OCCURRENCE OF THE BEET LEAFHOPPER AND ASSOCIATED INSECTS ON ...
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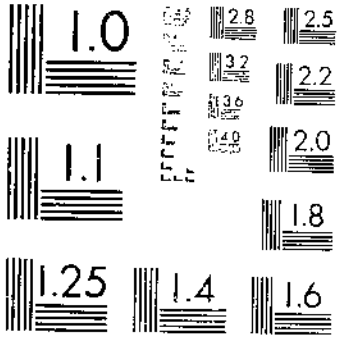

MICROCOPY RESOLUTION TEST CHART
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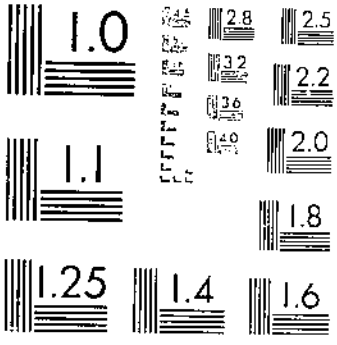

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OCCURRENCE OF THE BEET LEAFHOPPER AND ASSOCIATED INSECTS ON SECONDARY PLANT SUCCESSIONS IN SOUTHERN IDAHO[1]

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CONTENTS

INTRODUCTION

In a study of the beet leafhopper (*Eutettix tenellus* (Baker)) and its relationship to the insect populations of the secondary plant successions of the sagebrush association in southern Idaho, the most important fact revealed, from an economic standpoint, is that this insect is significantly abundant upon the plants of the earlier weed growth but is either lacking or constitutes an insignificant part of the insect fauna of both the later successions and the original sagebrush association.

The study of the beet leafhopper, the insect vector of curly top, which is an important virus disease of sugar beets, tomatoes, and other cultivated crops in the Western States, was first undertaken as a formal project by the Bureau of Entomology in 1925. Twin Falls,

[1] Received for publication April 26, 1937.

[2] In the accumulation of the necessary data many individuals eventually became more or less intimately associated with this work. The study was conceived and the project inaugurated in 1928 by Walter Carter, then of the Bureau of Entomology, and was carried out under his direction from 1928 to 1929. The work was under the direction of P. N. Annand from 1930 to 1931, and under J. C. Chamberlin from 1932 until its termination in 1933. With the cooperation of the Bureau of Plant Industry a study of the plant successions was begun in the spring of 1928 by R. L. Piemeisel. All of the plant-succession data used in this bulletin were collected and treated by Piemeisel, who also gave valuable criticisms and suggestions while the manuscript was in the course of preparation. Acknowledgements are also due to C. T. McCoy and J. A. Gillett, who did most of the sorting of collections and pinning of specimens during 1929, 1930, and 1931, and to W. C. Cook, who gave valuable criticisms of the manuscript.

Idaho, was selected as the headquarters for the study because of the periodic economic damage which occurred in that locality and because it is in an important permanent breeding area.

Carter (*2*),[3] early in his investigation of the problem in southern Idaho, pointed out that the weeds covering the abandoned land served as important breeding hosts for the beet leafhopper. It was therefore determined to make a study of the particular relationship that existed between the succession of the various secondary plants and the abundance of the beet leafhopper and associated insects.

CULTURAL HISTORY OF THE AREA

The Snake River Plains, in which the Twin Falls beet-growing district is situated, are located in the northern desert shrub region. The sagebrush (*Artemisia tridentata* Nutt.) association originally formed the vegetative cover. Extensive areas of this perennial cover have been cleared to prepare the land for cultivation, and, while most of it is continuously farmed, thousands of acres, particularly the borderlands and those sections having an inadequate water supply, are farmed intermittently or have been abandoned.

Piemeisel (*9*) states that these denuded tracts, now in the early stages of reverting to the original vegetation, are covered with weeds, chiefly five annuals—tumblemustard (*Norta altissima* (L.) Britton), flixweed (*Sophia parviflora* (Lam.) Standl.), green tansymustard or sage mustard (*Sophia longipedicellata* (Fourn.) Howell), Russian-thistle (*Salsola pestifer* A. Nels.), and downy bromegrass or downy chess (*Bromus tectorum* L.). Of these, the first four are of particular importance in that they are the first to occupy denuded lands after abandonment and are of special economic importance on such areas because they serve as favorable hosts for the beet leafhopper.

The seasonal sequence of these weed hosts from green tansymustard late in the winter and in the early part of spring to Russian-thistle during the summer and fall affords, under optimum conditions, an unbroken series of favorable food plants for the development of large populations of the beet leafhopper. A discussion of this seasonal sequence and its relationship to the beet leafhopper is given in a later section (p. 7). Downy chess, an introduced annual, which appears somewhat later on the denuded lands, is not regarded as a host of the beet leafhopper and will be discussed in that connection.

Carter (*2*) and Annand and others (*1*) have emphasized the relation of the large abandoned areas adjacent to the Twin Falls beet-growing district to the abundance of the beet leafhopper and the curly top disease. Extensive surveys throughout southern Idaho by Haegele (*6*) gave additional information as to the importance of these weeds as hosts of the beet leafhopper. The flight and movements of the leafhopper from one host to another and from one area to another have been discussed somewhat in detail by Carter (*2*), Haegele (*6*), Annand and others (*1*), and Fulton and Chamberlin (*4*). It has been pointed out in these papers that these weed hosts, especially the rapidly growing spring mustards, are of prime importance in producing large early-spring populations of leafhoppers.

[3] Italic numbers in parentheses refer to Literature Cited, p. 43.

HISTORY OF THE PLOTS

An investigation of the succession of important predominating insect species was paralleled with a similar study of the succession of plant cover on denuded or newly abandoned lands. This phase of the investigation was carried out as an independent study by Piemeisel [4] of the Bureau of Plant Industry, who with Lawson (*10*) has completed a study of vegetation in its relation to the beet leafhopper in California.

The plots upon which this study was made were located near Hollister, Idaho, near the center of an important breeding area of the beet leafhopper. Six small plots, each comprising 100 square meters, were fenced and protected from the grazing of larger animals. Observations on plant growth and condition had been made early in 1928, but it was not until the last of May that the plots were enclosed and in June that routine insect collections were begun.

All of the plots were situated in fields that had been last irrigated and cropped in 1927. Each plot represented a particular phase in abandonment at the beginning, but only plots 1, 4, and 5 are considered in any detail in this discussion, and a chronological history of these three plots is given for the period beginning in 1927 and ended in 1933 (table 1).

TABLE 1.—*Plant composition of plots 1, 4, and 5, and percentage of the area covered by each species during the years 1927 to 1933, inclusive, Hollister, Idaho (Piemeisel's data)*

Plot and year	Type of stand	Proportion of area occupied	Plot and year	Type of stand	Proportion of area occupied
Plot 1:		*Percent*			*Percent*
1927	Irrigated alfalfa crop	--	1931	Flixweed	42
				Downy chess and flixweed	37
1928	Alfalfa	33		Downy chess	17
	Bare area	5		Nearly bare	4
	Downy chess	62			
			1932	Downy chess	99
1929	Alfalfa	23		Nearly bare	1
	Bare area	11			
	Downy chess	66		Downy chess	98
			1933	Nearly bare or sparse downy chess	2
1930	Alfalfa	[1]			
	Bare area	[1]	Plot 5:		
	Downy chess	[1]	1927	Irrigated alfalfa crop	-
1931	Alfalfa	4	1928	Alfalfa	9
	Bare area	13		Russian-thistle	91
	Downy chess	83			
			1929	Alfalfa	8
1932	Alfalfa	4		Flixweed	90
	Bare area	[2]		Downy chess	2
	Downy chess	95			
			1930	Alfalfa	10
1933	Alfalfa	[2]		Flixweed	85
	Nearly bare	39		Downy chess	5
	Downy chess	61			
Plot 4:			1931	Alfalfa	7
1927	Irrigated crop of barley	--		Flixweed	10
				Downy chess	76
1928	Russian-thistle and barley stubble	70		Nearly bare	7
	Russian-thistle (second growth)	30	1932	Alfalfa	3
				Downy chess	92
1929	Russian-thistle and flixweed	99		Nearly bare	5
	Downy chess	1			
			1933	Alfalfa	[2]
1930	Flixweed	94		Downy chess	98
	Tumble mustard	2		Bare	1
	Downy chess	4			

[1] No record.

[2] Less than 1 percent.

[4] PIEMEISEL, R. L. CHANGES IN WEEDY PLANT COVER ON CLEARED SAGEBRUSH LANDS AND THEIR PROBABLE CAUSES. (Unpublished manuscript.)

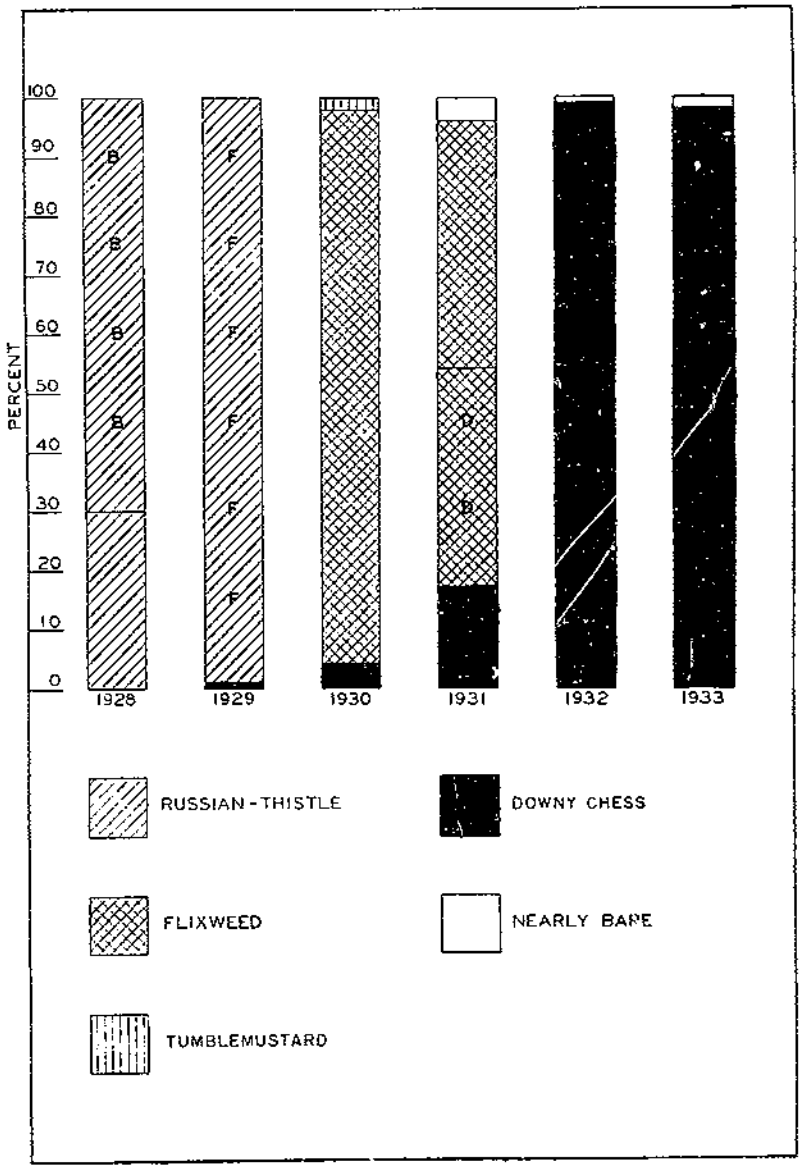

FIGURE 1.—The percentages of the area of plot 4, Hollister, Idaho, covered by Russian-thistle, flixweed, tumblemustard, and downy chess during the years 1928 to 1933, inclusive. In 1928 Russian-thistle occurred as a pure stand in dense patches over 30 percent of the plot and was the dominant plant, though less dense and mixed with barley stubble (*B*) over the remaining 70 percent of the area. In 1929 a sparse growth of flixweed (*F*) was mixed with Russian-thistle, and in 1931 37 percent of the area was covered by an inseparable mixture of flixweed and downy chess (*D*).

All three of these plots showed the same general trend of succession from abandonment, after the removal of a cultivated crop, to a final cover of downy chess. In this first attempt at correlating the growth of successive weed hosts of the beet leafhopper with the predominating species of insects throughout the various stages of the succession,

plot 4 was selected as being the one which furnished the most-clear-cut example of such a succession. Apparently, climatological and biotic factors had operated in such a manner on this plot as to produce definite changes in plant cover during each year (table and fig. 1).

This vegetative cover began during the summer of 1928 with a mixture of Russian-thistle and short-lived annuals and changed in 1929 to a mixture of Russian-thistle and flixweed. During the spring and summer of 1930 the plot produced an approximately 94-percent stand of flixweed, with only a few plants of tumblemustard and downy chess. This in turn was followed in 1931 by a mixture of flixweed and downy chess, with the complete elimination of both Russian-thistle and tumblemustard. The excessive drought early in the summer of 1931 prevented the flixweed from producing seed, so during the succeeding 2 years (1932 and 1933) this host was eliminated from the plot, and its place was occupied by a pure stand of downy chess.

METHODS OF SAMPLING AND LIMITATIONS OF THE STUDY

All insect collections were taken by means of the sweep net, a standard of 50 sweeps having been adopted as a unit of measure for this study. The collections were made on various dates from April to October, inclusive, 50 sweeps being made on each plot on each date. It is recognized that sweeping has many disadvantages and introduces serious errors if too much reliance is placed upon records taken in this manner. DeLong (*3*) has pointed out some of the inaccuracies that will very likely occur if collections are taken in this manner without regard to qualifying factors, while Gray and Treloar (*5*) have conclusively demonstrated the same thing. Temperature and wind are probably the most important factors adversely influencing the quantitative accuracy of net collections in the types of vegetative growth encountered on these plots. For the purposes of this study, however, the net has served as an excellent qualitative measure and, to all appearances, gives generally a more or less reliable estimate of adult populations of the predominating species.

Quantitative sampling for all of the species present was not attempted, owing to the limited amount of time and personnel that could be given to the project. Neither was any attempt made to estimate the numbers of immature forms of any of the species, owing, primarily, to the inefficiency of sweeping as a sampling method for them and, secondarily, to the great difficulty of obtaining accurate determinations of the species involved. Those species that confine their activities to the surface of the ground were sampled in a very incidental manner, so that the records of their presence, at best, can be considered accurate only in a broad qualitative way. The incidence of Aphiidae, Locustidae, Thysanoptera, and flower-visiting Diptera and Hymenoptera have been considered only in a very broad and general way. No attempts were made to sample for either soil-inhabiting forms or nocturnal species. Members of each of these groups were undoubtedly present, and, since each must bear some significance in the biotic community, they should be considered if an accurate concept of specific interrelationships is to be obtained; but the general nature of the data available for this report will necessarily preclude them from a detailed discussion. Therefore, only the adults of the various species are given consideration, the predominating

species are discussed in detail, and the incidental species are treated in a more general manner.

