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CHANGES IN THE INSECT FAUNA OF A NEW ENGLAND WOODLAND FOLLOWING THE APPLICATION OF DDT

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THE widespread and extensive use of DDT as an insecticide to lessen the damage and annoyance caused by noxious insects has raised in the minds of many biologists a very pertinent and basically important question. The efficacy of the methods of mass destruction already devised and applied against a great variety of insects has been demonstrated under the most varied climatic and environmental conditions. If such methods may be pushed to their anticipated conclusion, the widely prevalent mosquitoes and other biting or disease bearing insects, as well as many agricultural and forest pests, will be so reduced in abundance that their detrimental influence will sink far below its present level.

The question which has been raised concerns the effects of such eradication upon the insect fauna as a whole when measures are undertaken to control specific members of the fauna. The ecological relation of the innumerable forms of insect life among themselves and these relations with other animals and plants are so complex that wholesale destruction may have serious repercussions. It may induce "chain-reactions" among the various insects that are predatory or parasitic on other insects, those that serve as food for fishes or birds, those that help to control noxious weeds, and many others whose role in maintaining the balance of nature is less readily apparent though undoubtedly no less vital. Grave doubts have consequently arisen as to the wisdom of expanding the use of DDT over large areas without rather definite assurance that serious consequences may not follow. The modern world is so plagued by insects, weeds and other organisms which we ourselves have transplanted to foreign soil, that measures further disrupting the balance of nature in yet another direction are quite naturally viewed with alarm by those acquainted with past performances.

Like many other entomologists, I was naturally interested in these matters and inclined to speculate in a general way on the probable faunal changes that might follow the wide use of DDT. A more immediate interest in the problem was aroused by a suggestion from the National Audubon Society through its Executive Secretary, Ludlow Griscom, that I undertake to follow certain experimental work done during the summer of 1945 by the U. S. Bureau of Entomology aiming at control of the gypsy moth through the application of DDT to some areas of woodland in Massachusetts. It appeared at the time that extensive poisoning of birds might be expected and also that a serious depletion of the food supply of insectivorous birds might result in the sprayed woodlands. Although utterly incompetent as an ornithologist, this offered an opportunity to look into the strictly entomological phases of faunal change in a part of New England where I had already made somewhat similar studies (Brues '33) of the insect fauna of forests.

At this point I must extend my heartiest thanks to Mr. R. A. Sheals and his associates of the Gypsy Moth Laboratory at Greenfield, Massachusetts, for their interest in my undertaking and for their courtesy in furthering its accomplishment. So far as I am aware, this is the only study of the kind to be made in New England, although far more elaborate investigations were pursued by a group of entomologists from the Bureau of Entomology in the extensive area in Pennsylvania now infested by the gypsy moth.

My previous study mentioned above was made to secure a comparison of the abundance of the several groups of insects in present-day forests and in the Oligocene forests where the insects now preserved in Baltic amber were existent. For that purpose samples of the insect fauna were collected by exposing sheets of sticky "Tanglefoot" fly paper on the trunks of trees. This work was carried on in several groves of mature timber in the Harvard Forest at Petersham, Massachusetts. These were selected with a view to duplicating as nearly as possible the conditions that prevailed in the undisturbed primeval forests.

Material thus trapped may be freed from the paper by immersion in a solvent, transferred to alcohol and then readily studied or mounted as desired.[1]

The same method was employed in the present studies and the papers were tacked on trees in the woodland at heights of from two to six feet above the ground. The area treated with DDT is approximately 50 acres in extent, about two miles north of Athol, Massachusetts. It was sprayed from an airplane only once, on June 2, 1945, at the rate of approximately 1.46 lbs. to the acre. The DDT was dissolved in xylene, then diluted with kerosene and applied in the still air of the early morning. This area was very heavily infested by the gypsy moth as determined by earlier counts of egg-masses and as evidenced by the presence of innumerable gypsy caterpillars, then in the second larval instar. Without treatment this area would have suffered the severe defoliation which occurs from such heavy infestation, and which did later actually take place in the adjacent woodlands which had not been sprayed.

The sprayed plot is a typical farm woodland with a mixture of white pine, gray birch and red maple, a little ash and the usual undergrowth, on high and well drained ground. Two unsprayed check areas were selected, one in the township of Petersham, about five miles south of the sprayed area, and the second about the

[1] Formerly a bath of 95% alcohol sufficed to remove the tanglefoot material and also the band of wax that borders the paper sheets. However, war-time substitutes required another solvent for the tanglefoot and we found that a mixture of alcohol (⅔) and carbon tetrachloride (⅓) was satisfactory although a longer time was required. The wax does not dissolve, but after the insects have come off the paper, the solvent may be removed by filtration and the flakes of wax separated from the insects by a bath of warm chloroform. After this is removed by another filtration the insects may be transferred to 95% alcohol. On account of the poisonous nature of the solvents, these operations must be conducted in a well ventilated hood and require a considerable expenditure of time and patience.

same distance to the north in the township of Royalston. As nearly as one could judge, the woodland flora and the general ecological conditions were essentially similar in all three areas.

Papers were put out and collections begun immediately after the spraying of the experimental plot and continued until September 19, a period of approximately 16 weeks. Due to weather conditions there were some irregularities in the dates of collection and replacement of the papers, and no papers were put out in the Petersham check area till June 13. Altogether 349 sheets (totalling 4709 sheet days) were exposed, collected, and the insects trapped thereon removed for examination. These details are shown on the accompanying chart (Table 1.).

TABLE No. 1

Periods of Exposure of the Tanglefoot Sheets from which the Collections were Obtained

Lot No.	*DDT Sprayed Plot*			*Royalston Check Plot*			*Petersham Check Plot*		
	Dates of Exposure	*No. of Days*	*No. of Sheets*	*Dates of Exposure*	*No. of Days*	*No. of Sheets*	*Dates of Exposure*	*No. of Days*	*No. of Sheets*
1	6/1-6/12	11	14	6/3-6/12	9	10	—	—	—
2	6/12-7/2	20	20	6/12-7/1	19	10	6/13-7/2	19	20
3	7/2-7/11	9	16	7/1-7/11	10	10	7/2-7/10	8	18
4	7/11-7/22	11	15	7/11-7/23	12	10	7/10-7/23	13	18
5	7/22-8/5	14	18	7/23-8/5	13	10	7/23-8/4	12	18
6	8/5-8/12	7	20	8/5-8/12	7	10	8/4-8/13	9	18
7	8/12-9/3	22	20	8/12-9/3	22	10	8/13-9/1	19	18
8	9/3-9/19	16	18	9/3-9/19	16	10	9/1-9/18	19	18
	Totals	110	141		108	80		99	128
	1829 Sheet Days			1080 Sheet Days			1800 Sheets Days		

