon a pilot sample estimate of the numbers of arthropods present. In the small plot tests each plot replicated was sampled; in the large scale field test, there were five sampling areas staked out in the sprayed part of the field and five in the check area. Samples were taken before treatment, immediately after and subsequently at various intervals, usually weekly, weather permitting. The procedure used has been reported by Fenton & Howell (1957). Determinations were made by specialists.[2]

Due to the enormous numbers of insects and spiders collected it is impossible to present all of the data by species, nor is this necessary. However, it is well to point out that a total of 396 species of insects, 15 species of spiders, and several species of mites were collected. Most of these were not taken in sufficient numbers to be included in a statistical analysis of the data. Instead, with the exceptions noted later in this report, they were grouped together for one part of the study, into four

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continued to remain low in the parathion plots. The increase of the aphid population July 15 over that recorded July 8 was due to migration into the plots.

THE INFLUENCE OF POPULATION CHANGES CAUSED BY MIGRATIONS.—There was a continuous change in the quantitative species components in the unsprayed alfalfa between dates of sampling. Sometimes this was due to a combination of the attraction of large numbers of predators which was followed by a decline in their principal prey. The early heavy pea aphid population was practically wiped out in 1954, by a combination of lady beetles, lacewings, and a braconid parasite. The same was true for the spotted alfalfa aphid and the pea aphid in the large scale test in 1955. Just as soon as collections showed large numbers of thrips this was followed by large numbers of adult *Orius*, later by their nymphs and then both the thrips and *Orius* populations decreased.

Migrations into both sprayed and unsprayed plots tended to mask the effects of the insecticides. If this happened at or just before a spray treatment then it was possible to evaluate the effectiveness of the insecticides. This was the case with the alfalfa leafhopper in 1955. When migration came later as was the case often with the potato leafhopper or the six-spotted leafhopper, then no data were obtained.

The spotted alfalfa aphid has strong migratory tendencies. Therefore, records were taken in the small plot tests in 1955 of the percentage of winged aphids. At the time the plots were sprayed July 6, an average of 19.3% were winged, July 8, 23.1% and July 15, 40.4%. When comparisons were made of the effects of the insecticides by counts of wingless aphids it was found that there were 1706 in the check plots per 125 sweeps, compared with 829 for toxaphene-treated plots, 224 for endrin plots, 127 for parathion and only 32 for demeton plots. Thus an influx of winged aphids into all plots masked the real residual effect of these insecticides.

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