THE PREDOMINATING INSECT SPECIES ENCOUNTERED DURING THE STUDY

Any attempted evaluation of the importance of a limited number of species in an association must be partly speculative, unless the effects of all members are known, but certain tentative conclusions, at least, can be drawn from a study of the fluctuations of the species occurring more commonly than those of lesser abundance. It is certain that periodic seasonal fluctuations of the species are intimately tied up with the type and condition of vegetative cover and that radical changes in the composition of the plant community must necessarily result in drastic changes in the number, as well as in the kind, of species it supports.

The few species found to be of general predominance throughout the successive changes in the plant cover on plot 4 are shown in table 2. Those given specific designation in the table include three species of Homoptera, all belonging to the family Cicadellidae; five species of Heniptera, representing the families Miridae, Nabidae, and Lygaeidae; and one species of Coleoptera, of the family Chrysomelidae.

TABLE 2.—*Total numbers of the more abundant species of insects and spiders collected on plot 4 during 1928–33, Hollister, Idaho*

Species	Common name	1928	1929	1930	1931	1932	1933
Homoptera:							
Eutettix tenellus (Baker)	Beet leafhopper	1,553	433	86	291	0	0
Accratagallia fuscoscripta Oman	Alfalfa leafhopper	91	49	5	39	0	0
Thamnotettix cenditarius Ball	Mustard leafhopper	0	0	0	27	0	0
Other Homoptera		6	0	0	10	0	0
Hemiptera:							
Geocoris pallens Stål	Big-eyed bug	10	16	2	31	0	0
Nysius ericae (Schilling)	False chinch bug	0	206	1,072	64	0	0
Lygus elisus Van Duzee	Pale legume bug	28	3	2	13	0	0
Melanotrichus conjulatus (Uhler)	Mottled plant bug	9	3	0	1,000	0	0
Nabis alternata Parshley	Damsel bug	3	1	2	7	0	0
Other Hemiptera		4	4	0	1	0	0
Coleoptera:							
Phyllotreta albionica (LeConte)	Mustard flea beetle	32	38	21	82	0	0
Other Coleoptera		7	12	4	26	0	0
Hymenoptera		7	1	5	2	0	0
Diptera		23	1	21	1	0	0
Araneida		...	23	51	55	0	0

Frequently a single species would predominate enormously over all others, but at other times, and under certain environmental conditions, all of those listed in table 2 would be more or less equal in their abundance. The beet leafhopper (*Eutettix tenellus*) was present in relatively large numbers, whenever one of its preferred hosts formed a part of the vegetative cover. Since these relatively few species constituted such a large percentage of the visible animal life of the plot, it seemed desirable to make a detailed study of their relative abundance, fluctuation, and final disappearance, along with a similar study of successive vegetative covers. The less abundant species, which are grouped by orders in table 2, are discussed in much less detail in a later section of this bulletin

A detailed discussion of the abundance and fluctuation of the beet leafhopper, in relation to the appearance and disappearance of its host plants from year to year, will be given, but such complete information is not available for the remainder of the predominating species. Each will be treated, however, as completely as is necessary to show its host preferences and to furnish some basis for comparing the abundance of that species with the abundance of the beet leafhopper and other important species of the population.

THE BEET LEAFHOPPER

The beet leafhopper (*Eutettix tenellus* (Baker)) lives through the winter in the adult stage and produces a new brood in the spring on the mustard host plants. The adults of this spring brood move indiscriminately to some other available food supply later in the spring or early in the summer. It is during this annual spring movement that beets and other cultivated crops become infested with the leafhoppers. It should be emphasized, however, that not all, and probably not even a large percentage, of the moving leafhoppers find their way into the more or less distant beet fields, for most of them become established upon the extensive stands of Russian-thistle, which constitutes the principal summer weed host within this area. The remainder of the season is spent in either situation, and rapid multiplication produces enormous numbers of individuals by the time of maturation or drying up of Russian-thistle and the harvesting of beets late in September and throughout October. The large fall populations of the beet leafhopper are naturally placed in a rather precarious position by this fall drying of Russian-thistle and elimination of beets by harvesting, so it becomes necessary for them to make another movement in search of food. Under favorable conditions, where there has been sufficient precipitation late in the summer or in the early fall months to germinate mustard seeds over the outlying and abandoned lands, a transfer is made by the beet leafhoppers remaining on dry Russian-thistles to these fresh plants. If, however, there has been insufficient precipitation to bring about this germination, the leafhoppers are forced by necessity to move to any green plant available.

In the Snake River Plains area the most abundant of these hold-over hosts is sagebrush, which is a very undesirable food plant for the beet leafhopper, and a heavy mortality results in the transfer from Russian-thistle to sagebrush. If fall rains are delayed from 4 to 8 weeks after the drying of the Russian-thistles, such heavy mortality may result among the leafhoppers that what was an enormous population on Russian-thistle late in October can be reduced to a relatively few individuals by the middle of December.

Physical factors are of importance in holding the populations of the beet leafhopper at a low ebb throughout the summer months. Perhaps the most effective of these are continued summer drought conditions, occasionally extended into the fall, and accompanied by high temperatures. Under these conditions Russian-thistle dries prematurely throughout the season, resulting in a constant thinning of the stands and at times the complete elimination of large areas of this host plant. Eggs and newly hatched nymphs of the beet leafhopper survive under these conditions with extreme difficulty, or not at all, with the result that high fall populations cannot be attained.

THE ALFALFA LEAFHOPPER [3]

The alfalfa leafhopper (*Aceratagallia fuscoscripta*) generally overwinters in the adult stage and may be found abundant in the spring on grasses, alfalfa, and almost any green plant, but it usually prefers leguminous plants. It is, however, rather general in its food habits and may be found on all of the host plants of the beet leafhopper. The data presented in table 3 give a comparison of the numbers of adults of *A. fuscoscripta* collected on plot 4 with those taken from plots 1 and 5. At the time the studies began, the vegetation of both plots 1 and 5 included a considerable percentage of alfalfa (table 1). This plant is preferred by this leafhopper, and consequently a larger population of this species was recorded from these two alfalfa plots than from plot 4 which was covered by a stand of Russian-thistle and short-lived annuals as shown in table 1.

TABLE 3.—*Comparison of the numbers of Aceratagallia fuscoscripta from plots 1 and 5 with those from plot 4, Hollister, Idaho, 1928–31* [1]

Year [1]	Plot	April 11	May 4	May 20	June 2	June 13	June 23	June 29	July 5	July 10	July 19	July 24
1928	1						5		17		125	
	4						8		0		7	
	5						26		11		61	
1929	1									258		
	4									18		
	5									67		
1930	1	2								9		27
	4	0								1		3
	5	7								3		4
1931	1		0	2	0	1		0		0		1
	4		0	12	5	10		12		0		0
	5		0	0	6	2		10		1		3

Year [1]	Plot	August 1	August 7	August 11	August 17	August 22	August 28	September 4	September 10	September 24	October 1	October 24
1928	1	102			59		73		12	14	10	2
	4	8			33		12		10	7	0	0
	5	20			43		19		32	20	2	2
1929	1	217			358		53		52			
	4	4			16		9		2			
	5	31			142		28		21			
1930	1		29		19			2		7		
	4		0		0			6		1		
	5		3		2			1		1		
1931	1			0		1		0		0	0	
	4			0		0		0		0	0	
	5			0		1		0				

[1] No individuals were collected on any plot in 1932 or 1933.

It is of interest to note that the numbers of *Aceratagallia fuscoscripta* taken from plots 1 and 5 during 1928 and 1929 greatly exceeded the numbers collected on plot 4 during the same periods. By 1931, however, the numbers collected were low in all plots, as a result of the gradual replacement of alfalfa in plots 1 and 5 by annual weeds that

[3] All of the specimens collected and grouped under this heading were originally determined as *Agallia sanguinolenta* (Provancher) and were so considered until the recent revision of the agallian leafhoppers by Oman (8) made that designation untenable. It is quite possible that *Aceratagallia arida* Oman was also present in the material here considered as *A. fuscoscripta*. In view of the fact that the common name clover leafhopper has been used to designate *A. sanguinolenta* (Provancher) it is proposed that *A. fuscoscripta* Oman be given the common name alfalfa leafhopper.

were not so greatly preferred by *A. fuscoscripta*. Further reference to the data of table 1 shows that the percentage of alfalfa in plot 1 did not decrease materially until 1931, but the continued reduction in numbers of the insect would indicate that the alfalfa had become progressively less desirable as a host plant from 1929 on.

THE MUSTARD LEAFHOPPER [6]

Little of the life history of the mustard leafhopper (*Thamnotettix renditarius*) is known as yet, but the insect apparently passes the winter in either the egg or nymphal stage, for nymphs are always found in the spring on mustards before any adults make their appearance. Apparently it is a single-brooded species, for only occasional specimens have been taken during the summer and fall months.

This species has a much more limited range of food plants than either *Aceratagallia fuscoscripta* or *Eutettix tenellus* and appears to favor the mustards, for it is from these hosts that it is generally taken. An indication of its preference for the spring mustards is shown in a series of collections made during June 1932, at a point not far distant from plot 4 in the Hollister area. A long series of collections made on flixweed, one of the mustards, and paralleled by a similar series from an adjacent stand of Russian-thistle revealed that on an average 4.9 mustard leafhoppers per 50 sweeps of the net were taken from flixweed while the parallel set of collections from Russian-thistle produced an average of only 1.6 individuals per 50 sweeps. *Thamnotettix renditarius* is never excessively abundant in this area but is almost always present and is included in this discussion merely as an example of the preference shown for the spring mustards by some species.

THE BIG-EYED BUG [7]

The big-eyed bug (*Geocoris pallens*), a species of Hemiptera, is known to act as a predator of the beet leafhopper and other leafhoppers, as well as of certain other Homoptera and Hemiptera. Knowlton (7) has described in detail the predatory behavior of a variety of this species, *G. pallens* var. *decoratus* Uhler, upon caged beet leafhoppers, and has indicated the probable importance of this variety as a natural check upon the activities of the beet leafhopper in northern Utah.

Geocoris pallens passes the winter in the adult stage and becomes active during the relatively warm days throughout this time of the year. It appears very early in the spring and is active at lower temperatures than is either *Eutettix tenellus* or *Aceratagallia fuscoscripta*. Early in the spring *G. pallens* is frequently found to be so numerous in small areas as to outnumber all other species combined. This, coupled with its activity at low temperatures, in all probability increases its efficiency as a predator and causes it to become particularly important in this regard during the spring. This predator is often found running rapidly over the surface of the soil, particularly in the

[6] Although the greater percentage of the specimens recorded in this report as *Thamnotettix renditarius* are of that identity, it is possible that some of the records may also have included specimens of *T. geminatus* Van Duzee, a closely related species.

[7] Earlier determinations of material from this area gave the name *Geocoris bullatus* (Say) to the bulk of the specimens of this genus found in these collections. This was later found to be apparently erroneous, since more recent determinations have shown that a very large percentage of the specimens were *G. pallens* Stål and that *G. bullatus* is relatively scarce in the fauna of this area. Bearing this correction in mind, all of the specimens of *Geocoris* have been grouped under the species name *G. pallens* even though *G. bullatus* may have been present in small numbers.

spring, but with warmer weather it does not limit itself to this habitat, for it may be taken repeatedly by sweeping tall vegetation and has been, at times, taken in numbers from a trap placed 50 feet above the ground. In the fall it is usually most abundant in those situations where adults and nymphs of the beet leafhopper are present in large numbers.

THE MOTTLED PLANT BUG [8]

Although it is not definitely known, it seems highly probable that the mottled plant bug (*Melanotrichus coagulatus*) passes the winter in the egg stage. Up to the present time adults have not been found previous to the sudden appearance of large numbers of nymphs on the young spring mustards, usually in April and May. Enormous numbers of this species are produced in the spring and the early part of the summer on mustard host plants, but even adults are extremely scarce on Russian-thistle later in the season. In the light of this information it seems highly probable either that *M. coagulatus* is a single-brooded species that appears in abundance only during the early part of the season when the mustards are green, or that some unknown host plant supports the subsequent broods during the summer months. The rapid increase of this species from almost negligible numbers early in the spring to extreme predominance during May and June is well shown by the studies made on plot 4 and by observations made in other sections of the Hollister area. Frequently it will rise to such predominance in a few weeks as to outnumber all other species 4 to 1 (table 4), after which it practically disappears with the maturing of the spring mustards.

THE PALE LEGUME BUG [9]

Lygus elisus, which has been called the pale legume bug by Shull (*11*), is generally present in relatively constant numbers throughout the season although never becoming excessively abundant, and it may be found equally abundant on all the preferred host plants of the beet leafhopper.

This plant bug spends the winter in the adult stage and may be found active on the warmer days of winter. It becomes active very early, feeding upon the various mustards during spring and later transferring to Russian-thistle, upon which it persists throughout the summer and fall months. On individual plants it may become relatively abundant, but in general it maintains a rather low mean density of population throughout the season.

THE FALSE CHINCH BUG

The false chinch bug (*Nysius ericae*) spends the winter in the adult stage and appears early in the spring on the host plants of the beet leafhopper. It is a general feeder, and at times occurs in abundance on plants that are not preferred hosts of the beet leafhopper.

The false chinch bug frequently builds up enormous populations, both on the spring mustards and on Russian-thistle, but its peaks of

[8] The majority of the specimens included in this group were *Melanotrichus coagulatus*, but a few individuals of *M. flavosparsus* (Sahlberg) and certain other species of the genus were also grouped here.

[9] Two species of *Lygus* are found to be present in the Hollister area, *L. elisus* Van Duzee and *L. hesperus* Knight, but the majority taken in the collections of this study have been of the former species. Consequently, for the purpose of this report, the name *Lygus elisus* has been used to designate both.

abundance are rather erratic and are determined by factors as yet unknown. During certain periods of some seasons both nymphs and adults become so abundant in localized areas as actually to cover the ground, as well as all the plants, in the infested area. Under such conditions they undoubtedly cause considerable change in the environment and disturb the normal distribution of the beet leafhopper and other species by actual crowding.