It will be noted that there were eight lots of papers exposed during the summer. All the insects from each of these lots were kept separate in order that any marked differences in seasonal distribution might be determined. As the length of time of exposure and the number of sheets of tanglefoot were not uniform, all counts of specimens were corrected to a basis of twenty sheets for a period of two weeks equivalent to 280 sheet days. The numbers thus obtained by simple arithmetical procedure differ from the actual count of specimens in the individual lots, but are strictly comparable, and do not alter appreciably the grand total of all specimens which was slightly over 304,000. These corrected numbers are the only ones cited in the text. As the vast majority of the specimens obtained were members of a very small number of families (Phoridae, 51%; midges, 17%; Chalcidoidea, 4.3%; Aphididae, 4.1%) these were estimated after specimens belonging to other families had been picked out individually and counted. This was done by floating them out thinly and evenly in a Petri dish of alcohol and counting under a binocular microscope the number of specimens in one-twentieth of the area of each dishful as indicated by a paper ruled in squares, following the method used in making blood cell counts. Such a treatment of the very abundant groups may seem too summary, but with the large numbers concerned the probable error is not great, and complete counts were not possible without an unjustifiable expenditure of time and effort. Even with this subterfuge, the present report has been long delayed. In the tedious procedure of sorting and counting, I have had the assistance of Miss Ruth C. Dunn whose patience never lagged during the many days required to complete this task.

The data thus secured have been compiled and are presented in the form of a number of tables in which are listed the several families (or, in two or three instances, larger groups) represented in the collections. The majority of specimens belong to three orders, Diptera, Hymenoptera and Coleoptera. Each of these is represented by members of twenty or more families. The number of groups belonging to other orders of insects is only about twenty, although it must be noted that the Orthoptera (mainly small Acrididea), the smaller Hemiptera, Thysanoptera, Corrodentia, Ephemerida, Trichoptera and moths (mostly Tineoidea) are not listed by families, as the numbers of these were either too small to consider statistically, or in the case of the small moths, specimens were not recognizable after the treatment they had suffered in the tanglefoot, solvents and alcohol. In addition a considerable number of Arachnida, mainly spiders and some harvestmen (Phalangida) were trapped on the papers. Diplopoda were represented by occasional specimens. Finally, one small centipede, two very small snails (Planorbis) and a single butterfly (Cercyonis) were caught, and, most surprisingly a hippoboscid fly (Lynchia) which evidently dropped from its bird host to the sticky tanglefoot. With the exception of a few such obviously accidental captures, all these data are included in the census presented in tables 2-13, where it will be noted that the counts of each lot, representing the seasonal sequence of abundance, have been listed separately.

Even before the insects were removed from the papers, it was evident that by far the greatest number came from the sprayed area. The final count shows 191,741 from the sprayed plot, 54,916 from the Royalston check plot and 57,052 from the Petersham check plot. Thus the two check areas showed approximately an equal number, but the DDT plot yielded well over three times as many specimens of insects of all kinds, including also the few other arthropods, mainly Arachnida. In view of the insecticidal potency of DDT this result was totally unexpected, and we shall consider its implications on a later page.

On account of the excessively large number of Phoridae, midges and aphids from all three areas, these have been subtracted from the totals and the collections thus reduced show DDT 26,489, Royalston 16,394, Petersham 14,567. With these omissions the remainders from the two check plots do not differ greatly, but each is only slightly more than half as large as that from the sprayed plot (Royalston 62%, Petersham 55%). Therefore, the fauna as represented by the less abundant groups yielded far more specimens from the sprayed than from the check plots. It may be said, then, that the fauna as a whole showed without question a greater abundance in the sprayed area.

As the experiment was undertaken primarily to test the efficacy of DDT to control the gypsy moth, it is interesting to compare the number of larvae of this species found in the collections from our three areas during the

TABLE 2

Census of Diptera Collected in the Area Sprayed with DDT

(Partial and total counts by families)

	Lot No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*% of Total*
53	Tipuloidea	2	26	12	2	3	4	3	1	.03
173	Psychodidae	4	....	....	....	....	120	....	49	.10
3	Culicidae	...	2	....	....	....	....	1	....	.002
5	Simuliidae	2	3	....	....	....	....	....	....	.003
73	Anisopodidae	5	....	6	15	16	12	10	9	.06
67	Bibionidae	...	....	....	....	....	....	13	54	.05
21,522	Mycetophilidae & other midges	190	2559	5556	1848	2955	5888	1654	872	13.8
46	Stratiomyiidae	...	1	23	11	2	8	1	....	.03
403	Rhagionidae	37	208	127	12	9	10	....	....	.26
6	Tabanidae	...	....	....	3	3	....	....	....	.004
0	Therevidae	...	....	....	....	....	....	....	....	....
28	Asilidae	1	6	8	3	2	4	2	2	.02
227	Empididae	55	23	84	3	46	2	3	11	.15
778	Dolichopodidae	2	16	112	66	228	222	66	66	.51
124,847	Phoridae	327	724	36,703	11,794	28,433	35,512	6,261	5,093	80.3
3	Pipunculidae	...	1	....	2	....	....	....	....	.002
....	Muscoidea	...	....	....	....	....	....	....	....	....
2446	Thecostomata	15	72	132	1195	308	450	93	181	1.58
4791	Haplostomata	99	193	1382	1277	705	616	245	274	3.15
154,471	Totals	739	3834	44,145	16,231	32,710	42,848	8,352	6,612	....

TABLE 3

Census of Diptera Collected in the Royalston Check Plot

DIPTERA (Partial and total counts by families)

	Lot No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*% of Total*
19	Tipuloidea	3	....	14	2	....	....	....	....	.04
68	Psychodidae	....	....	....	....	43	....	25	....	.16
2	Culicidae	....	....	....	....	2	....	....	....	.005
3	Simuliidae	3	....	....	....	....	....	....	....	.007
35	Bibionidae	....	....	....	....	....	....	....	35	.08
8,238	Mycetophilidae & other midges	97	87	1,671	830	1,283	3,424	600	246	19.6
3	Stratiomyiidae	....	....	3	....	....	....	....	....	.007
814	Rhagionidae	56	107	628	19	4	....	....	....	1.92
1	Tabanidae	....	1	....	....	....	....	....	....	.002
....	Therevidae	....	....	....	....	....	....	....	....	....
10	Asilidae	....	3	3	2	....	....	....	2	.02
126	Empididae	25	7	22	2	....	....	5	65	.29
1,276	Dolichopodidae	10	104	240	203	78	272	83	286	2.9
28,393	Phoridae	274	988	3,498	2,787	5,662	10,356	1,716	3,112	66.7
34	Pipunculidae	....	....	....	2	....	28	4	....	.08
....	Muscoidea	....	....	....	....	....	....	....	....	....
267	Thecostomata	15	9	22	76	58	64	16	7	.63
3,033	Haplostomata	117	124	438	456	544	1036	55	263	7.3
42,322	Totals	600	1,430	6,539	4,379	7,674	15,180	2,504	4,016	....

season. The sprayed area yielded 9, Royalston 331 and Petersham 93. The difference so far as damage to foliage is concerned is even more marked, for as may be seen from Tables 11, 12, and 13, only one gypsy caterpillar was caught in the DDT plot after July 2 although many larger ones were present till July 22 in the two check plots.