A DAMSEL BUG

The damsel bug *Nabis alternata*, a representative of the family Nabidae, is known to be a predator of the beet leafhopper and probably includes many other species of Homoptera and Heniptera in its diet. Its larger size, in comparison with that of *Geocoris pallens*, undoubtedly enables it to prey upon larger species than Cicadellidae. Knowlton (7) has given detailed accounts of the predatory activity of this species with caged beet leafhoppers. In this study he found that this damsel bug, owing to its larger size, is a much more efficient predator of the beet leafhopper than is *G. pallens*, but that because of its lesser abundance in the habitat of the beet leafhopper it is probably of much less importance.

This damsel bug passes the winter in the adult stage and probably acts most efficiently as a predator during the early part of the season, as is the case with *Geocoris pallens*. In general, after the plants have reached some height this insect becomes semiarboreal, largely confining its activities to the plant rather than using both plant and soil as hunting grounds, as is usually the case with the species of *Geocoris*.

This damsel bug is generally present in the habitat of the beet leafhopper and is active from spring to fall, but it is not known to occur in large numbers, even in restricted areas. Collections made throughout the Hollister and other breeding areas of the beet leafhopper have indicated that this predator maintains itself in very small numbers and for this reason can be considered of only limited importance as a factor in the natural control of the beet leafhopper.

THE MUSTARD FLEA BEETLE

The mustard flea beetle (*Phyllotreta albionica*) spends the winter in the adult stage and may be found generally distributed on mustards, particularly *Norta altissima*, in the spring. The peak of adult abundance usually occurs at about the time these plants are maturing. At times, and in areas outside of the Hollister section, it has been observed to be enormously abundant on tumblemustard, even after that plant has dried completely. On June 22, 1931, two collections on tumblemustard in an area north of Burley, Idaho, gave 12,161 and 13,170 individuals per 50 sweeps, and it was not at all uncommon to net as many as 500 to 1,000 specimens in average collections taken from this host over this relatively large area. Flixweed frequently supports large populations of flea beetles, but never so great as those found on tumblemustard. This flea beetle prefers the mustards to all other hosts and maintains itself in active adult abundance only during the life of these annuals. Occasionally it may be taken from Russian-thistle in the summer or fall, but only in such small numbers as to cause it to be considered rare in that habitat.

WEEDS ABUNDANT ON ABANDONED LAND AND THEIR IMPORTANCE AS HOST PLANTS OF PREDOMINATING INSECT SPECIES

SPRING HOST PLANTS (TUMBLEMUSTARD AND FLIXWEED)

Portions of the abandoned lands immediately adjacent to the cultivated tract in the Hollister area are covered more or less completely, year after year, by varying stands of tumblemustard and flixweed. Flixweed has the more limited distribution of the two and is usually confined to those areas surrounding barnyards and feed lots, and frequently it is found to occur on lands that are cultivated intermittently. At times, however, it may be distributed over rather extensive areas, although always on lands that have been rather recently cultivated.

Tumblemustard, on the other hand, is much more widely distributed than flixweed and may occur on overgrazed or burned-over lands as well as on abandoned farming areas. It may be found either in extremely thick, pure stands or may be fairly uniformly scattered in stands of downy chess or Russian-thistle, or in overgrazed stands of sagebrush.

Both tumblemustard and flixweed support complex insect populations made up of a relatively large number of species. Many of these, of course, are merely flower-visiting Diptera and Hymenoptera that appear only during blossoming time and apparently exert no particular influence upon the more permanent fauna. Many of the more permanent members reproduce so rapidly and so prolifically that frequently, during the short life of their hosts, enormous populations are built up. The beet leafhopper is a member of this population, but on the spring host it usually must be relegated to a minor position if its abundance is measured on a strictly numerical basis in comparison with the other species.

In general, tumblemustard and flixweed support equivalent populations of insect species, both in kind and number, but preferences of certain species for one or the other of these mustards becomes markedly noticeable at times.

For purpose of comparison, series of data derived from net collections taken on adjacent stands of tumblemustard and flixweed during 1928 and 1931 are summarized in table 4 to show especially the preferences of two insect species which frequently build up large populations, one on tumblemustard and the other on flixweed.

This comparison, although considering only single areas of the two plants and representing only those collections made during a single year, indicates rather clearly some of the preference of these two species for one or the other of the mustard hosts. It will be noticed that the total numbers of *Eutettix tenellus* taken on flixweed throughout the collection period greatly exceeded the numbers of that species collected on tumblemustard. This evidence, although extremely fragmentary if used alone, supports the general observation that the beet leafhopper naturally prefers flixweed and that it will build up larger populations on this plant than on tumblemustard. *Phyllotreta albionica*, however, shows an even greater preference for tumblemustard and frequently builds up enormous populations on that host. The actual distribution of *P. albionica* on these two hosts is rather clearly shown

by the data of table 4, the accuracy of which is substantiated by observations made during several years of collecting in various localities and under varying growth conditions of these plant species. A further indication of this same effect in regard to both *E. tenellus* and *P. albionica* is shown in table 4, using data from collections made on these hosts in 1931. The data show, in addition, the great preponderance frequently attained by *Melanotrichus coagulatus* on flixweed and indicate the relative unimportance of tumblemustard as a host plant for this species.

Table 4 and the discussion of the data therein have been presented primarily to emphasize the fact that frequently and in certain locations a single species will predominate enormously upon either tumblemustard or flixweed. They should not be considered to represent average or mean values for populations of the predominating insect species found on these host plants.

In order to present the spring population values, the average numbers of each of the predominating species found on the mustard hosts throughout the entire Hollister area are given in table 5. Collections were taken from tumblemustard, flixweed, and occasionally from green tansymustard, beginning as early in the spring as the growth of the plants and weather conditions permitted and continuing until maturation and drying of the hosts in the early part of the summer. A study of these data reveals the fact that the beet leafhopper, during all the years under consideration, never predominated over the other species on these plants, but that it occupied an intermediate position each year, for it never ranked higher than third or lower than sixth. The mottled plant bug (*Melanotrichus coagulatus*) was probably the most consistent species in maintaining its position of relative numerical importance from year to year, for it was the most abundant species during three of the included years and never ranked lower than third at any period. The mustard flea beetle (*Phyllotreta albionica*) reached its greatest peak of relative abundance in the Hollister area in the spring of 1928, when it totaled 85.76 percent of all species combined. Its lowest point was reached in 1930, when it dropped to fifth position and represented only 1.64 percent of all the predominating species. During 1931–33 it again became an important member of the spring mustard community and was relatively well represented in all the collections from spring mustards for each of these years.

SUMMER AND FALL HOST PLANT (RUSSIAN-THISTLE)

Newly abandoned or recently disturbed and fallow lands in the Hollister area are covered each year by a more or less thick growth of Russian-thistle. This annual plant makes its appearance in the spring as soon as there has been enough warm weather to permit the seed to germinate, and when the mustard species are no longer green it has made good growth and offers the only succulent plant available over large areas to which the insect species of the drying mustards may transfer themselves and continue to reproduce. Apparently only a few of the insects found to be common on the mustards in the spring take advantage of this opportunity, so the insect populations found on Russian-thistle during September differ markedly from those found on the mustard hosts during the spring and early summer months.

TABLE 4.—*Comparison of insect populations found on tumblemustard (Norta altissima) and on flixweed (Sophia parviflora) in 1928 and 1931, Hollister, Idaho*

Year and insect	Host	1928										1931[1]						
		June 14	June 21	June 28	July 6	July 13	July 19	July 26	Aug. 2	Total	Percent of total	May 4	May 20	June 2	June 13	June 26	Total	Percent of total
Eutettix tenellus	Tumblemustard	36	1	4	5	54	135	300	29	564	6.92	0	0	16	74	33	123	4.45
	Flixweed	11	3	10	6	109	191	358	306	994	21.64	1	92	21	93	83	290	11.44
Aceratagallia fuscoscripta	Tumblemustard	10	0	0	0	16	4	25	0	55	------	1	1	0	7	8	17	------
	Flixweed	0	1	2	1	8	5	63	10	100	------	0	12	5	10	12	39	------
Thamnotettix venditarius	Tumblemustard	1	1	0	0	1	0	0	0	3	------	0	0	1	11	13	25	------
	Flixweed	6	0	0	0	0	0	0	0	6	------	0	20	2	1	4	27	------
Geocoris pallens	Tumblemustard	0	0	0	0	2	2	28	0	32	------	0	0	5	2	0	7	------
	Flixweed	8	2	0	0	4	5	28	4	51	------	0	10	4	11	5	30	------
Melanotrichus coagulatus	Tumblemustard	95	9	0	1	2	1	1	0	109	1.34	0	0	25	41	4	70	2.53
	Flixweed	41	22	10	0	4	2	4	0	83	1.81	0	1,063	469	415	43	1,990	78.50
Lygus elisus	Tumblemustard	8	15	6	13	23	3	1	0	69	------	0	1	6	81	54	142	------
	Flixweed	22	13	12	15	7	7	5	4	85	------	0	8	1	1	3	13	------
Nysius ericae	Tumblemustard	56	8	0	0	73	4	81	1	223	2.73	0	0	6	51	717	781	28.28
	Flixweed	140	52	44	25	88	328	98	32	807	17.57	0	36	22	5	1	64	2.52
Nabis alternata	Tumblemustard	0	0	1	0	0	0	0	0	1	------	0	0	0	1	2	3	------
	Flixweed	0	0	1	0	4	0	0	0	5	------	0	1	0	4	2	7	------
Phyllotreta albionica	Thumblemustard	82	20	145	3,366	2,793	487	189	17	7,099	87.05	1	1	1	20	1,570	1,593	57.70
	Flixweed	7	263	472	1,440	137	47	91	5	2,462	53.60	2	4	1	0	68	75	2.96
Total	Tumblemustard	288	54	156	3,385	2,964	636	625	47	8,155	------	2	3	60	295	2,401	2,761	------
	Flixweed	235	356	551	1,487	361	595	647	361	4,593	------	3	1,246	525	540	221	2,535	------

[1] The collections on tumblemustard were made on plot 2, and those on flixweed on plot 4.

TABLE 5.—*Average numbers of the predominating insects found in all collections on mustards in the Hollister, Idaho, area during the spring of the years 1928–33*

Species	1928				1929				1930			
	Total[1] collected	Average[2] per collection	Proportion of total	Rank	Total collected	Average per collection	Proportion of total	Rank	Total collected	Average per collection	Proportion of total	Rank
	Number	*Number*	*Percent*		*Number*	*Number*	*Percent*		*Number*	*Number*	*Percent*	
Phyllotreta albionica	5,904	369.00	85.76	1	565	47.08	18.25	3	196	4.00	1.64	5
Nysius ericae	381	23.81	5.53	2	988	82.33	31.91	2	7,963	162.51	66.85	1
Melanotrichus coagulatus	282	17.62	4.10	3	1,081	90.08	34.92	1	2,712	55.35	22.73	2
Lygus elisus	137	8.56	1.99	4	74	6.17	2.39	5	180	3.67	1.51	7
Eutettix tenellus	111	6.94	1.61	5	280	23.33	9.04	4	361	7.37	3.03	3
Aceratagallia fuscoscripta	33	2.06	.48	6	68	5.67	2.20	6	285	5.82	2.39	4
Geocoris pallens	19	1.19	.28	7	21	1.75	.68	7	22	.45	.18	8
Thamnotettix renditarius	15	.94	.22	8	14	1.17	.45	8	183	3.73	1.54	6
Nabis alternata	2	.12	.03	9	5	.42	.16	9	10	.20	.08	9
Total	6,884	430.24			3,096	258.00			11,912	243.10		

Species	1931				1932				1933				Average rank
	Total collected	Average per collection	Proportion of total	Rank	Total collected	Average per collection	Proportion of total	Rank	Total collected	Average per collection	Proportion of total	Rank	
	Number	*Number*	*Percent*		*Number*	*Number*	*Percent*		*Number*	*Number*	*Percent*		
Phyllotreta albionica	10,525	154.78	22.51	2	45	2.81	20.09	2	53	5.30	20.78	2	2
Nysius ericae	3,364	49.47	7.19	4	13	.81	5.80	6	21	2.10	8.23	5	3
Melanotrichus coagulatus	22,506	330.97	48.13	1	86	5.37	38.39	1	45	4.50	17.65	3	1
Lygus elisus	1,185	17.43	2.53	6	23	1.44	10.27	4	44	4.40	17.25	4	6
Eutettix tenellus	6,592	96.94	14.10	3	26	1.62	11.61	3	9	.90	3.53	6	4
Aceratagallia fuscoscripta	422	6.21	.90	7	9	.56	4.02	7	80	8.00	31.37	1	7
Geocoris pallens	377	5.54	.81	8	2	.12	.89	9	3	.30	1.17	7	8
Thamnotettix renditarius	1,748	25.70	3.74	5	16	1.00	7.14	5	0	.00	.00		5
Nabis alternata	41	.60	.09	9	4	.25	1.78	8	0	.00	.00		9
Total	46,760	687.64			224	13.98			255	25.50			

[1] The total numbers of the predominating species collected during April, May, and June.

[2] Average numbers per 50 sweep-net collections during April, May, and June. Sixteen 50-sweep-net collections were made in 1928; 12 in 1929; 49 in 1930; 68 in 1931; 16 in 1932; and 10 in 1933.

The data in table 6 represent the average numbers of the predominating species per 50 net sweeps on Russian-thistle throughout the Hollister area for the 6 years covered by this study. Comparison of the data of this table and those of table 4 shows that a radical change in the relative predominance of the various insect species has taken place. In the fall, on Russian-thistle, the beet leafhopper invariably predominates over all the other species and to such an extent that this species alone made up over 75 percent of the total number of individuals present in 5 of the 6 years. This was especially true during the fall seasons of 1928 and 1929, when over 90 percent of the total number of individual insects taken on Russian-thistle were beet leafhoppers. It is of further interest to note that *Melanotrichus coagulatus* and *Phyllotreta albionica*, which were so predominant in the spring on flixweed and tumblemustard, were either entirely absent or were present in very small numbers on Russian-thistle late in the summer and in the fall.

TABLE 6.—*Fall insect collections taken on Russian-thistle in the Hollister, Idaho, area, September 1 to October 10*

Species	1928		1929		1930	
	Average per 50 sweeps	Percent of total	Average per 50 sweeps	Percent of total	Average per 50 sweeps	Percent of total
	Number		*Number*		*Number*	
Eutettix tenellus	200.6	97.75	225.8	94.63	405.3	87.35
Aceratagallia fusconcripta	1.7	.57	3.8	1.59	15.9	3.43
Thamnotettix vendit. ius	.0	.00	.0	.00	.0	.00
Geocoris pallens	.5	.17	.5	.21	2.5	.54
Melanotrichus coagulatus	.0	.00	.7	.29	9.3	2.00
Lygus elisus	.4	.13	2.8	1.17	20.7	4.46
Nysius ericae	1.9	.64	4.7	1.97	9.7	2.09
Nabis alternata	.0	.00	.0	.00	.2	.04
Phyllotreta albionica	2.2	.74	.3	.13	.4	.09
Total	207.3		238.6		464.0	

Species	1931		1932		1933		Average, all years
	Average per 50 sweeps	Percent of total	Average per 50 sweeps	Percent of total	Average per 50 sweeps	Percent of total	
	Number		*Number*		*Number*		*Percent*
Eutettix tenellus	86.9	79.58	81.5	89.06	12.5	43.40	82.11
Aceratagallia fusconcripta	4.0	3.66	1.4	1.55	8.1	28.12	6.48
Thamnotettix vendituriusa	.0	.00	.0	.00	.0	.00	.00
Geocoris pallens	10.4	9.52	.0	.00	.4	1.39	1.97
Melanotrichus coagulatus	.4	.37	2.7	2.98	.3	1.04	1.11
Lygus elisus	.0	.00	3.5	3.86	.0	.00	1.60
Nysius ericae	7.4	6.78	1.1	1.21	7.5	26.04	6.45
Nabis alternata	.1	.09	.0	.00	.0	.00	.02
Phyllotreta albionica	.0	.00	.4	.44	.9	.00	.23
Total	109.2		90.6		28.8		

FLUCTUATIONS IN BEET LEAFHOPPER POPULATIONS FOLLOWING CHANGES IN PLANT COVER

The nature of the available data from plot 4, or from the entire Hollister area during the 6 years of study, limits this analysis to a study of seasonal host sequence, changes in the composition of plant

cover from year to year, and fluctuations in the numbers of beet leafhoppers themselves as a result of annual changes in host-plant composition and climatological conditions. The following experimental and observational data are presented only as an attempt to illustrate the gross effects of certain environmental changes upon the development and survival of populations of the beet leafhopper in weed areas and should not be construed as an effort to show all of the effects of the various physical factors in the environment.

The climatological data (table 7 and fig. 2) have been included in order to show the relation between climate and the changes in plant cover with their resulting drastic changes in beet leafhopper populations both in plot 4 and in the entire Hollister area.

TABLE 7.—*Total monthly precipitation and monthly mean temperatures with departures from the normals, September 1927 to August 1933, inclusive,*[1] *Hollister, Idaho*

Month	1927–28				1928–29				1929–30			
	Precipitation		Temperature		Precipitation		Temperature		Precipitation		Temperature	
	Actual	Departure	Mean	Departure	Actual	Departure	Mean	Departure	Actual	Departure	Mean	Departure
	Inches	*Inches*	*° F.*	*° F.*	*Inches*	*Inches*	*° F.*	*° F.*	*Inches*	*Inches*	*° F.*	*° F.*
September	[2] 0.70	+0.20	[2] 57.0	−2.7	0.03	−0.47	63.0	+3.3	0.16	−0.34	53.8	−5.9
October	[2] .78	−.21	[2] 50.8	+1.9	.86	−.13	50.1	+1.2	.50	−.49		
November	2.06	+1.25	41.8	+3.7	.81	.00	38.1	.0	.15	−.66	37.0	−1.1
December	[2] .77	+.01	[2] 25.0	−3.4	.55	−.21	24.4	−4.0	.81	+.05	36.7	+6.3
January	.44	−.29	32.6	+5.3	1.78	+1.05	20.1	−7.2	1.10	+.37	18.3	−9.0
February	.40	−.42	33.2	+.7	.33	−.49	22.4	−9.1	1.26	+.44	39.6	+8.1
March	1.86	+1.24	41.8	+3.4	.84	+.22	38.8	+.4	.37	−.25	41.0	+2.6
April	.42	−.71	43.9	−2.0	.91	−.22	44 0	−1.6	1.56	+.43	53.5	+7.9
May	.20	−1.00	61.0	+7.3	.00	−1.20	54.2	+.5	2.70	+1.50	52.6	−1.1
June	1.70	+.87	61.0	−2.5	1.32	+.49	62.9	−.6	.17	−.66	63.4	−.1
July	.13	−.24	72.8	+.1	.00	−.37	73.7	+1.0	.16	−.21	74.6	+1.9
August	.00	−.48	68.8	−.8	.46	−.02	72.1	+2.5	1.98	+1.50	72.4	+2.8
Total	9.46	+.22			7.89	−1.35			10.92	+1.68		
Average			49.1	+.9			47.0	−1.1			48.3	+1.2

Month	1930–31				1931–32				1932–33			
September	0.23	−0.27	59.0	−0.7	0.42	−0 08	60.6	+0.3	0.00	−0.50	61.7	+2.0
October	1.24	+.25	47.8	−1.1	.77	−.22	49.8	+.9	.10	−.89	48.6	−.3
November	.56	−.25	33.6	−4.5	.40	−.41	32.6	−5.5	.84	+.03	41.8	+3.7
December	.56	−.20	21.5	−6.9	.76	.00	25.8	−2.6	.71	−.05	19.3	−9.1
January	.17	−.56	28.4	+1.1	.62	−.11	22.6	−4.7	.44	−.29	25.6	−1.7
February	.51	−.31	33.0	+1.5	.87	+.05	26.0	−5.5	.62	−.20	15.0	−16.5
March	.85	+.23	37.8	−.6	1.69	+1.07	35.4	−3.0	.30	−.32	37.2	−1.2
April	.80	−.33	47.9	+2.3	.91	−.22	46 2	+.6	.80	−.33	39.8	−5.8
May	.31	−.89	57.4	+3.7	1.51	+.11	53.6	−.1	.67	−.53	48.8	−4.9
June	.12	−.71	67.6	+4.1	1.67	+.84	61.6	−1.9	.00	−.83	67.2	+3.7
July	.04	−.33	76.8	+3.9	.79	+.42	69.8	−2.9	.08	−.29	74.5	1.8
August	.12	−.36	74.4	+4.8	.41	−.07	66.6	−3.0	.06	−.42	68.7	−.9
Total	5.51	−3.73			10.62	+1.38			4.62	−4.62		
Average			46.8	+0.6			45.8	−2.3			45.7	−2.4

[1] Compiled from the published records of the U. S. Weather Bureau for Hollister, Idaho, with the exceptions noted by footnote 2.

[2] From records of Bureau of Entomology and Plant Quarantine, Hollister, Idaho.

PLANT-COVER CHANGES AND BEET LEAFHOPPER POPULATIONS IN PLOT 4

During the summer of 1928 approximately 30 percent of the area of plot 4 was occupied by a dense stand of Russian-thistle while in the remainder of the plot Russian-thistle was dominant though growing

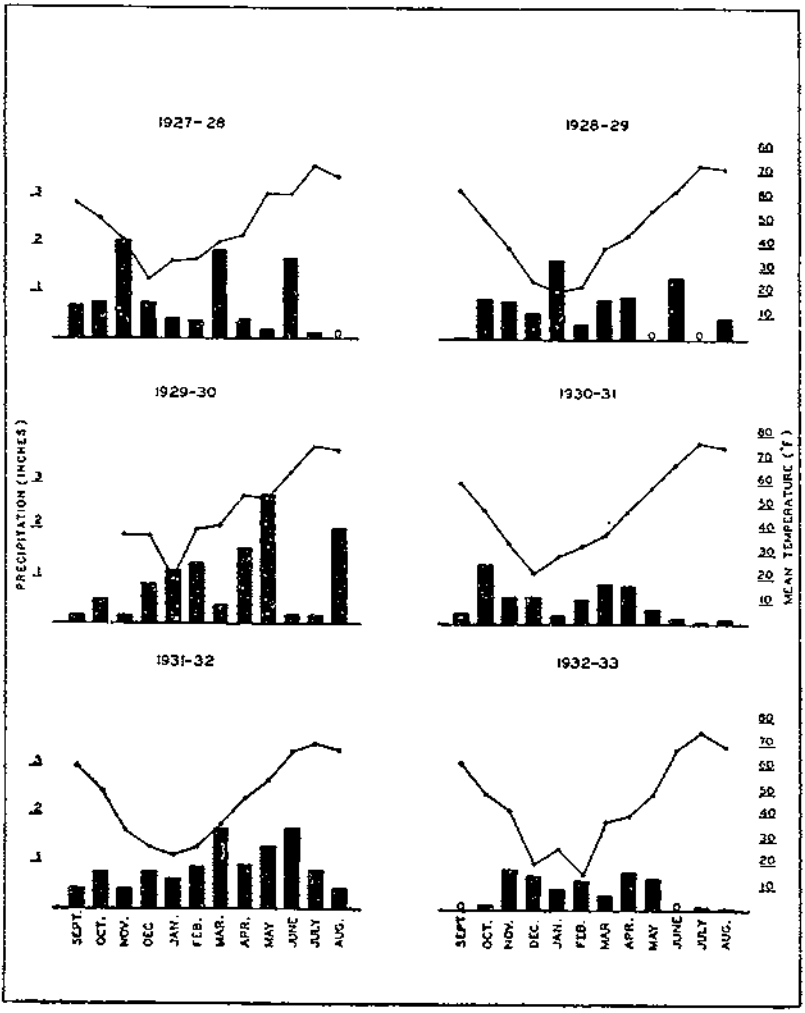

FIGURE 2.—The total monthly precipitation (black bars) and the monthly mean temperature (light line), September 1927 to August 1933, inclusive. These data were taken from the records of the U. S. Weather Bureau station at Hollister, Idaho.

less densely and mixed with barley stubble (table 1 and fig. 1). Conditions were so suitable for the Russian-thistle remaining on the plot after maturation of the short-lived annuals that it continued in a green and succulent condition throughout the season. Consequently, an almost ideal situation for the rapid multiplication of the beet leafhopper developed. Relatively few individuals moved to the Russian-thistle from nearby mustard early in the summer, but with conditions so admirably fitted for their continued increase the numbers had reached a considerable magnitude by September 5 (table 8).

In the spring of 1929 the plot was covered by a mixture of Russian-thistle and flixweed. Both species formed such an extremely thick cover over the entire plot that most of the plants were dwarfed and did not make a growth comparable to that of 1928. The flixweed

reached maturity and was almost completely dry by July 16. At that time the Russian-thistle had begun to show some signs of premature drying, and by the end of the summer large numbers of the plants had dried prematurely.

TABLE 8.—*Total number of beet leafhoppers per 50 net sweeps [1] in plot 4, 1928–31, Hollister, Idaho [2]*

Date	1928	1929	1930	1931	Date	1928	1929	1930	1931
	Number	*Number*	*Number*	*Number*		*Number*	*Number*	*Number*	*Number*
Mar. 29			0		Aug. 11	246	150	6	0
Apr. 11			0		Aug. 24	155	120	6	0
Apr. 17			0		Sept. 5	425	107	12	0
May 2		8	0	1	Sept. 24	426		1	0
May 13		2			Oct. 1				0
May 24			0	92	Oct. 12	180			
June 5		5	0	21	Oct. 24	36			
June 17		34	3	93					
June 26	19			63	Total	1,571	482	93	271
July 9	7		6	0					
July 16	14	25			Average per collection	157.1	53.5	7.1	22.6
July 24			59	1					
July 30	63	31							

[1] 1 set of 50 net sweeps was made in the plot on each collecting date.
[2] No beet leafhoppers were collected in 1932 and 1933.

This early and continued drying of the Russian-thistle held the beet leafhopper population in the plot to a low figure as compared to the average of the general area in which the plot was situated, and also as compared with that of the previous year, even though Russian-thistle was present during the summer and fall of both years. In 1929 the continued drying of the extremely thick growth of the Russian-thistle throughout the summer, accompanied, in all probability, by a constant mortality of beet leafhoppers, resulted in fall populations about one-fourth as large as during the same period of 1928 (table 8).

The late summer and fall rains of 1929 fell only in light showers and, accompanied as they were by moderately high temperatures, proved to be inadequate for a general germination of mustard (table 9). Some scanty germination did occur in certain localities, but there was none within the plot or in the vicinity. This condition served to reduce materially the number of beet leafhoppers entering hibernation late in the fall, and consequently no overwintered specimens were found in the plot the following spring.

In the spring of 1930 the plot was covered with an almost pure stand of flixweed that had germinated during the winter or early spring months (table 1). This host was sparsely populated with beet leafhoppers that came in from other sources probably not earlier than the middle of June, and since the flixweed dried completely by the last of July there was insufficient time for the development of a large population. A lack of Russian-thistle within the plot late in the summer and in the fall of 1930 prevented the development of fall populations comparable to those found in 1928 and 1929. In spite of the absence of Russian-thistle, however, a small population of beet leafhoppers was found in the plot late in the summer, as shown in table 8, but this can be accounted for by the extremely early germination of the mustard host plants that took place in August (table 9) following the unusually heavy precipitation (table 7 and fig. 2) of that

month, and the fact that the leafhoppers had established themselves upon these young plants after the maturation of the mustards they had lived on in the spring.

TABLE 9.—*Precipitation and fall germination of the mustards in the Hollister, Idaho, area (Piemeisel's data)*

Year	First germination			Precipitation	
	Date observed	Extent	Survived or dried	Date	Amount
					Inches
1928	Oct. 21	General during November	Survived	Oct. 10–17	0.25
1929	Oct. 17 [1]	Local, scant, patchy	Dried by Nov. 15	Oct. 8	.29
1930	Aug. 22	Widespread, scant, patchy	Survived	Aug. 5–13	1.71
1931	Nov. 4	General, scant, uniform	do	Oct. 23–28	1.17
1932	Nov. 17	do	do	Nov. 3–17	.84

Year	Final germination		Precipitation	
	Date observed	Extent	Date	Amount
				Inches
1928	Nov. 10	General	Oct. 31	0.52
1929		None to freezing		
1930	Oct. 8	General, dense	Oct. 1–8	1.05
1931		None to freezing		
1932		do		

[1] This germination was localized around a large plot 5 miles from plot 4; it had dried up almost entirely by Nov. 15. Repeated notes made in the vicinity of Hollister and on the small plots up to freezing time showed no germination.

Late summer and fall precipitation was above normal in 1930, so some germination of mustards occurred early, and some of the plants survived until the more complete germination of the first week in October (table 9). This assured the few individuals within the plot an ample food supply throughout the fall and winter months and pointed toward a good survival of leafhoppers the following spring.