As the balance of nature among insects depends to a great extent upon the comparative abundance of vegetarian, predatory and parasitic species of the insects themselves, it is appropriate to examine the collections from the three plots on this basis. This can be done only approximately in the absence of more complete data than are available, but by grouping the various categories as shown on the tables here presented, we arrive at the following comparisons. Among the Hymenoptera it is easy to segregate the families with reference to vegetarian, predatory and parasitic habits (omitting the Formicidae). In all three plots the parasitic forms were most abundant; DDT 90%, Royalston 89% and Petersham 93% of the total Hymenoptera. Predatory forms (wasps) were DDT 0.7%, Royalston 0.8%, Petersham 0.9%. Vegetarian forms were DDT 0.6%, Royalston 3.2% (due to numerous leaf-mining sawflies), Petersham 0.7%. Considering the discrepancy in the two unsprayed areas, it is very clearly evident that no significant abnormality in the proportions of these three types of Hymenoptera followed the spraying. The total number of Hymenoptera obtained in the DDT plot was several times greater than in either of the check plots, due mainly to the great abundance of small chalcid wasps, probably pupal parasites of the large muscoid flies that were very numerous in the DDT plot. An evident, but much less pronounced abundance of Chalcidoidea on the Petersham plot was probably due to the same cause, as the large muscoid flies were more abundant there than at Royalston. The larger number of Braconidae in the DDT plot appears to be due to the abundance of aphids, since many of the Braconidae were minute species of Aphidiinae that parasitize aphids.

The majority of the insects of other orders listed in Table 17 are vegetarian forms of which a large proportion are aphids. The latter formed 94% of the miscellaneous insects in the DDT plot, 32% at Royalston and 40% at Petersham.

Due to the abundance of spiders and Phalangida the number of predatory forms in this series is much enhanced. They represent only 2% of the total miscellaneous series from the DDT plot, 20% from Royalston and 15% from Petersham. This great disparity is due to the enormous number of aphids that appeared on the leaves of the birches on the sprayed plot. If the aphids are omitted, we find the proportion of predatory forms much more nearly equal on the three plots (DDT 33%, Royalston 30%, Petersham 30%). From this it appears that there was no general reduction in predatory forms as a result of the spraying. The great abundance of aphids may have been partly due to the full foliage retained by the birches in the absence of gypsy moth larvae, but other factors must be involved also, as the birches were by no means defoliated in the check areas, although badly infested by a leaf-miner which was much less noticeable in the sprayed plot. Whether the scarcity of the leaf-miner, which is generally abundant in the region, was due to the DDT cannot be stated, but such may possibly be the case.

An analysis of the populations of Coleoptera disclosed by the tanglefoot census is difficult to make in detail as a large number of families are concerned, most of them represented by a small number of specimens. The totals show that fewer individuals were obtained from the DDT plot (1,182) than at Royalston (2,575) or at Petersham (2,519).

From this it would appear at first blush that the beetle population must have suffered noticeably as a result of the spraying. Of the 41 families of Coleoptera, 19 were most abundant on the sprayed plot, 7 at Royalston and 10 at Petersham, while five were represented equally in two of the three places. Some six common families (cf. Table 16), Cantharidae, Cleridae, Mordellidae, Throscidae, Helodidae, and Latridiidae showed great variations which distort the percentage representation of the

Table 4

Census of Diptera Collected in the Petersham Check Plot

(Partial and total counts by families)

	Lot No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*% of Total*
63	Tipuloidea	....	2	14	17	3	5	19	3	0.14
112	Psychodidae	....	....	....	24	....	34	32	22	0.24
....	Culicidae	....	....	....	....	....	....	....	....	....
1	Simuliidae	....	1	....	....	....	....	....	....	0.002
3	Anisopodidae	....	....	....	....	....	....	....	3	0.006
29	Bibionidae	....	....	....	....	....	14	1	14	0.06
25,963	Mycetophilidae & other midges	....	59	10,106	3,384	4,481	6,307	1078	548	56.7
....	Stratiomyiidae	....	....	....	....	....	....	....	....	....
537	Rhagionidae	....	119	188	91	55	78	6	....	1.87
....	Tabanidae	....	....	....	....	....	....	....	....	....
2	Therevidae	....	....	....	....	1	....	1	....	0.004
26	Asilidae	....	....	8	7	4	....	2	5	0.05
126	Empididae	....	15	78	12	10	5	5	1	0.31
759	Dolichopodidae	....	17	239	181	93	157	35	37	1.78
14,961	Phoridae	....	254	3,045	3,070	2,195	3,415	1,740	1,242	32.5
12	Pipunculidae	....	....	....	....	1	10	1	....	0.025
....	Muscoidea	....	....	....	....	....	....	....	....	....
289	Thecostomata	....	5	35	23	17	106	29	74	0.63
2,848	Haplostomata	....	40	1,065	798	232	582	72	59	6.2
45,731	Totals	....	512	14,778	7,607	7,092	10,713	3,021	2,008	....

TABLE 5

Census of Hymenoptera Collected in the Sprayed Area with DDT

(Partial and total counts by families)

	Lot No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*% of Total*
7	Xyelidae	....	1	2	....	1	2	1	....	0.04
41	Tenthredinoidea	1	4	....	12	....	10	14	....	0.25
1180	Braconidae	9	60	185	164	122	184	120	336	7.40
841	Ichneumonidae	12	72	138	89	57	274	83	116	5.28
11,430	Chalcidoidea	16	75	168	168	3,402	6,556	764	281	72.2
20	Mymaridae	....	1	....	2	....	....	....	17	0.12
60	Belytidae	1	8	...	3	2	2	39	5	0.37
41	Diapriidae	....	2	2	2	....	2	13	20	0.25
519	Scelionidae	3	47	38	...	90	194	78	69	3.26
684	Platygastridae	4	4	376	89	113	40	38	20	4.28
151	Calliceratidae	....	10	....	49	....	40	13	39	0.95
87	Bethylidae	....	1	44	....	1	40	....	1	0.54
4	Dryinidae	....	2	....	....	1	....	1	....	0.02
38	Cynipoidea	....	4	2	23	8	....	1	....	0.23
674	Formicidae	24	76	48	96	149	146	108	27	4.24
14	Chrysididae	....	4	2	3	1	2	....	2	0.09
29	Psammocharidae	....	3	8	....	3	12	3	....	0.18
96	Other Wasps	2	18	22	22	11	13	6	2	0.60
2	Cephidae	...	2	....	....	....	....	....	....	0.01
2	Evaniidae	....	....	....	....	....	2	....	....	0.01
4	Apoidea	....	....	....	....	1	2	1	....	0.02
15,924	Totals	72	394	1,035	722	3,962	7,521	1,283	935	....

less abundant families, as these six represent together 5178 specimens, or 81% of the total Coleoptera collected. In the case of at least one family, the Cleridae, it seems probable that their abundance at Petersham was due to the greater amount of hurricane-felled timber still remaining on the ground; the same may be true of the Mordellidae also, but hardly for the other families. Certainly it would seem that the beetle fauna was reduced by the spraying.