In the spring of 1931 the plot was covered by a mixture of flixweed and downy chess with flixweed predominating (table 1). The favorable temperatures experienced during April, May, and June, accompanied by some rainfall, induced rapid development of the mustard hosts as well as of the beet leafhopper (table 7 and fig. 2). Beet leafhoppers rapidly increased in number on the host within the plot with the result that during June an unusually high spring population had been produced (table 8). However, drought conditions and the crowding of plants became so severe that all of this host dried prematurely before July. The lack of any immediately available living host within the plot resulted in the practical extinction of the insect fauna. This premature drying of the host plants was particularly disastrous to the beet leafhoppers since it occurred at a time when the nymphal population was at its peak.

Following the premature drying of flixweed in 1931 the plot became covered with a stand of downy chess in the spring of 1932. The undesirable nature of this plant as a host for the beet leafhopper is clearly shown by the fact that not a single specimen was taken from the plot during the spring and summer of 1932 (table 8). Downy chess

has a short life and remains green only during the winter and spring months. Its seeds are usually matured early and drying commonly takes place before the last of May. It continues, in its cured state, to cover the soil throughout the summer and into the fall and winter. When there has been sufficient precipitation for the germination of seed the young downy chess plants grow up among the dried stalks and remain green throughout the winter and until maturation in the following spring. These young plants, however, are neither desirable as an overwintering host for the beet leafhopper nor are they suitable as a place for the reproduction of this insect the following spring.

In some localities and under certain conditions downy chess has been known to serve as a host plant for some insect species, but such was not the case in the plot either in 1932 or during the following year. In plot 4, only a few specimens of Diptera and some nymphs of Locustidae were found to occur on this plant.

The plot was again covered by a thick stand of downy chess in 1933 (table 1) and, as had been the case in 1932, no beet leafhoppers were found.

PLANT-COVER CHANGES AND BEET LEAFHOPPER POPULATIONS IN THE HOLLISTER AREA

The pronounced effects of climatic changes, particularly those that resulted in changes in the plant cover, and their influence on the populations of the beet leafhopper have been shown for a small section of a breeding range of this species. The changes throughout the larger area, of which this small section is a part, were necessarily somewhat different during the several successive years under consideration. For this reason it is important to include in the discussion some mention of the entire Hollister area and to compare the development of beet leafhopper populations for the area as a whole with those of plot 4.

The data presented in table 10 give the average number of beet leafhoppers per 50 sweeps on Russian-thistle throughout the entire Hollister area during September and the early part of October for each of the years covered by the study.

TABLE 10.—*Average number of beet leafhoppers per 50 sweeps on Russian-thistle throughout the Hollister, Idaho, area during the fall months of 1928–33*

Year	Collection date	Average leafhoppers collected	Average of all collections	Year	Collection date	Average leafhoppers collected	Average of all collections
		Number	*Number*			*Number*	*Number*
1928	Sept. 4	361.3	290.65	1931	Sept. 4	92.8	86.90
	Oct. 5	220.0			Sept. 24	30.3	
1929	Sept. 8	146.8	225.85		Oct. 1	137.6	
	Oct. 2	304.9		1932	Sept. 9	84.7	81.46
1930	Sept. 5	453.2	405.30		Sept. 26	119.5	
	Sept. 19	464.6			Oct. 12	40.2	
	Oct. 5	298.1		1933	Sept. 7	10.3	12.55
					Sept. 20	14.8	

During the summer of 1928 the growth of Russian-thistle was generally favorable for the development of moderately large populations of beet leafhoppers (table 10). It will be noted that during the fall of 1928 the average number of beet leafhoppers collected in plot 4 (table 8) was considerably greater than those taken throughout the general area, but this is not surprising when it is remembered that the plot

was covered by an almost ideal growth of Russian-thistle, whereas the average condition of this host plant throughout the area was much poorer, and the area included sections that had, in large part, been abandoned for a greater period than the one represented by the plot.

The climatological data (table 7 and fig. 2) and the data on precipitation and germination (table 9) for the late summer and fall months of 1928 indicate rather clearly that even though late summer and fall rains were extremely light until the first of October, continued light rains throughout the first half of the month were instrumental in causing fall germination of mustards by at least the last of October.

As a result of this, overwintered populations of the beet leafhopper were moderately abundant and active in the field during the spring months of 1929 (table 8). The subsequent beet leafhopper populations, however, were not so large as during the same period of 1928. The mean minimum temperature for May 1929 was decidedly lower than it had been in 1928, but generally higher temperatures prevailed throughout the summer of 1929 (table 7 and fig. 2). The drying of Russian-thistle, however, did not appear to be so marked throughout the area as it was in plot 4. In consequence, the average fall populations of beet leafhoppers during September and the early part of October of 1929 were approximately equal to those found over the same general section during the comparable period of 1928 (table 10).

The lack of suitable fall host plants resulted in a reduction of these populations so that comparatively few leafhoppers entered hibernation.

The exceptionally early spring season of 1930 (table 7 and fig. 2) proved to be extremely favorable for the extensive germination of large areas of flixweed and tumblemustard, so the low overwintered populations of beet leafhoppers had ample chance for rapid and continued multiplication. Russian-thistle was abundant during the summer and remained in excellent growing condition until fall, with the result that relatively enormous numbers of beet leafhoppers were found on this host during September and early in October (table 10).

In a previous section of this bulletin it has been pointed out that ideal host-plant conditions prevailed during the summer and fall of 1930 and that large populations of beet leafhoppers were built up. In the discussion of plot 4 it has been shown that conditions during the spring of 1931 were very favorable for the rapid development of both the leafhopper and its host plants, but that the severe drought which followed early in the summer caused premature drying of mustard hosts and resulted in an enormous mortality of leafhoppers, particularly those in the nymphal stages.

The period of drought which had begun in May 1931 continued through the fall of that year, so fall germination of mustards did not take place until after the first of November (table 9). In view of the fact that the last of the Russian-thistle areas had dried completely by the middle of October, and since there was no abundance of mustards until after the middle of November, the already low populations of beet leafhoppers were still further reduced. As a result of the relatively low fall populations and unfavorable food conditions, overwintered beet leafhoppers were extremely scarce in the spring of 1932.

The spring and the early part of the summer of 1932 were extremely cool, and all plant and insect development was greatly retarded. In

spite of the fact that precipitation adequate for the continued growth of Russian-thistle had fallen early in the summer (table 7 and fig. 2), beet leafhopper populations in the fall did not average as high as they did the previous season (table 10). This can probably be largely accounted for by the scarcity of overwintered beet leafhoppers and the retardation of their activities by the cool weather in the spring.

As a result of a deficiency in precipitation late in the summer and in the early fall months, fall germination of mustards did not take place in 1932 until after the middle of November (table 9). This again subjected moderately low fall populations to a long period during which they were without a suitable food plant; and again, as had been the case the previous year, conditions pointed decidedly to a minimum of survival the following spring.

This proved to be the case, and spring populations in 1933 were nearly as low as in 1932 (table 5). Again a cold spring followed (table 7 and fig. 2) and retarded both plant and insect development to such an extent that beet leafhopper populations were scarcely detectable until after the first of June. Patches of mustard were very sparse and scattered, and Russian-thistle grew so very slowly that, in most localities, this host had barely begun its growth by the first of June. The combined effects of a low winter survival of beet leafhoppers, the great retardation of development of both plants and insects in the spring, and greatly reduced host-plant areas operated in 1933 to produce the lowest fall populations on record for the Hollister area (table 10).

SUCCESSIVE POPULATIONS OF PREDOMINATING INSECTS FOUND ON PLOT 4

The preceding discussions have shown that beet leafhopper populations fluctuated from year to year with the changes in plant composition both in plot 4 and throughout the Hollister area. In addition, there has been given a generalized account of the fluctuations in abundance of others of the predominating species as they occurred in the area on mustards in the spring and on Russian-thistle during the summer and fall. A study of the data derived from net collections made on plot 4 during the years covered by this study reveals more in detail the fact that the other predominating insect species fluctuated with changes in plant composition in a manner very similar to that of the beet leafhopper, although not always in parallel.

The data presented in table 11 show clearly the great predominance attained by the beet leafhopper during the summer and fall of 1928. During that season Russian-thistle maintained itself in a green and succulent condition until maturation in the fall. In consequence, the insect populations developed without the retarding influence exerted by a prematurely drying host plant.

The data presented in table 11, showing the relation of insect populations to host-plant abundance in 1928 on plot 4, are graphically shown in figure 3, *A*. The fact that the total number of beet leafhoppers collected during the year was so much greater than that of all other species combined is but further substantiation of the general observation that the beet leafhopper generally predominates on Russian-thistle.

TABLE 11.—*Seasonal distribution and abundance of species of insects* [1] *collected on plot 4 from a stand of Russian-thistle in 1928, Hollister, Idaho*

Species	June	July		August		
	23	5	16	1	14	28
Predominating:	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Eutettix tenellus	19	7	14	63	246	155
Aceratagallia fuscoscripta	8	0	7	8	33	12
Thamnotettix penditarius	0	0	0	0	0	0
Geocoris pallens	1	0	1	0	9	5
Melanotrichus coagulatus	1	0	3	1	1	1
Lygus elisus	0	3	1	0	9	5
Nysius ericae	0	0	0	0	1	0
Nabis alternata	0	0	0	0	1	0
Phyllotreta albionica	3	18	9	0	0	0
Total						
Others:						
Homoptera	1	0	0	0	2	1
Hemiptera	0	1	0	1	0	1
Coleoptera	6	3	7	15	1	0
Hymenoptera	2	1	0	2	0	3
Diptera	2	0	4	3	17	11
Orthoptera	0	0	0	0	0	0
Total						
Grand total						

Species	September		October		Total	Proportion of the predominating species
	11	25	9	24		
Predominating:	*Number*	*Number*	*Number*	*Number*	*Number*	*Percent*
Eutettix tenellus	425	426	180	18	1,353	88.7
Aceratagallia fuscoscripta	16	7	9	0	91	5.2
Thamnotettix penditarius	0	0	0	0	0	.0
Geocoris pallens	8	2	0	0	26	1.5
Melanotrichus coagulatus	2	0	0	0	9	.5
Lygus elisus	8	2	0	0	28	1.6
Nysius ericae	6	0	2	0	9	.5
Nabis alternata	1	0	1	0	3	.2
Phyllotreta albionica	1	0	0	1	32	1.8
Total					1,751	
Others:						
Homoptera	2	0	0	0	6	
Hemiptera	1	0	0	0	4	
Coleoptera	1	0	0	0	33	
Hymenoptera	1	0	0	0	9	
Diptera	3	2	0	1	43	
Orthoptera	0	0	1	0	1	
Total					96	
Grand total					1,847	

[1] No record of spiders was made during 1928.

The remainder of the species listed in table 11 were of little numerical importance during the summer and fall of 1928 and appeared, actually, barely to maintain themselves. It is of interest to note, however, that those species that are commonly found on mustard hosts in the spring were either entirely absent or appeared only in extremely small numbers.

During the 1929 season plot 4 was covered with a thickly growing mixture of flixweed and Russian-thistle (table 1, 1929), and it was found that the introduction of the mustard (flixweed) into the community resulted in a marked change in the fauna of the plot during that season. Table 12 gives a list of the insect species taken on plot 4

TABLE 12.—*Seasonal distribution and abundance of species of insects and spiders collected from a stand of Russian-thistle and flixweed on plot 4 in 1929, Hollister, Idaho*

Species	May		June		July	
	7 [1]	13 [1]	5 [1]	19 [1]	16	30
Predominating:	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Eutettix tenellus	8	2	5	34	25	31
Aceratagallia fuscoscripta	0	0	1	0	18	4
Thamnotettix venditarius	0	0	2	3	0	0
Geocoris pallens	0	0	1	3	4	2
Melanotrichus coagulatus	0	0	320	90	2	1
Lygus elisus	0	0	3	7	1	0
Nysius ericae	3	10	33	151	140	27
Nabis alternata	0	0	1	1	1	0
Phyllotreta albionica	0	5	15	0	37	0
Total						
Others:						
Homoptera	0	2	22	2	8	1
Hemiptera	0	0	0	0	2	1
Coleoptera	0	4	2	3	12	0
Hymenoptera	1	1	30	27	0	1
Diptera	3	2	24	48	4	23
Lepidoptera	0	1	1	0	0	0
Orthoptera	0	0	0	0	0	0
Spiders	0	1	4	3	1	6
Total						
Grand total						

Species	August		September	Total	Proportion of the predominating species
	13	28	11		
Predominating:	*Number*	*Number*	*Number*	*Number*	*Percent*
Eutettix tenellus	150	120	107	482	33.3
Aceratagallia fuscoscripta	16	9	2	50	3.4
Thamnotettix venditarius	0	0	0	5	.3
Geocoris pallens	5	4	1	20	1.4
Melanotrichus coagulatus	1	0	0	414	28.6
Lygus elisus	2	0	0	13	.9
Nysius ericae	24	5	10	403	27.8
Nabis alternata	0	0	0	3	.2
Phyllotreta albionica	0	0	0	57	3.9
Total				1,447	
Other:					
Homoptera	1	0	2	38	
Hemiptera	1	0	0	4	
Coleoptera	0	0	0	21	
Hymenoptera	2	5	0	67	
Diptera	12	8	2	128	
Lepidoptera	0	0	0	2	
Orthoptera	0	0	1	1	
Spiders	9	5	2	31	
Total				290	
Grand total				1,737	

[1] Collections were made on a nearby area having a plant composition very similar to that of plot 4.

and an adjoining area during 1929 and shows the actual numbers of each of the predominating members of the community as it was collected. Such species as *Melanotrichus coagulatus* and *Nysius ericae*, which were present in such insignificant numbers during 1928, became very abundant, particularly during the earlier part of the