Many other comparisons of a minor nature might be drawn, but the data presented show quite clearly that the single spraying of the woodland at Athol caused little really significant change in the composition of the insect fauna.

Greater abundance of insects in general in the sprayed plot is, however, very obvious and deserves a careful inquiry as to the factors involved. At the time the spraying was done, on June 2, the trees and other vegetation were in excellent condition. Although very numerous, the small gypsy moth caterpillars had as yet caused an entirely negligible amount of damage, and the woodland was in the normally healthy state that prevailed in years gone by, before the gypsy moth invasion.

With the practically complete destruction of these caterpillars, the main damage to foliage during the remainder of the summer was averted and the plot remained in a normally healthy condition. Thus, there was an abundance of vegetation with normal shade and moisture in contrast to the defoliation, especially of oaks and birches, and the consequent parched conditions which prevail in a woodland suffering a heavy infestation of gypsy moth. Herein appears to lie the explanation of the greater abundance of the native insect fauna which requires food, shelter and moisture to maintain itself at the normal level. In other words, with the gypsy moth population removed, the native fauna was able to return to at least an approximation of its original complexion. There can be no doubt that the application of DDT caused considerable damage to other insects present in the treated plot. This was evident by the numerous specimens which succumbed immediately and fell into the trays that had been set out just before the spraying. Nevertheless it is evident that this mortality was far less in the aggregate than that produced by the conditions resulting from a heavy infestation of the gypsy moth like that which prevailed in surrounding territory.

It would appear, therefore, that a single spraying of DDT of the strength used in the Athol woodland, applied at this time when the larvae are still at an early stage of their growth is sufficient to eradicate them almost completely without causing any significant change in the general insect fauna. This was certainly true throughout the course of the summer, and no further consequences could be expected to develop at a later date.

In my preliminary report ('46) it was suggested that such sprayings might best be made by a strip method such as is sometimes done in lumbering operations to allow for seeding and forest reproduction. Such a method would minimize any danger of interference with the normally more or less balanced general insect fauna. As the gypsy moth spreads slowly and infiltrates uninfested territory in abundance only after several years, such strips need be only some hundred feet in width, sprayed alternately from year to year in order to maintain the gypsy moth population at a very low level. Once in operation, undoubtedly the intervals between sprayings could be lengthened.

TABLE 6

Census of Hymenoptera Collected in the Royalston Check Plot

(Partial and total counts by families)

	Lot No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*% of Total*
1	Xyelidae	....	....	....	....	....	....	1	....	.02
111	Tenthredinoidea	9	....	11	5	38	8	40	....	2.68
668	Braconidae	9	17	14	77	22	308	65	156	16.70
806	Ichneumonidae	59	46	70	119	241	176	36	59	19.50
488	Chalcidoidea	....	7	116	152	39	....	31	143	11.80
76	Mymaridae	....	....	....	....	....	....	76	....	1.84
257	Belytidae	....	12	6	44	9	32	35	119	6.22
7	Diapriidae	....	....	3	....	....	4	....	....	.17
544	Scelionidae	....	4	304	96	43	8	....	89	13.90
297	Platygastridae	....	....	181	....	91	....	25	....	7.19
478	Calliceratidae	....	3	....	47	252	4	25	147	11.60
36	Bethylidae	....	1	....	....	....	....	....	35	.82
1	Dryinidae	....	1	....	....	....	....	....	....	.02
18	Cynipoidea	3	9	6	....	....	....	....	....	.43
284	Formicidae	12	26	31	49	22	44	67	33	6.88
3	Chrysididae	....	....	3	....	....	....	....	....	.07
15	Psammocharidae	....	....	3	....	2	8	....	2	.36
19	Other Wasps	....	....	6	2	....	8	3	....	.46
0	Cephidae	....	....	....	....	....	....	....	....	....
2	Evaniidae	....	....	....	2	....	....	....	....	.05
3	Apoidea	3	....	....	....	....	....	....	....	.07
4,114	Totals	95	126	754	593	759	600	404	783	....

TABLE 7

Census of Hymenoptera Collected in the Petersham Check Plot

(Partial and total counts by families)

	Lot No.	1	2	3	4	5	6	7	8	% of Total
2	Xyelidae	....	....	....	....	....	...	2	....	.04
21	Tenthredinoidea	....	2	....	2	1	6	10	....	.42
792	Braconidae	....	4	190	160	39	186	123	90	16.1
638	Ichneumonidae	....	14	99	139	109	148	82	47	12.9
1,310	Chalcidoidea	....	3	158	174	253	525	149	120	26.40
213	Mymaridae	....	....	26	....	....	69	18	100	4.34
206	Belytidae	....	1	55	44	27	9	23	47	4.18
51	Diapriidae	....	2	2	25	5	....	17	....	1.03
639	Scelionidae	....	....	168	25	24	196	74	154	12.8
431	Platygastridae	....	....	78	85	26	175	65	2	8.73
388	Calliceratidae	....	....	124	2	27	148	87	....	7.87
50	Bethylidae	....	1	2	....	6	....	16	25	1.01
9	Dryinidae	....	....	....	....	....	9	....	....	.18
7	Cynipoidea	....	3	4	....	....	....	....	....	.14
126	Formicidae	....	4	27	29	17	29	15	5	2.55
7	Chrysididae	....	1	....	1	3	....	2	....	.14
21	Psammocharidae	....	2	9	1	6	....	2	1	.42
25	Other Wasps	....	....	8	4	9	....	2	2	.51
0	Cephidae	....	....	....	....	....	....	....	....	....
0	Evaniidae	....	....	....	....	....	....	....	....	....
2	Apoidea	....	....	....	2	....	....	....	....	.04
1	Oryssidae	....	1	....	....	....	....	....	....	.02
4,939	Totals	....	38	876	693	552	1500	687	593	....

APPENDIX

SUBSIDIARY COMMENTS ON THE INSECT FAUNA OF NEW ENGLAND

Wholly aside from any considerations concerning the effects of treatment with DDT on the composition of the insect fauna, I had hoped to secure information which might bear on my previous census of insects in the near-primeval forests of New England. This (Brues '33) showed in brief, that the composition of the fauna was clearly different from that of the early Tertiary in the northwestern part of Europe which has been preserved in Baltic amber. The extensive amber fauna has been examined in sufficient detail to furnish a rather clear picture of the Oligocene fauna of that region, and to indicate also the general terrain of the region at the time the amber insects were trapped in the exuding resin in which they are now preserved as fossils.

On the basis of such information, together with other comparative data on the flora, it seemed reasonable to believe that an approximate idea might be obtained of any consistently progressive changes in the composition of the insect fauna that may have occurred since early Tertiary times. The results obtained showed quite conclusively, as might be expected, a preponderance of the more primitive families of the specialized orders of insects to be represented in the amber fauna, and furthermore that the period of greatest evolution among the insects appears at the present time to have already been passed in the history of life on our planet. These details have been discussed (Brues '33) and need not be repeated here. Further work has become especially desir-

TABLE 8

Census of Coleoptera Collected in the Area Sprayed with DDT

(Partial and total counts by families)

	Lot No.	1	2	3	4	5	6	7	8	% of Total
8	Carabidae	....	2	4	2	....	....	....	....	0.6
....	Silphidae	....	....	....	....	....	....	....	....	....
27	Staphylinidae	....	3	....	24	....	....	....	....	2.1
4	Pselaphidae	2	1	....	....	1	....	....	....	0.3
1	Cucujidae	....	....	....	....	....	....	1	....	0.1
13	Lampyridae	2	2	8	....	1	....	....	....	1.1
284	Cantharidae	37	233	....	....	11	2	1	....	22.5
1	Lycidae	....	....	....	....	1	....	....	....	0.1
9	Malachiidae	....	1	....	3	....	4	1	....	0.8
107	Cleridae	....	....	4	7	6	18	49	23	8.4
8	Oedemeridae	....	3	2	....	....	....	1	2	0.6
31	Mordellidae	....	1	2	8	20	....	....	....	2.5
2	Rhipiphoridae	....	....	....	2	....	....	....	....	0.2
2	Pyrochroidae	....	....	....	....	....	2	....	....	0.2
39	Elateridae	....	13	4	7	3	10	1	1	3.1
35	Throscidae	7	22	....	2	1	2	....	1	2.9
15	Helodidae	....	1	2	7	2	2	1	....	1.3
....	Dermestidae	....	....	....	....	....	....	....	....	....
4	Byrrhidae	....	....	....	....	....	4	....	....	0.3
1	Histeridae	....	1	....	....	....	....	....	....	0.1
2	Ostomatidae	....	....	....	2	....	....	....	....	0.2
....	Cryptophagidae	....	....	....	....	....	....	....	....	....
....	Nitidulidae	....	....	....	....	....	....	....	....	....
....	Mycetophagidae	....	....	....	....	....	....	....	....	....
....	Erotylidae	....	....	....	....	....	....	....	....	....
2	Phalacridae	....	2	....	....	....	....	....	....	0.2
20	Anobiidae	....	1	4	5	2	6	1	1	1.6
510	Latridiidae	11	69	157	94	126	50	3	....	40.5
4	Endomychidae	....	....	....	....	....	4	....	....	0.3
1	Mycetaeidae	....	....	....	....	1	....	....	....	0.1
44	Coccinellidae	....	7	2	3	....	20	7	5	3.5
3	Tenebrionidae	....	....	....	....	....	2	....	1	0.3
34	Cistelidae	....	8	2	....	22	2	....	....	2.9
1	Lagriidae	....	1	....	....	....	....	....	....	0.1
6	Melandryidae	....	3	....	....	1	2	....	....	0.5
9	Cerambycidae	....	....	2	5	1	....	1	....	0.7
25	Chrysomelidae	....	8	4	....	8	2	3	....	2.0
1	Brentidae	....	1	....	....	....	....	....	....	0.1
14	Curculionidae	....	10	....	....	3	....	....	1	1.1
13	Scolytidae	3	8	....	....	1	....	1	....	1.0
2	Scarabaeidae	2	....	....	....	....	....	....	....	0.2
1282	Totals	64	401	197	171	211	132	71	35	....

Table 9

Census of Coleoptera Collected in the Royalston Check Plot

(Partial and total counts by families)

	Lot No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*% of Total*
11	Carabidae	3	....	3	2	....	....	....	3	0.4
....	Silphidae	....	....	....	....	....	....	....	....	....
29	Staphylinidae	....	8	3	2	2	12	....	2	1.1
1	Pselaphidae	....	....	....	....	....	....	1	....	0.1
....	Cucujidae	....	....	....	....	....	....	....	....	....
73	Lampyridae	6	12	48	2	2	....	....	3	2.8
139	Cantharidae	3	1	119	5	7	4	....	....	5.4
4	Lycidae	....	....	....	2	2	....	....	....	0.2
6	Malachiidae	....	4	....	....	2	....	....	....	0.2
24	Cleridae	....	....	8	9	2	....	3	2	0.9
14	Oedemeridae	....	1	11	2	....	....	....	....	0.5
20	Mordellidae	....	3	3	7	7	....	....	....	0.8
....	Rhipiphoridae	....	....	....	....	....	....	....	....	....
....	Pyrochroidae	....	....	....	....	....	....	....	....	....
52	Elateridae	3	....	34	7	....	8	....	....	2.0
389	Throscidae	....	3	376	5	2	....	3	....	14.8
49	Helodidae	....	2	31	2	6	2	4	2	1.9
52	Dermestidae	....	....	....	52	....	....	....	....	2.0
....	Byrrhidae	....	....	....	....	....	....	....	....	....
....	Histeridae	....	....	....	....	....	....	....	....	....
3	Ostomatidae	....	....	3	....	....	....	....	....	0.1
....	Cryptophagidae	....	....	....	....	....	....	....	....	....
11	Nitidulidae	....	....	11	....	....	....	....	....	0.4
....	Mycetophagidae	....	....	....	....	....	....	....	....	....
....	Erotylidae	....	....	....	....	....	....	....	....	....
14	Anobiidae	....	....	14	....	....	....	....	....	0.5
1499	Latridiidae	246	25	564	77	135	332	68	52	58.3
10	Endomychidae	....	....	8	....	...	....	....	2	0.4
....	Mycetaeidae	....	....	....	....	....	....	....	....	....
16	Coccinellidae	6	4	....	....	. ..	....	3	3	0.6
7	Tenebrionidae	....	1	6	....	....	....	....	....	0.3
51	Cistelidae	....	4	6	28	4	8	1	....	1.9
9	Lagriidae	....	1	6	2	....	....	....	....	0.3
13	Melandryidae	....	5	....	2	4	....	....	2	0.5
13	Cerambycidae	....	....	3	2	7	....	1	....	0.5
28	Chrysomelidae	6	....	9	....	2	4	5	2	1.1
....	Brentidae	....	....	....	....	....	....	....	....	....
20	Curculionidae	6	1	3	....	....	8	....	2	0.8
18	Scolytidae	....	3	....	5	2	8	....	....	0.7
....	Scarabaeidae	....	....	....	....	....	....	....	....	....
2575	Totals	279	78	1,269	213	186	386	89	75	....