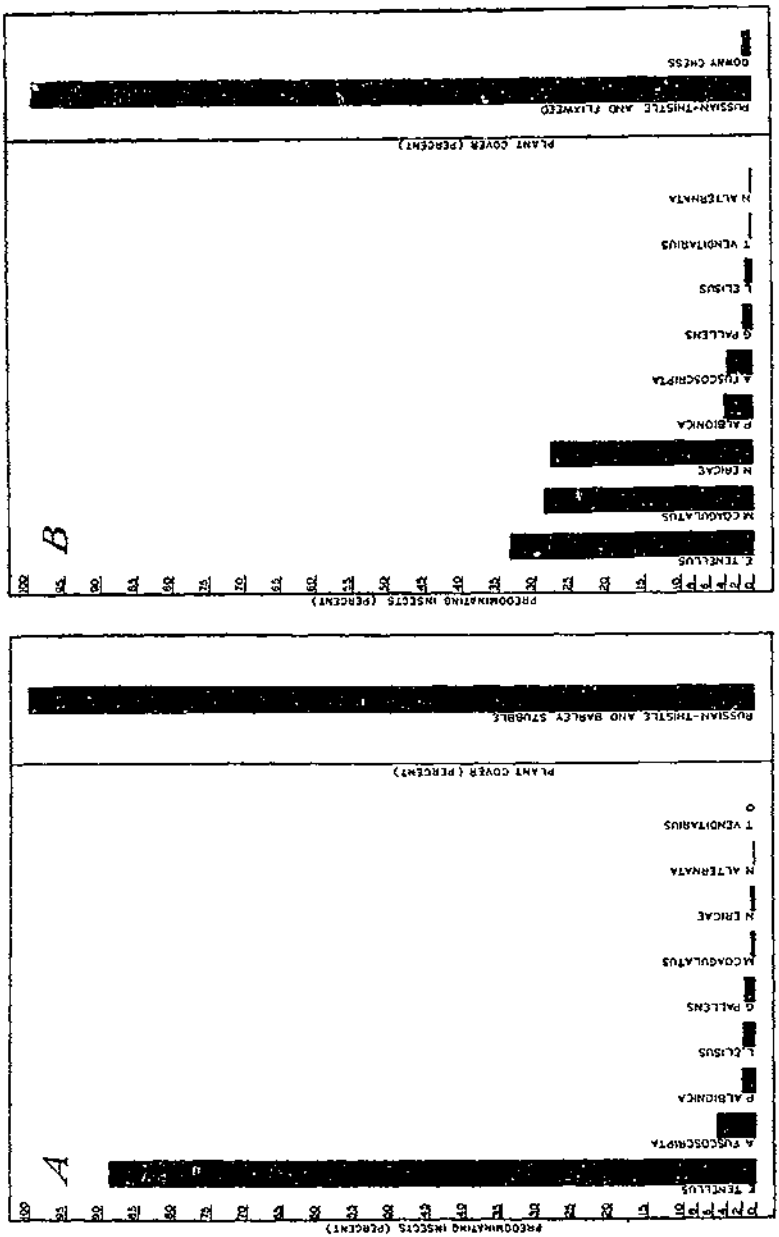

FIGURE 3.—Relative abundance of the predominating insect species, presented as percentages of the total, and the percentages of plant composition as they occurred on plot 4, Hollister, Idaho, during 1928 (*A*) and 1929 (*B*). 0 indicates that *Thamnotettix sanditarius* was not found.

collecting season. This increase in numerical importance is obviously due, in a large measure, to the introduction of flixweed into the community.

The plant composition of the plot in 1929 and the various insects that were collected during the entire season are shown in figure 3, *B*.

The mottled plant bug (*Melanotrichus coagulatus*) appeared in the collections only during the life of flixweed, whereas *Eutettix tenellus* and *Nysius ericae* were present in numbers throughout the entire season. Beet leafhopper populations failed to reach the magnitude of those of 1928 even though Russian-thistle was present. This apparent discrepancy can readily be accounted for by the fact that there was a great difference between the succulence of Russian-thistle on plot 4 in 1928 as compared to that in 1929. In 1928 the plants were well spaced and had sufficient moisture to allow them to continue in a green and succulent condition until fall; but during 1929 the plants grew much more thickly and continued to dry prematurely throughout the season, which resulted, in all probability, in a continual dying of the beet leafhoppers during the summer and early fall months.

The data of table 12 reveal that a few specimens of *Thamnotettix venditarius*, a species which had been entirely absent from the collections of 1928, appeared in the spring of 1929. In addition it will be noted that the numbers of specimens of Hymenoptera and Diptera were greatly increased over those present during 1928, but the larger percentage of these appeared in June, during the time of flowering of flixweed, thus offering a very strong indication that the majority of them were flower-visiting forms which, because of their brief persistence in the community and the fact that they do not compete with the other and more permanent members, may be considered of negligible importance from the standpoint of this study.

The percentage of predators such as *Nabis alternata* and *Geocoris pallens* did not show any significant increase over the numbers found in 1928. The numbers of spiders remained reasonably constant throughout the season, and although the total number taken in all collections was not great, their undoubted predatory activities cannot be overlooked.

During the 1929 season Russian-thistle had been eliminated almost completely from plot 4, and it was replaced in the spring of 1930 with a dense stand of flixweed. In addition a few scattered plants of tumblemustard and some small islands of downy chess were present (table 1, 1930). The drought of the preceding year had so effectively reduced all green-plant areas either late in the summer or early in the fall that all insect species were hard pressed to find suitable food plants upon which to live during the remainder of the fall and winter months. The lack of sufficient moisture to cause early fall germination of mustard hosts undoubtedly reduced materially the numbers of surviving insects and indicated that small populations would be the rule, even in mustard areas, the following spring. This proved to be the case, and the early collections on plot 4 in 1930 revealed but few insects until the last of May (table 13). At this time one species, *Nysius ericae*, became predominatingly abundant and continued in that position until late in the summer, persisting even after the maturation of flixweed.

TABLE 13.—*Abundance and seasonal distribution of species of insects and spiders collected from a stand of flixweed on plot 4 in 1930, Hollister, Idaho*

Species	March	April		May		June		July	
	29 [1]	11 [1]	17 [1]	2 [1]	24 [1]	7 [1]	21 [1]	10	24
Predominating:	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Eutettix tenellus	0	0	0	0	0	0	3	6	59
Aceratagallia fuscoscripta	0	7	0	10	0	1	0	1	3
Thamnotettix sanditarius	0	0	0	0	0	3	7	0	0
Geocoris pallens	0	0	0	0	0	3	0	0	2
Melanotrichus coagulatus	0	0	0	0	0	31	47	6	0
Lygus elisus	0	0	0	0	4	0	0	3	1
Nysius ericae	0	0	0	0	95	399	328	34	499
Nabis alternata	0	0	0	0	0	0	1	0	2
Phyllotreta albionica	5	2	0	2	0	1	27	22	19
Total									
Others:									
Homoptera	0	0	0	1	0	8	4	0	3
Hemiptera	0	0	0	1	0	3	1	0	0
Coleoptera	1	0	0	0	0	3	0	10	4
Hymenoptera	0	0	0	0	4	95	50	2	5
Diptera	0	0	1	0	2	40	109	20	5
Lepidoptera	0	0	0	2	5	1	6	0	0
Orthoptera	0	0	0	0	0	0	0	0	0
Thysanoptera	0	0	0	0	0	2	0	0	0
Spiders	0	1	1	0	0	9	0	1	23
Total									
Grand total									

Species	August		September		Total	Proportion of predominating species
	7	21	5	19		
Predominating:	*Number*	*Number*	*Number*	*Number*	*Number*	*Percent*
Eutettix tenellus	6	6	12	1	93	4.2
Aceratagallia fuscoscripta	0	0	0	1	23	1.0
Thamnotettix sanditarius	0	0	0	0	10	.4
Geocoris pallens	0	0	0	0	5	.2
Melanotrichus coagulatus	0	0	0	0	84	3.8
Lygus elisus	1	0	0	0	9	.4
Nysius ericae	47	517	9	0	1,928	86.3
Nabis alternata	0	0	0	0	3	.1
Phyllotreta albionica	0	0	0	0	79	3.5
Total					2,234	
Others:						
Homoptera	1	0	1	0	18	
Hemiptera	0	0	0	0	5	
Coleoptera	0	0	0	0	18	
Hymenoptera	2	2	2	2	174	
Diptera	22	9	2	2	212	
Lepidoptera	0	0	0	0	14	
Orthoptera	0	0	1	0	1	
Thysanoptera	0	0	0	0	2	
Spiders	4	8	12	3	52	
Total					506	
Grand total					2,740	

[1] Collections made on a nearby area having a plant composition very similar to that of plot 4.

Beet leafhopper populations were slow in building up and, owing to the lack of a late summer and fall host plant, failed to reach high numbers by the end of the season. All of the species, with the previously noted exception of *Nysius ericae*, were of minor numerical importance on plot 4 during the entire season of 1930 (table 13). These same data, with their relation to plant composition (table 1),

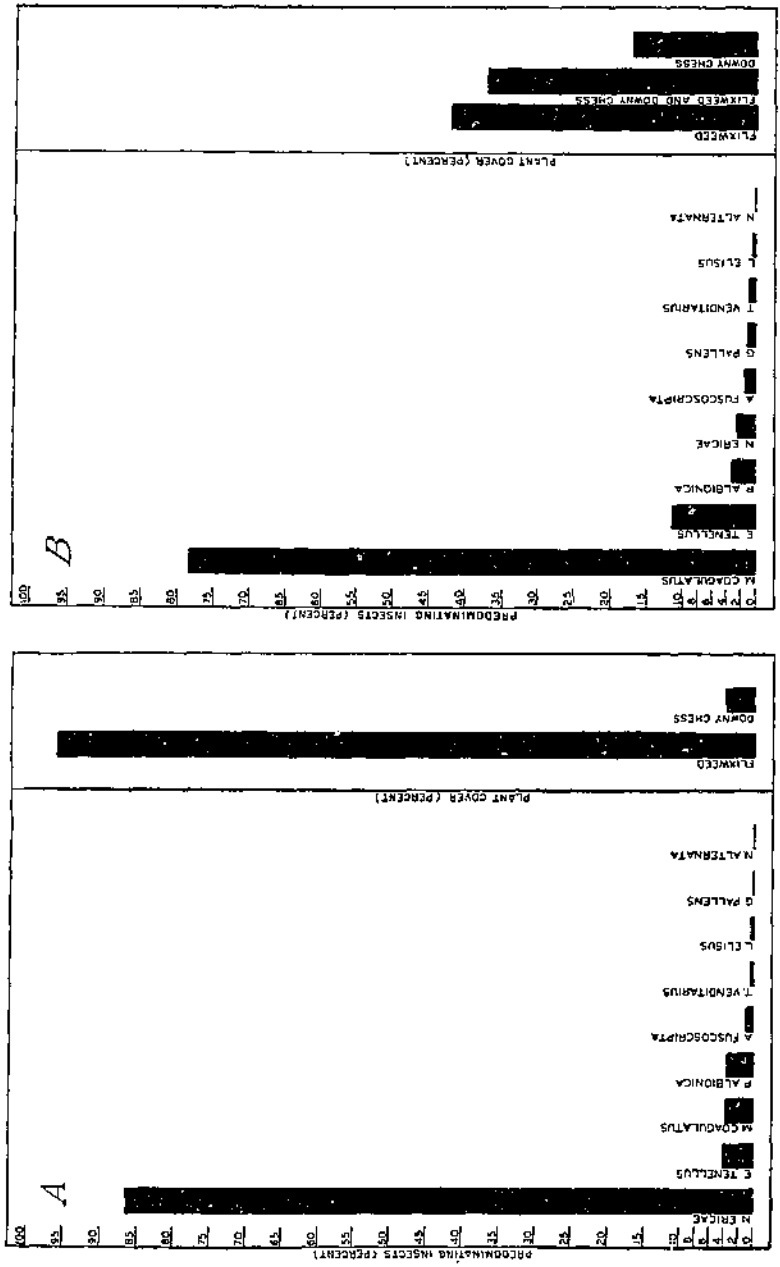

FIGURE 4.—Relative abundance of predominating insect species, shown as percentages of the total, and the percentages of plant composition as they occurred on plot 4, Hollister, Idaho, during 1930 (*A*) and 1931 (*B*).

are shown graphically in figure 4, *A*, and indicate clearly the great predominance of a single species on plot 4 during 1930.

As had been the case during the season of 1929, the Hymenoptera and Diptera taken in the collections reached their greatest numbers during the time flixweed was in bloom.

The number of *Nabis alternata* remained almost unchanged from those taken during 1928 and 1929, but there was a decided decrease in the number of *Geocoris pallens* as compared to the two previous seasons. There was, however, a decided increase in the number of spiders taken in the collections of 1930, with the result that even though one predatory group decreased in numbers another showed an increase and thereby helped to maintain the balance between the predators and the species upon which they prey.

The fall precipitation of 1930 was extremely favorable for the early and extensive germination of mustard hosts throughout the Hollister area. As a result of this, flixweed was abundant on plot 4 during the winter of 1930–31 and furnished an ample supply of food plants for the survival of many insects, for all of the species which had predominated the previous year were very abundant. Even those, such as *Geocoris pallens* and *Nabis alternata*, that had usually been present in relatively small numbers, appeared to be more abundant than at any other time during the period of this study; however, *Melanotrichus coagulatus* predominated enormously over all others (fig. 4, *B*, and table 14).

TABLE 14.—*Abundance and seasonal distribution of species of insects and spiders collected from a stand of flixweed and downy chess on plot 4 in 1931, Hollister, Idaho*

Species	May		June			July	
	4	20	2	13	26	11	21
Predominating:	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Eutettix tenellus	1	92	21	93	83	0	1
Acratagallia fuscoscripta	0	12	5	10	12	0	0
Thamnotettix venditarius	0	20	2	1	4	0	0
Geocoris pallens	0	10	4	11	5	0	0
Melanotrichus coagulatus	0	1,063	469	415	43	0	0
Lygus elisus	0	8	1	1	3	0	0
Nysius ericae	0	36	22	5	1	0	0
Nabis alternata	0	1	0	4	2	0	0
Phylloxreta albionica	2	4	1	0	68	7	0
Total							
Others:							
Homoptera	0	2	10	1	2	0	0
Hemiptera	0	0	0	0	0	0	0
Coleoptera	1	5	4	17	10	1	0
Hymenoptera	2	0	7	11	5	0	0
Diptera	10	8	5	1	2	2	0
Lepidoptera	0	1	2	0	0	0	0
Orthoptera	0	0	0	0	3	7	0
Thysanoptera	0	7	1	2	3	0	0
Spiders	0	8	5	8	21	1	5
Total							
Grand total							

TABLE 14.—*Abundance and seasonal distribution of species of insects and spiders collected from a stand of flixweed and downy chess on plot 4 in 1931, Hollister, Idaho*—Continued

Species	August		September	Total	Proportion of the predominating species
	31	2	9		
Predominating:	*Number*	*Number*	*Number*	*Number*	*Percent*
Eutettix tenellus	0	0	0	291	11.4
Acrotagallia fuscoscripta	0	0	0	39	1.5
Thamnotettix vendilarius	0	0	0	27	1.1
Geocoris pallens	0	0	1	34	1.3
Melanotrichus coagulatus	0	0	0	1,999	78.2
Lygus elisus	0	0	0	13	.5
Nysius ericae	0	0	0	64	2.5
Nabis alternatus	0	0	0	7	.3
Phyllotreta albionica	0	0	0	82	3.2
Total				2,544	
Others:					
Homoptera	0	0	0	15	
Hemiptera	0	0	0	0	
Coleoptera	0	0	1	39	
Hymenoptera	0	0	0	34	
Diptera	0	2	0	30	
Lepidoptera	0	0	0	3	
Orthoptera	1	1	1	16	
Thysanoptera	0	0	0	13	
Spiders	2	1	0	51	
Total				201	
Grand total				2,745	

The relatively large numbers of each species taken in collections on plot 4 during the spring and early summer months of 1931 seemed to presage a year of extremely high populations for all species, but the unusually dry weather of the early summer season caused such a rapid premature drying of flixweed that by the 1st of July practically every plant on the plot was dead. There being no other source of food on plot 4, the high population of insects which had been present earlier in the summer disappeared very rapidly (table 14), and only a few scattered individuals were found during the remainder of the season.