TABLE 10

Census of Coleoptera Collected in the Petersham Check Plot

(Partial and total counts by families)

	Lot No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*% of Total*
4	Carabidae	....	1	2	....	1	....	....	....	0.2
1	Silphidae	....	....	....	1	....	....	....	....	0.1
12	Staphylinidae	....	7	2	1	1	....	....	1	0.5
3	Pselaphidae	....	1	2	....	....	....	....	....	0.1
....	Cucujidae	....	....	....	....	....	....	....	....	....
51	Lampyridae	....	4	32	6	....	2	....	7	2.0
25	Cantharidae	....	2	17	4	2	....	....	....	1.0
4	Lycidae	....	....	....	1	....	2	1	....	0.2
37	Malachiidae	....	1	21	8	5	2	....	....	1.5
708	Cleridae	....	2	16	9	61	321	219	80	28.0
8	Oedemeridae	....	....	6	....	....	....	2	....	0.3
113	Mordellidae	....	1	17	14	28	40	11	2	4.5
....	Rhipiphoridae	....	....	....	....	....	....	....	....	....
4	Pyrochroidae	....	....	2	2	....	....	....	....	0.2
49	Elateridae	....	1	26	10	10	2	....	....	1.9
147	Throscidae	....	24	43	32	23	5	16	4	5.8
109	Helodidae	....	2	31	23	21	22	7	3	4.3
2	Dermestidae	....	....	....	....	2	....	....	....	0.1
....	Byrrhidae	....	....	....	....	....	....	....	....	....
....	Histeridae	....	....	....	....	....	....	....	....	....
1	Ostomatidae	....	....	....	....	....	....	....	1	0.1
1	Cryptophagidae	....	1	....	....	....	....	....	....	0.1
....	Nitidulidae	....	....	....	....	....	....	....	....	....
1	Mycetophagidae	....	1	....	....	....	....	....	....	0.1
1	Erotylidae	....	....	....	....	....	....	1	....	0.1
6	Phalacridae	....	....	4	....	....	2	....	....	0.2
20	Anobiidae	....	1	4	5	5	2	2	1	0.8
974	Latridiidae	....	191	70	269	221	191	32	....	38.5
11	Endomychidae	....	....	6	....	....	3	2	....	0.4
....	Mycetaeidae	....	....	....	....	....	....	....	....	....
15	Coccinellidae	....	3	2	2	1	6	....	1	0.6
4	Tenebrionidae	....	....	....	1	3	....	....	....	0.2
74	Cistelidae	....	1	51	5	5	10	2	....	2.9
3	Lagriidae	....	....	3	....	....	....	....	....	0.2
32	Melandryidae	....	2	14	1	5	7	3	....	1.3
6	Cerambycidae	....	1	4	....	1	....	....	....	0.2
89	Chrysomelidae	....	1	56	7	11	10	4	....	3.5
....	Brentidae	....	....	....	....	....	....	....	....	....
18	Curculionidae	....	2	4	1	5	3	2	1	0.7
8	Scolytidae	....	1	2	2	....	3	....	....	0.3
3	Scarabaeidae	....	1	2	....	....	....	....	....	0.1
2554	Totals	....	252	439	404	411	633	304	101	....

TABLE 11

Census of Insects belonging to Miscellaneous Groups Collected in the Area Sprayed with DDT

(Partial and total counts by groups)

	Lot No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*% of Total*
7	Diplopoda	....	3	....	....	....	2	1	1	0.03
322	Spiders & Phalangida	12	117	45	25	33	12	13	65	1.6
27	Orthoptera	....	11	4	2	2	6	1	1	0.13
32	Thysanoptera	2	1	....	....	....	....	....	29	0.16
6	Blattidae	....	5	....	....	1	....	....	....	0.03
25	Corrodentia	....	1	....	....	....	20	....	4	0.12
....	Membracidae	....	....	....	....	....	....	....	....	....
117	Jassoidea	11	6	12	14	24	8	6	36	0.57
1	Fulgoroidea	....	....	....	....	....	....	....	1	0.01
18,883	Aphididae	5	34	227	268	666	1424	7657	8,602	93.5
....	Pentatomidae	....	....	....	....	....	....	....	....	....
1	Tingitidae	....	1	....	....	....	....	....	....	0.01
113	Other small Hemiptera	....	....	40	24	22	10	6	11	0.56
15	Plecoptera	....	10	....	....	1	4	....	....	0.07
1	Odonata	....	....	....	....	....	....	....	1	0.01
3	Ephemerida	....	1	....	2	....	....	....	....	0.01
32	Hemerobiidae	1	8	8	3	2	2	3	5	0.16
7	Chrysopidae	....	1	2	2	1	....	....	1	0.03
1	Panorpidae	....	....	1	....	....	....	....	....	0.01
41	Trichoptera	3	9	12	5	11	....	1	....	0.20
418	Moths	5	85	135	29	41	114	6	3	2.08
9	Gypsy moth larvae	3	5	....	....	1	....	....	....	0.04
3	Other caterpillars	....	3	....	....	....	....	....	....	0.02
20,064	Totals	42	301	486	374	805	1,602	7,694	8,760	....

TABLE 12

Census of Insects belonging to Miscellaneous Groups Collected in the Royalston Check Plot

(Partial and total counts by groups)

	Lot No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*% of Total*
36	Diplopoda	....	5	....	....	....	....	21	10	0.61
1176	Spiders & Phalangida	63	72	233	131	84	156	215	222	19.6
45	Orthoptera	....	9	22	2	4	8	....	....	0.76
91	Thysanoptera	....	....	56	....	....	....	....	35	1.54
3	Blattidae	....	3	....	....	....	....	....	....	0.05
465	Corrodentia	....	25	6	166	4	12	23	229	7.9
7	Membracidae	....	5	....	2	....	....	....	....	0.12
804	Jassoidea	6	30	17	14	69	260	77	331	13.6
2	Fulgoroidea	....	....	....	2	....	....	....	....	0.03
1891	Aphididae	6	4	....	12	11	28	506	1324	32.4
1	Pentatomidae	....	1	....	....	....	....	....	....	0.02
13	Tingitidae	....	....	6	....	....	4	3	....	0.22
247	Other small Hemiptera	....	12	6	19	71	52	54	33	4.21
162	Plecoptera	12	....	148	....	....	....	....	2	2.75
1	Odonata	....	....	....	1	....	....	....	....	0.02
3	Ephemerida	....	....	3	....	....	....	....	....	0.05
11	Hemerobiidae	3	1	....	5	....	....	....	2	0.19
....	Chrysopidae	....	....	....	....	....	....	....	....	....
25	Panorpidae	....	3	6	7	6	....	....	3	0.42
100	Trichoptera	6	5	22	9	11	36	8	3	1.70
485	Moths	21	25	168	23	105	126	14	3	8.20
331	Gypsy moth larvae	18	35	249	23	6	....	....	....	5.61
6	Other caterpillars	....	....	....	....	....	....	6	....	0.10
5,905	Totals	135	235	942	416	371	682	927	2197	....

TABLE 13

Census of Insects belonging to Miscellaneous Groups Collected in the Petersham Check Plot

(Partial and total counts by groups)

	Lot No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*% of Total*
5	Diplopoda	....	....	....	....	....	....	....	5	0.13
590	Spiders & Phalangida	....	14	151	69	106	105	96	49	15.4
7	Orthoptera	....	4	2	1	....	....	....	....	0.18
346	Thysanoptera	....	....	41	5	47	217	20	16	9.1
....	Blattidae	....	....	....	....	....	....	....	....	....
121	Corrodentia	....	5	8	5	5	26	3	69	3.16
9	Membracidae	....	1	4	....	1	3	....	....	0.23
663	Jassoidea	....	2	96	68	94	106	179	118	17.3
5	Fulgoroidea	....	....	4	1	....	....	....	....	0.13
1561	Aphididae	....	1	128	19	5	613	114	681	40.6
2	Pentatomidae	....	....	....	....	....	1	....	1	0.05
54	Tingitidae	....	1	41	....	3	2	1	6	1.42
55	Other small Hemiptera	....	....	4	1	10	10	26	4	1.43
32	Plecoptera	....	29	....	2	....	1	....	....	0.84
....	Odonata	....	....	....	....	....	....	....	....	....
....	Ephemerida	....	....	....	....	....	....	....	....	....
9	Hemerobiidae	....	....	2	1	1	3	....	2	0.24
....	Chrysopidae	....	....	....	....	....	....	....	....	....
11	Panorpidae	....	1	4	....	....	3	1	2	0.29
21	Trichoptera	....	5	6	1	1	2	2	4	0.55
242	Moths	....	21	72	27	35	71	13	3	6.31
93	Gypsy moth larvae	....	44	26	15	4	4	....	....	2.42
2	Other caterpillars	....	....	....	....	....	....	....	2	0.05
3,828	Totals	....	128	589	215	312	1167	455	962	....

TABLE 14

Comparative Abundance of the Several Families of Diptera in the Sprayed Area and Check Plots

Family	DDT	Royal-ston	Peters-ham	% of totals DDT	R	P
Tipuloidea	53	19	63	0.03	0.04	0.14
Psychodidae	173	68	112	0.10	0.16	0.24
Culicidae	3	2	. .	0.002	0.005	
Simuliidae	5	3	1	0.008	0.007	0.002
Anisopodidae	73	. . . .	3	0.05	. . . .	0.006
Bibionidae	67	35	29	0.04	0.08	0.06
Mycetophilidae & other midges	21,522	8,238	25,963	14.7	19.6	56.7
Stratiomyiidae	46	3		0.03	0.007	. . . .
Rhagionidae	403	814	537	0.26	1.93	1.87
Tabanidae	6	1	. . . .	0.004	0.002	. . .
Therevidae			2			0.004
Asilidae	28	10	26	0.02	0.02	0.05
Empididae	227	126	126	0.15	0.29	0.31
Dolichopodidae	778	1276	759	0.52	2.9	1.78
Phoridae	124,847	28,393	14,961	80.3	66.7	32.5
Pipunculidae	3	34	12	0.002	0.08	0.02
Muscoidea	. . . .	. . . .	. . . .	. . . .	. . . .	
Thecostomata	2,446	267	289	1.58	0.65	0.63
Haplostomata	4,791	3,033	2,848	3.15	7.3	6.2
Totals	154,471	42,322	45,731			

able, since the validity of some of the conclusions reached at that time have been questioned in a recent paper by Ander ('42). The collections considered in the present paper were made only a few miles from the several sites selected for the earlier study but in areas which have been more recently cut over for lumber and fire wood. Such operations, resulting in highly significant changes in the forest flora, should be sharply reflected in the insect fauna. Definite indications that very extensive changes do take place are furnished by the present census when it is compared with the earlier one, and any attempt to reconstruct the insect fauna of the primeval New England forest is admittedly only an approximation.

Ander believes that the region where the first census was made is much drier than was the amber forest. This is true in general for the area, but at least not very noticeably so for the heavily forested areas of mature timber, well watered by running streams and including swampy spots. These were selected for the collections. Furthermore, it may be stated with assurance that the wood and bark inhabiting insect fauna (of this region at least) now includes most abundantly the most primitive living types of the specialized orders (cf. Brues '27). There can, therefore, be no reason to believe that the first census selected a more modern sample of our recent fauna such as that dealt with in the present paper. Certainly any selective tendency would be in the other direction, and approach the conditions that prevailed in the amber forests.

Concerning any selectivity which might be exercised by the use of a specific sticky substance such as the castor oil and rosin of which the tanglefoot was composed, I am convinced that this plays no significant part in determining the nature of the catch. Continued observation indicates that the insects are trapped quite at random when they blunder on the sticky surface either in flight,

TABLE 15

Comparative Abundance of the Several Families of Hymenoptera in the Sprayed Area and Check Plots

Order HYMENOPTERA

Family	DDT	Royal-ston	Peters-ham	% of totals DDT	R	P
Xyelidae	7	1	2	0.04	0.02	0.04
Oryssidae			1		. .	0.02
Tenthredinoidea	41	111	21	0.25	2.68	0.42
Cephidae	2			0.01	. . . .	. . . .
Braconidae	1180	668	792	7.40	15.9	16.7
Evaniidae	2	2		0.01	0.05	
Ichneumonidae	841	806	638	5.28	19.5	12.9
Chalcidoidea	11,430	488	1310	72.2	11.8	26.4
Mymaridae	20	76	213	0.12	1.84	4.34
Belytidae	60	257	206	0.37	6.22	4.18
Diapriidae	41	7	51	0.25	0.17	1.03
Scelionidae	519	544	639	3.26	13.9	12.8
Platygastridae	684	297	431	4.28	7.19	8.73
Calliceratidae	151	478	388	0.95	11.6	7.87
Bethylidae	87	36	50	0.54	0.82	1.01
Dryinidae	4	1	9	0.02	0.02	0.18
Cynipoidea	38	18	7	0.23	0.43	0.14
Formicidae	674	284	126	4.24	6.88	2.55
Chrysididae	14	3	7	0.09	0.07	0.14
Psammocharidae	29	15	21	0.18	0.36	0.42
Other Wasps	96	19	25	0.60	0.46	0.51
Apoidea	4	3	2	0.02	0.07	0.04
Totals	15,924	4,114	4,939			. . .