A rather large number of Hymenoptera and Diptera had been taken in collections on plot 4 early in the summers of 1929 and 1930 but these were not so abundant during the same period of 1931 even though a large percentage of the plot was covered by flixweed. Undoubtedly this was due to the premature drying of this mustard before any appreciable number of the plants blossomed. The very fact that the bulk of the specimens of Hymenoptera and Diptera that were collected during 1929 and 1930 were taken at the time the mustards were flowering, and the added fact that they were taken in much smaller numbers during 1931 when there were very few flixweed plants in bloom, gives almost conclusive proof that the majority of such species were merely flower-visiting forms and came to the plot only during the flowering period.

The premature drying of flixweed in 1931 resulted in the complete elimination of this plant from the plot, and there was left in its stead a very thick growth of downy chess (table 1, 1932 and 1933). Repeated collections on this plant throughout the spring and summer of both seasons revealed that only an occasional adult dipteron or a few locustid nymphs remained after the elimination of the more desirable food plants.

OTHER INSECTS FOUND ON ANNUAL WEEDS OF PLOT 4

In the preceding discussions detailed accounts have been given of the fluctuations of the predominating insects found on the various plant covers of plot 4 and the effects of radical changes in plant composition upon their abundance have been shown. The less abundant species of all groups have been mentioned, in most cases only casually, and discussed very briefly. Numerically, these species usually comprised but a small percentage of the total number of individuals present at any given time, but they were undoubtedly of considerable importance and at times must have exerted some influence upon the life of successive populations.

In order to facilitate the presentation of the data concerning these species and to offer some basis for arriving at an estimate of their relative abundance as compared with the more commonly encountered members of the insect populations, the collecting season of each year has been divided into two periods. The first of these, which covers the time from the beginning of insect activity in the spring to July 10 has been designated as the spring period. The second period, during which the remainder of the year's collections were made, from July 11 to the last of September, has been called the summer period. These two periods as thus defined are largely arbitrary, but they have been made to correspond roughly with the spring and early summer season, in which the mustard hosts were important members of the plant communities, and with the late summer and fall season, in which the mustards were no longer green but had been replaced by Russian-thistle as the important host plant.

The data presented in table 15 show the average numbers of specimens of each species collected in 50 sweeps made at different times during each period of each year. The predominating members of the population and the less abundant ones have been listed together, according to their respective orders, for purposes of comparison. It should be remembered that the data of the table represent average numbers for the entire periods and should not be considered to indicate population values for any particular date.

Nine species of Homoptera were identified and all of these were members of the family Cicadellidae. Two other families, Aphiidae and Psyllidae, were represented in the collections, but the lack of specific determinations made it necessary to list these two groups together under the heading "Other Homoptera." It is evident that only two species of the entire group, *Eutettix tenellus* and *Aceratagallia fuscoscripta*, were of any numerical importance during this period of the study and that the former was by far the most abundant species during both the spring and summer periods.

TABLE 15.—*Average seasonal collection of all insects per 50 sweeps in plot 4, 1928–33,*[1] *Hollister, Idaho*

[Blank spaces indicate that no specimens were taken]

Species	1928		1929		1930		1931	
	Spring	Summer	Spring	Summer	Spring	Summer	Spring	Summer
HOMOPTERA								
Cicadellidae:								
Aceratagallia fuscoscripta Oman	2.0	11.2	1.0	9.8	2.7	0.8	8.0	
Dikraneura carnicola (Stål)							.2	
Empoasca filamenta DeL.[1]							.6	
Eutettix tenellus (Baker)	13.0	193.1	27.0	86.6	5.7	16.8	60.0	0.2
Exitianus obscurinervis (Stål)							.6	
Neosteles neglectus DeL. and Dav							1.4	
Polyamia inimica (Say)	.5							
Thamnotettix vendilarius Ball			1.5		1.6		5.0	
Xerophloea viridis (F.)		.4		.2				
Other Homoptera[2]			10.5	2.6	1.3		.8	
HEMIPTERA								
Pentatomidae:								
Chlorochroa sayi Stål			0.1				0.2	
Coreidae:								
Corizus indentatus (Hambl.)		0.1						
Corizus viridicatus Uhler	0.5							
Neididae:								
Jalysus spinosus (Say)		.1		0.4	0.3			
Lygaeidae:								
Geocoris pallens Stål	.5	1.1	2.0	3.2	.4	0.4	6.0	0.2
Nysius ericae (Schill.)		1.2	88.0	41.2	265.1	211.4	13.0	
Reduviidae:								
Sinea confusa Caud.				.2				
Nabidae:								
Nabis alternata Parsh.		.5	.2	.2	.1	.4	1.0	
Anthocoridae:								
Orius insidiosus (Say)		.1			.3			
Miridae:								
Homoscelis modestus (Van D.)				.2	1			
Lygus elisus Van D.		3.1	1.3	5	1.6	.4	3.0	
Melanotrichus coagulatus (Uhler)	.5	1.0	99.3	6	12.0		88.0	
HYMENOPTERA								
Braconidae:								
Microbracon erucarum (Cush.)	0.5		0.1		0.1			
Tetrastichidae:								
Tetrastichus sp.							0.6	
Platygasteridae:								
Platygaster sp.							2	
Scelionidae:								
Telenomus ashmeadi Mrtl.							1.0	
Serphidae:								
Serphus floridanensis Roh.					.3	0.2		
Formicidae:								
Formica fusca var.?		0.4					1.0	
Formica rufa var.?						.2		
Formica subpolita Mayr		.2	3.3		4.0	.2	.4	
Formica subpolita camponoticeps Whlr.			4.7		11.4		.4	
Eumenidae:								
Odynerus sp.						.2		
Sphecidae:								
Astata neradica Cress.						.2		
Plenoculus albipes Ashm.							.2	
Plenoculus propinquus Fox							.2	
Psen sp.		.1						
Arpactus sp.							.2	
Crabronidae:								
Spilomena alboclypeata Brdly.						.2		
Halictidae:								
Halictus albohirtus Cwfd.	.5	.2			.1		.2	
Halictus hudsoniellus Ckll.				0.2			.2	
Halictus tripartitus Ckll.					.1	.2	.8	
Andrenidae:								
Andrena scurra Vier.	.5							
Other Hymenoptera[3]			8.4	1.4	6.4	1.2	.8	

See footnotes at end of table.

TABLE 15.—*Average seasonal collection of all insects per 50 sweeps in plat 4, 1928–33, Hollister, Idaho*—Continued

[Blank spaces indicate that no specimens were taken]

COLEOPTERA

Species	1928		1929		1930		1931	
	Spring	Summer	Spring	Summer	Spring	Summer	Spring	Summer
Carabidae:								
Blechrus linearis (Lec.)	0.5							
Staphylinidae:								
Platystethus americanus Er.	.5							
Melyridae:								
Collops bipunctatus Say	.5	0.2	..	1.8	.	0.3	4.0	
Dasytes depressulus Csy					....	.2	1.0	0.2
Elateridae:								
Limonius infuscatus Mots.	..	..	.	.	..	..	.2	
Coccinellidae:								
Hippodamia apicalis Csy	..	.2						
Hippodamia spuria Lec.	.5							
Hippodamia 13-punctata (L.)	..	.1						
Hippodamia oleana Csy.	.5							
Scymnus crepernus Muls.	..						.2	
Chrysomelidae:								
Phyllotreta albionica (Lec.)	7.0	1.5	6.1	.1	8.6	3.8	15.0	1.0
Psylliodes punctulata Melsh.	1.5	2.6		.0				
Curculionidae:								
Ceutorhynchus convexicollis Lec.			.1					

ARANEIDA

All species [4]			2.7	5.4	1.6	10.0	0.0	1.8

ORTHOPTERA

Locustidae	...	0.1		0.2	...	0.2	0.6	2.6

[1] Only 3 species were taken in 1932 and 1933, and in all cases the numbers were less than 0.1 percent per 50 sweeps. These were as follows: *Empoasca filamenta* in the spring of 1932, *Lygus elimus* in the spring of 1933, and unidentified species of Hymenoptera in the spring of both 1932 and 1933.

[2] The species recorded under this heading were largely of the family Aphiidae and are recorded under "Other Homoptera" because specific determinations were not obtainable.

[3] Undetermined specimens of Hymenoptera are grouped under this heading.

[4] The number of Araneida occurring during 1928 were not recorded.

Twelve species of Hemiptera, representing eight families, were taken at one time or another during the period of study and, as was the case with the Homoptera, two species (*Melanotrichus coagulatus* and *Nysius ericae*) were preponderatingly abundant. In each year, when *M. coagulatus* was abundant, it occurred almost exclusively during the spring period, whereas *N. ericae* appeared in numbers during both periods, but only in those years when flixweed formed a part of the plant cover during the earlier part of the season.

Twenty species of Hymenoptera, representing 11 families, are listed, but in only two cases was any member of this group present in large enough numbers to cause it to be considered even relatively abundant. *Formica subpolita* and its varietal form *camponoticeps* were moderately abundant during the spring of 1929 and again in 1930, but in no case was any species present in significant numbers during the summer period.

Thirteen species of Coleoptera were recorded from collections in plot 4 during the entire period of study, but of these only two species,

Phyllotreta albionica and *Collops bipunctatus*, were ever abundant enough to be considered of any numerical importance. *P. albionica* reaches its peak of abundance on mustards that are either completely dry or very nearly so.

Four species of Orthoptera, all members of the family Locustidae, were taken in the plot during the study. These species are *Melanoplus mexicanus mexicanus* Sauss., *M. packardi foedus* Scudd., *Oedaleonotus enigma* Scudd., and *Trimerotropis pallidipennis* Walk.

All of the Locustidae were collected during the summer periods with the exception of a few specimens found in the spring of 1931. These latter specimens were taken during the end of the period and show, by the mere fact that adult Locustidae were present so early in the season, that the June weather of 1931 was very warm and dry.

Five species of Araneida were collected in the plot during 1931. These were *Dictyna* sp., *Metepeira fori* G. and I., *Pellenes* sp., *Xysticus cunctator* Thrll., and *X. pallidissimus* Gtsch. These species represent all of the determined material of this group that was collected in the plot during 1931, but inasmuch as determinations of the specimens found in the collections of 1929 and 1930 are not complete, the seasonal occurrence of the group as a whole is given in table 15 rather than that of each species individually.

Undoubtedly there were species having considerable influence upon the life of the populations that are not represented in the foregoing list of Araneida, but at least a part of the numerical importance of this group, relative to the species of insects (Hexapoda) present throughout the various years, can be surmised by comparing this list and data regarding occurrence with the preceding records of insect occurrence and abundance. *Metepeira fori* was by far the most commonly occurring species, particularly during the early spring and late fall seasons. The webs of this spider frequently appear almost to cover stands of Russian-thistle during the fall, and relatively large numbers of individuals appear in any sweep collections taken in this habitat during that period of the year. Although our present knowledge of the predatory importance of this group is very meager, even in a qualitative way, it would appear that the occurrence of this species in abundance and the presence of other spiders during various periods of the year are evidence that they were important factors in the various insect populations.

The determinations of the specimens of Diptera have been very incomplete, considering all the collections made during the study, but at least a partial list of the species is available and offers some indication as to what species were present. The following list of Diptera includes only the species that were collected during 1928 and is not necessarily representative of the dipterous fauna during the entire period of study.

Asilus mesae Tek.
Cerodonta femoralis Meig.
Chloropisca glabra Meig.
Geron sp.
Hylemyia aldrichi Towns.
Hylemyia cilitrura Rond.
Lepidanthrax sp.
Madiza halteralis Coq.
Mythicomyia atra Cress.
Mythicomyia sp.
Phthiria sulphurea Loew.
Phorantha occidentis Walk.
Pipunculus subvirescens Loew.
Siphonella sp.
Tephritis clathrata Loew.
Tephritis radiata Coq.

A single species of Thysanoptera, *Aeolothrips fasciatus* (L.), represents the only determined species of this group from all of the collections. Undoubtedly several species were actually present in most seasons, but lack of complete specific determinations for representatives of this group prevents further consideration of their specific importance.

COMPARISON OF INSECT FAUNA OF SAGEBRUSH WITH THAT OF ANNUAL WEEDS OF ABANDONED LAND

In general, before they were cleared for cultivation, all of the abandoned lands in the Snake River Plains were originally covered by well-established stands of sagebrush. The removal of this protective covering of perennial native growth and subsequent abandonment upset an equilibrium of long duration and allowed the growth of annual weeds which constitute the first of the secondary plant successions. Consequently, these areas serve and have served as excellent breeding places for the beet leafhopper and other economically important insect species common to such environments. Thus, as Piemeisel (*9*) states:

> Whenever the vegetation thoroughly established on a soil is destroyed, an equilibrium of long duration is upset. This means not only the equilibrium between plants and soil but also the balance that existed between the plant and all the life that it supported.

The discussion in the preceding sections has taken into account the development and fluctuations in abundance of the insect species on weed areas following clearing of the original vegetation and abandonment of this land. It having been shown that the beet leafhopper, a species of extreme economic importance in this area, builds up enormous populations on the weeds occupying these areas after discontinuance of actual tilling operations, a comparison of the fauna of sagebrush with that of the weedy covering of newly abandoned lands becomes especially significant.