TABLE 16

Comparative Abundance of the Several Families of Coleoptera in the Sprayed Area and Check Plots

Family	DDT	Royal-ston	Peters-ham	% of totals DDT	R	P
Carabidae	8	11	4	0.6	0.4	0.2
Silphidae			1			0.1
Staphylinidae	27	29	11	2.1	1.1	0.4
Pselaphidae	4	1	3	0.3	0.1	0.1
Cucujidae	1			0.1		
Lampyridae	13	73	51	1.1	2.8	2.0
Cantharidae	284	139	25	22.5	5.4	1.0
Lycidae	1	4	4	0.1	0.2	0.2
Malachiidae	9	6	37	0.8	0.2	1.5
Cleridae	107	24	708	8.4	0.9	28.0
Oedemeridae	8	14	8	0.6	0.5	0.3
Mordellidae	31	20	113	2.5	0.8	4.5
Rhipiphoridae	2			0.2		
Pyrochroidae	2		4	0.2		0.2
Elateridae	39	52	49	3.1	2.0	1.9
Throscidae	35	389	147	2.9	14.8	5.8
Helodidae	15	49	109	1.3	1.9	4.3
Dermestidae		52	2		2.0	0.1
Byrrhidae	4			0.3		
Histeridae	1			0.1		
Ostomatidae	2	3	1	0.2	0.1	0.1
Cryptophagidae			1			0.1
Nitidulidae		11			0.4	
Mycetophagidae			1			0.1
Erotylidae			1			0.1
Phalacridae	2		6	0.2		0.2
Anobiidae	20	14	20	1.6	0.5	0.8
Latridiidae	510	1,499	974	40.5	58.3	38.5
Endomychidae	4	10	11	0.3	0.4	0.4
Mycetaeidae	1			0.1		
Coccinellidae	44	16	15	3.5	0.6	0.6
Tenebrionidae	3	7	4	0.3	0.3	0.2
Cistelidae	34	51	74	2.9	1.9	2.9
Lagriidae	1	9	4	0.1	0.3	0.2
Melandryidae	6	13	32	0.5	0.5	1.3
Cerambycidae	9	13	6	0.7	0.5	0.2
Chrysomelidae	25	28	89	2.1	1.1	3.5
Brentidae	1			0.1		
Curculionidae	14	20	18	1.2	0.8	0.7
Scolytidae	13	18	8	1.1	0.7	0.3
Scarabaeidae	2		3	0.2		0.1
Totals	1,282	2,575	2,554			

TABLE 17

Comparative Abundance of the Several Groups of Miscellaneous Insects in the Sprayed Area and the Check Plots

Family	DDT	Royal-ston	Peters-ham	% of Totals DDT	R	P
Diplopoda	7	36	5	0.03	0.61	0.13
Spiders and Phalangida	322	1176	590	1.6	19.6	15.4
Orthoptera	27	45	7	0.13	0.77	0.18
Thysanoptera	32	91	346	0.16	1.56	9.1
Blattidae	6	3		0.03	0.05	
Corrodentia	25	465	121	0.12	7.9	3.16
Membracidae		7	9		0.12	0.23
Jassoidea	117	804	663	0.57	19.6	17.3
Fulgoroidea		2	5		0.03	0.13
Aphididae	18,883	1891	1561	93.5	32.4	40.6
Pentatomidae		1	2		0.02	0.05
Tingitidae	1	13	54	0.01	0.22	1.41
Other small Hemiptera	113	247	55	0.56	4.21	1.44
Plecoptera	15	162	32	0.07	2.75	0.83
Odonata	1	1		0.01	0.02	
Ephemerida	3	3		0.01	0.05	
Hemerobiidae	32	11	9	0.16	0.19	0.23
Chrysopidae	7			0.03		
Panorpidae	1	25	11	0.01	0.43	0.29
Trichoptera	41	100	21	0.20	1.70	0.55
Moths	418	485	242	2.08	8.20	6.31
Gypsy moth larvae	9	331	93	0.04	5.61	2.42
Other caterpillars	3	6	2	0.02	0.10	0.05
Totals	20,064	5,905	3,828			

or in the case of typically cursorial and flightless forms, when their path leads them over the edges of the papers. Such forms, notably ants, spiders and harvestmen, are more numerous about the periphery of the sheets, although a surprisingly large number appear elsewhere, due probably to lost footholds or to sudden anemonal disturbances in the immediate environment.

As a check on the general accuracy of the previous survey and as an interesting corollary, a comparison of the insect fauna of the mature forest with that of the now prevailing second-growth woodland may be drawn from the data contained in the present account.

Without going into any great detail, a number of marked discrepancies are evident in the two censuses. These are readily apparent from the following tabulation in which the representation of the groups listed in the earlier census is compared with that in the two check areas where the 1945 collections were made. For further comparison the data for the sprayed area are included, although dealt with already on the preceding pages.

TABLE 18

Comparative Abundance of Several Representative Groups in the Mature Timber Areas (1930) and Second Growth Areas (1945)

	1930 Census	*1945 Census*	
		Unsprayed Areas	*Sprayed Areas*
Trichoptera	1.5%	0.09%	0.002%
Lepidoptera	0.7%	1.2%	0.02%
Homoptera	10.8%	4.4%	10.0%
Diptera	71.9%	78.2%	80.3%
Coleoptera	2.5%	4.6%	0.7%
Hymenoptera	5.0%	8.1%	8.3%
Arachnida	5.2%	1.6%	0.2%

These variations as indicated in the left-hand and middle columns are obviously due to widely different ecological conditions in the two types of forest, and any attempt to analyze these would be an utterly rash venture into the field of speculation. They serve, however, to indicate with great clarity that field studies of insect populations must be conducted with the greatest possible attention to details of habitat. In spite of the ability of flying insects to travel with great freedom, they do not do so extensively. As a major part of them is directly dependent on plants, frequently specific ones, the composition of the flora at once becomes a first consideration in determining their distribution. Secondarily this exerts a profound influence in regulating the range of the numerous predatory and parasitic species which prey most generally on insects of vegetarian habits. Obviously the most strikingly notable discrepancies noted in Table 14 can be attributed to differences in the immediate flora. With others, such as the caddis flies representing the order Trichoptera, the proximity of water is the chief determining factor, as the immature stages are exclusively aquatic. Atmospheric humidity and soil moisture are likewise primary factors, aside from their secondary effects as expressed through the composition of the flora. This is shown, for example, among flies of the family Dolichopodidae, characteristic of damp, shady situations and far more abundant in the mature forest where the earlier census was made.

Such considerations may tend to throw some doubt on the validity of the conclusions expressed in the body of the present paper, but it is felt by the writer that the data secured are sufficient to dispel without question the fear that a reasonable amount of spraying with DDT in New England woodlands will introduce any serious changes in the prevailing insect fauna.

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