The data presented in table 16 show the species, together with the average number per 50 net sweeps, collected on old sagebrush in an area within 300 yards of plot 4. These data represent averages of collections made during the spring, summer, and fall months of 1928–32, inclusive. The more abundant species are listed separately, while the less common ones have been grouped under their various orders.

In table 17 there is given a comparative summary of the data derived from net collections on mustards, Russian-thistle, and sagebrush. In treating these data the collecting season has been divided into two periods, the spring and summer. The spring period covers the time from the beginning of insect activity in the spring to July 10 and the summer period begins with July 11 and continues to the last of September. In this table the average numbers of the predominating insect species found in 50 net sweeps on sagebrush during the spring period are compared with those found in similar collections taken on the mustards, while the data from collections on sagebrush in the summer are compared in a like manner with those from Russian-thistle.

TABLE 16.—*The numbers of insects and spiders collected in 50 sweeps of a collecting net on dates specified from 1928 to 1932, inclusive, on old sagebrush adjacent to abandoned land, Hollister, Idaho*

Species	1928						1929						1930					
	August		September		October		July			August		September	July		August		September	
	27	28	11	25	9	21	11	16	30	13	28	11	10	24	7	21	5	19
	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number
Eutettix tenellus[1]	0	0	2	2	2	3	1	0	0	0	1	1	0	2	1	0	0	2
Empoasca aspersa	35	11	71	18	0	5	0	19	1	15	9	10	23	0	1	2	2	4
Aceratagallia fuscoscripta[1]	1	3	3	1	1	4	1	2	0	11	1	1	1	1	0	1	0	5
Hysteropterum cornutum var. *utahnum*	2	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Europiella decolor	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0
Geocoris pallens[1]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	5
Cercopeus artemisiae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phyllotreta albionica[1]	0	0	0	0	0	1	12	6	0	0	0	0	0	0	0	0	0	1
Spiders[2]							6	5	0	8	5	3	2	1	3	3	6	6
Other species grouped by orders:																		
Homoptera	6	1	3	2	3	1	41	2	0	9	0	0	3	0	0	0	0	1
Hemiptera	6	5	1	0	3	0	3	5	0	0	0	0	4	0	2	11	17	15
Coleoptera	2	1	0	0	0	0	3	0	0	3	2	1	0	0	0	1	0	0
Hymenoptera	2	0	1	0	1	1	17	8	1	0	3	3	9	1	1	1	4	2
Diptera	7	1	0	1	0	0	15	15	0	3	6	3	1	2	1	7	4	14
Lepidoptera	2	3	0	0	0	0	0	0	0	0	1	3	1	0	0	2	1	0
Orthoptera	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Thysanoptera[2]							1	0	0	0	0	0	0	0	0	0	0	0

See footnotes at end of table.

TABLE 16.—*The numbers of insects and spiders collected in 50 sweeps of a collecting net on dates specified from 1928 to 1932, inclusive, on old sagebrush adjacent to abandoned land, Hollister, Idaho*—Continued

Species	1931											1932									
	May		June			July		August		September		April	May	June	July		August		September		October
	4	20	2	13	26	11	24	11	20	4	24	11	10	17	9	30	9	24	9	26	12
	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number
Eutettix tenellus [1]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1
Empoasca aspersa	0	4	65	36	16	11	1	2	3	0	1	0	0	7	15	18	22	34	8	1	1
Aceratagallia fuscoscripta [1]	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Hysteropterum cornutum var. *utahnum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	11	4	2	0	0
Europiella decolor	0	0	0	9	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geocoris pallens [1]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cercopeus artemisiae	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phyllotreta albionica [1]	2	1	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Spiders [2]	0	0	0	0	0	0	1	1	2	2	0	0	0	0	1	2	1	0	1	------	5
Other species grouped by orders:																					
Homoptera	3	45	27	9	3	3	8	1	0	2	0	0	0	10	26	30	11	6	2	0	0
Hemiptera	0	2	5	9	5	0	0	0	0	0	0	0	1	3	11	3	0	1	0	0	1
Coleoptera	1	2	1	1	2	2	2	2	2	1	0	6	6	1	0	1	0	0	0	3	0
Hymenoptera	17	22	49	40	0	0	0	1	0	1	0	0	1	3	2	1	1	0	0	26	2
Diptera	10	2	0	5	2	6	3	1	1	1	0	0	0	2	0	2	0	1	1	0	3
Lepidoptera	0	0	1	1	1	0	0	0	0	0	0	0	1	0	2	1	0	1	1	0	0
Thysanoptera	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemerida	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Orthoptera	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0

[1] These species occur in great abundance on the annual weeds of abandoned land.
[2] Records of spiders and Thysanoptera are not available for 1928.

TABLE 17.—*Comparative summary of average numbers of predominating insect species found in 50 sweeps made at various times on mustards, Russian-thistle, and sagebrush during the spring and summer of 1928–32, Hollister, Idaho*

Species	Hosts	1928 [1]		1929 [1]		1930 [1]		1931		1932	
		Spring [2]	Summer [3]	Spring	Summer	Spring	Summer	Spring	Summer	Spring	Summer
Eutettix tenellus (Baker)	Mustards [4]	7.4		15.0		10.1		81.5		0.5	
	Sagebrush		1.8		0.5		0.8	.0	0.0	.2	0.3
	Russian-thistle		290.6		225.8		405.3		86.9		81.5
Aceratagallia fuscoscripta Oman	Mustards	2.8		3.8		6.4		8.6		.9	
	Sagebrush	.0	2.2		2.6		1.8	1.1	.0	.0	.3
	Russian-thistle		1.7		3.8		15.9		4.0		1.4
Empoasca aspersa G. and B	Mustards	.0		.0		.0		.0		.0	
	Sagebrush		23.3		9.0		5.6	22.0	1.1	5.5	14.0
	Russian-thistle		.0		.0		.0		.0		.0
Thamnotettix vendilarius Ball	Mustards	1.4		1.0		4.2		27.8		.0	
	Sagebrush		.0		.3		.1	.0	.0	.0	.3
	Russian-thistle		.0		.0		.0		.0		.0
Hysteropterum cornutum var. *utahnum* Ball	Mustards	.0		.0		.0		.0		.0	
	Sagebrush		1.7		.0		.0	.0	.0	.0	3.6
	Russian-thistle		.0		.0		.0		.0		.0
Melanotrichus coagulatus (Uhl.)	Mustards	24.1		82.4		56.2		215.2		.8	
	Sagebrush		.0		.0		.1	.5	.0	2.7	.0
	Russian-thistle		.0		.7		9.3		.4		2.7
Nysius ericae (Schill.)	Mustards	27.4		67.4		130.6		54.6		.5	
	Sagebrush		.0		.0		7.1	.1	.0	.0	.0
	Russian-thistle		1.9		4.7		9.7		7.4		1.1
Lygus elisus Van D	Mustards	9.4		2.2		6.8		13.0		.8	
	Sagebrush		1.1		.0		.0	.1	.0	.2	.0
	Russian-thistle		.4		2.8		20.7		.0		3.5
Europiella decolor (Uhl.)	Mustards	.0		.0		.0		.0		.0	
	Sagebrush		.0		.3		.1	.3	.0	.0	.1
	Russian-thistle		.0		.0		.0		.0		.0

See footnotes at end of table.

TABLE 17.—*Comparative summary of average numbers of predominating insect species found in 50 sweeps made at various times on mustards, Russian-thistle, and sagebrush during the spring and summer of 1928–32, Hollister, Idaho*—Continued

Species	Hosts	1928 [1]		1929 [1]		1930 [1]		1931		1932	
		Spring [2]	Summer [3]	Spring	Summer	Spring	Summer	Spring	Summer	Spring	Summer
Nabis alternata Parsh.	Mustards	0.1		0.6		0.1		0.3		0.06	
	Sagebrush		0.0		0.0		0.0	.1	0.0	.0	0.0
	Russian-thistle		.0		.0		.2		.1		.0
Geocoris pallens Stål	Mustards	1.0		1.6		.3		3.6		.2	
	Sagebrush		.0		.0		1.1	.0	.0	.0	.0
	Russian-thistle		.5		.5		2.5		10.4		.0
Phyllotreta albionica (Lec.)	Mustards	363.0		11.4		9.0		72.8		4.7	
	Sagebrush		.2		3.0		.0	1.1	.0	.0	.3
	Russian-thistle		2.2		.3		.4		.0		.4
Cercopeus artemisiae Pierce	Mustards	.0		.0		.0		.0		.0	
	Sagebrush		.0		.0		.0	1.8	.0	.0	.0
	Russian-thistle		.0		.0		.0		.0		.0
Total	Mustards	436.9		185.4		223.7		477.4		8.46	
	Sagebrush		30.3		15.7		16.7	27.0	1.1	8.6	18.9
	Russian-thistle		297.3		238.6		464.0		109.2		90.6

[1] Records of sagebrush are not available for the spring season of 1928, 1929, and 1930.
[2] The spring season includes all collections made on mustards and sagebrush from Apr. 1 until July 10, inclusive.
[3] The summer season includes all collections made on Russian-thistle and sagebrush from July 11 to Oct. 15, inclusive.
[4] The mustards include the 3 species, *Sophia parviflora*, *S. longipedicellata*, and *Norta altissima*.

It should be emphasized here that those species that were found to be so abundant on the mustards and Russian-thistle either occupy a very minor position or are entirely lacking from the sagebrush fauna. The beet leafhopper appears in small numbers in the sagebrush environment, but these occurrences are nearly always confined to the fall periods, at which time but few other green plants are available, so it must be concluded that they have moved to this plant through necessity rather than choice. Past experience, as well, has shown that the beet leafhopper uses sagebrush only as a temporary or "hold-over" host during the fall months when the more desirable plants are not available, and that it is apparently neither able to survive upon it through the winter months nor to reproduce in this situation the following spring except possibly with very limited success. It is certain that the enormous numbers of this species that develop on the annual weeds of abandoned lands would be greatly reduced and perhaps eliminated if sagebrush and the plant species normally associated with it were the only available host plants.

The small, green sage leafhopper, *Empoasca aspersa*, is frequently found on sagebrush in relatively large numbers. The data presented in table 16 show that this species was the most abundant one taken in all collections on sagebrush throughout each year and that usually it was more abundant than all of the other species combined. The sage leafhopper is rarely found on either the annual weeds of abandoned lands or the cultivated crops and consequently is to be considered of extremely small economic importance.

The remaining species listed in table 16 were found in only small numbers on sagebrush, and it will be noted that, only four of the species listed in the table, *Eutettix tenellus*, *Aceratagallia fuscoscripta*, *Phyllotreta albionica*, and *Geocoris pallens*, occurred on the annual weeds previously considered.

A large percentage of the Homoptera listed in table 16 were members of the family Aphiidae and apparently represented species that occur only on sagebrush and are not to be found on cultivated crops.

A large percentage of the Diptera and Hymenoptera were either gall forming, predatory, or parasitic. The species of the remaining orders were represented in all cases by only occasional specimens. All of these species are apparently relatively rare in the cultivated and abandoned weedy areas.

The data presented in table 18 represent the average of a large number of net collections on sagebrush in an area 5 to 15 miles from either newly abandoned or cultivated land. These collections were made only during the fall months of 1932, after the beet leafhopper had moved from already dead or rapidly drying Russian-thistle stands. Only the four most abundant species have been included in this table for purposes of comparison with those found during a similar period on sagebrush adjacent to abandoned land. From these data it is evident that the sage leafhopper (*Empoasca aspersa*) is by far the most abundant species to be found on sagebrush either adjacent to abandoned land or at some considerable distance from it.

TABLE 18.—*Comparison of the more abundant insect species collected in 50 net sweeps on sagebrush adjacent to abandoned land with those similarly collected on sagebrush at some distance from either abandoned or cultivated land, Hollister, Idaho, 1932*

Species	Near abandoned land				Distant from abandoned land			
	Aug. 24	Sept. 9	Sept. 26	Oct. 12	Sept. 4	Sept. 13	Sept. 23	Sept. 30
Eutettix tenellus	1.0	0.0	0.0	1.0	2.7	0.8	0.8	4.0
Empoasca aspera	34.0	8.0	1.0	1.0	67.3	13.6	73.8	43.8
Geocoris pallens	.0	.0	.0	.0	.9	.0	.3	1.2
Hysteropterum cornutum var. *utahnum*	.0	.0	.0	.0	.2	.0	.3	.5

The beet leafhopper appeared in very small numbers in both situations, but its span of existence on this plant is very short. The sage leafhopper, on the other hand, is undoubtedly native to this environment and has been taken but rarely in either the abandoned weedy areas or on cultivated crops.

These data merely serve to point out the great differences existing between the insect fauna of the sagebrush and the annual weeds and emphasize the fact that no species of economic importance has been found to occur abundantly in the sagebrush community, whereas the annual weeds do support such insects in large numbers.

SUMMARY AND CONCLUSIONS

During the years 1928–33 a study was made of the successions of plant cover on newly abandoned lands in southern Idaho and also a similar but less detailed study of a general breeding area of the beet leafhopper (*Eutettix tenellus* (Baker)). These studies have shown that following abandonment, the first weed cover to develop was Russian-thistle (*Salsola pestifer*). This was later replaced by stands of flixweed (*Sophia parviflora*), and tumblemustard (*Norta altissima*), which in turn finally gave way to downy chess (*Bromus tectorum*). A study of the successive insect populations of these various plant associations was made to parallel the observations on plant succession.

These studies have demonstrated the important role played by the annual weeds covering recently abandoned lands in producing large populations of injurious insects, especially the beet leafhopper, which is the most important economic species in this area. It has been shown further that after the plant succession on abandoned lands has proceeded far enough, i. e., to downy chess and sagebrush, there ceases to be an economically important production of the beet leafhopper or other injurious insect species.

It was found that Russian-thistle and the spring-growing mustards supported large insect populations of which the beet leafhopper was an important member. The spring-growing mustards were found to support the most complex groups of species, in which *Melanotrichus coagulatus* and *Phyllotreta albionica* usually predominated enormously over all others. In contrast, Russian-thistle was found to support during the summer and fall much less complex insect populations, in which the beet leafhopper always predominated.

Russian-thistle and the spring-growing mustards were later displaced by downy chess which never served as a host plant for the beet leafhopper, and, during the period covered by this study in the

Hollister area, very rarely attracted any but visiting insect species and these never in large numbers.

Sagebrush (*Artemisia tridentata*) did not support any populations of economically important insect species, though it does serve as a temporary or "hold-over" host for the beet leafhopper during the fall and other seasons of the year when the more desirable food plants are not available. It is not a suitable host for the building up and maintenance of large populations of this or other economically important insects.

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