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JANUARY, 1939

Montana Insect Pests For 1937 and 1938

THE TWENTY-SEVENTH REPORT OF THE
STATE ENTOMOLOGIST OF
MONTANA

BY
HARLOW B. MILLS, STATE ENTOMOLOGIST

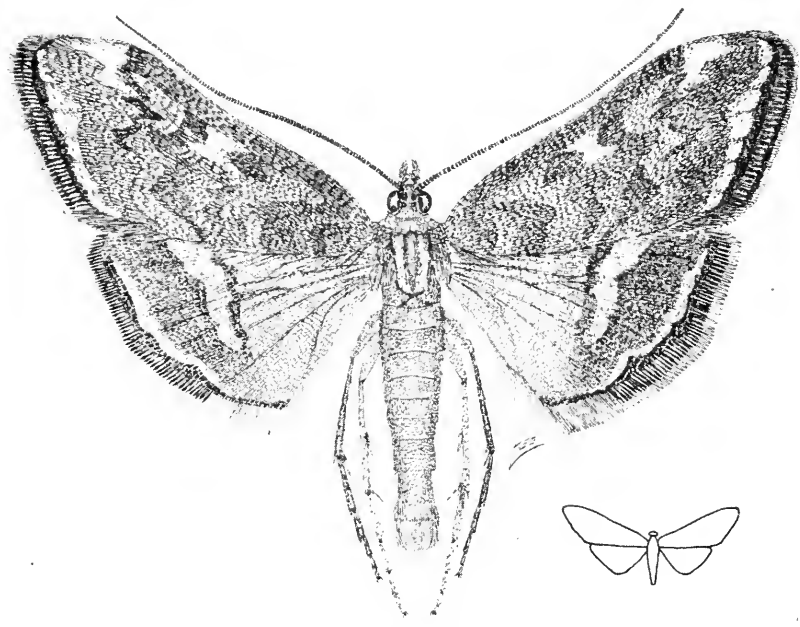


Figure 1.—Adult of the sugar beet webworm (*Loxostege sticticalis* L.)

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LETTER OF TRANSMITTAL

Bozeman, Montana.
December 15, 1938.

To His Excellency,
Governor Roy E. Ayres,
Helena, Montana.
My Dear Sir:

I present herewith the 27th Report of the State Entomologist of Montana.

There have been some changes in the status of the insect outbreaks reported to you for 1935 and 1936. Grasshopper injury was intense in parts of the State in 1937, the areas affected most severely being affected also by drought. For 1938 a great decrease in infestation was forecast, and this decrease was clearly evident up until July 1, 1938. The injury caused by these pests would have been the smallest on record for Montana in many years had not an invasion from the Dakotas occurred in July. This invasion cost Montana over six millions of dollars but, fortunately, such mass migrations involving large areas seldom occur. Indications are that "native" Montana hoppers will be considerably more abundant in 1939 than they were in 1938.

The worst infestation of Mormon crickets ever experienced by this or any other State occurred in 1937 and was successfully combatted through an allocation of W. P. A. funds. Crops valued at over five million dollars were saved and about five hundred thousand dollars worth of crops were lost. In 1938 there was a change in procedure in fighting these pests, involving a reduction in hand labor and an increase in the use of power dusters and barriers. Again the savings-loss ratio was about 10:1. Control work for these pests is working toward a sounder basis.

The Federal side of insect control is now invested in a division of the Bureau of Entomology and Plant Quarantine which is in charge of control procedure alone. Definite contributions are required of the State in order to receive this Federal assistance. The direction of these cooperative projects in the State is the duty of the State Entomologist. Responsibility for the financing of these campaigns falls, however, on several agencies and groups. I should like to call your attention especially to the discussion of this distribution of responsibility, and suggestions for its equalization among those involved, as given in this report.

Respectfully submitted,
Harlow B. Mills,
State Entomologist.



Twenty-Seventh Report of the State Entomologist

Harlow B. Mills

INSECT CONTROL IN MONTANA, 1937-1938

Since 1930 large scale control of insect pests in Montana has received increasing attention. During the drought of the past few years certain insects have increased greatly in numbers and have been of serious concern to Montana farmers. Assistance for the control of grasshoppers and Mormon crickets increased during the last biennium, both from State and Federal sources, and a considerable measure of success was experienced.

Indications are that grasshoppers will be considerably more abundant in 1939 than in 1938, and that Mormon crickets are increasing in some areas of the State and decreasing in others. It is therefore, highly essential that both of these major crop pests be considered seriously in farming operations next year.

The control of insect pests in the State of Montana should not be considered a passing thing. If we can reason from past experience the farmers of the State, in approximately two-thirds of the years to come, will have to fight grasshoppers and Mormon crickets. In going through the past Reports of the State Entomologist we find that outbreaks of grasshoppers or Mormon crickets have occurred in 25 out of the last 37 years in some parts of the State. This does not take into consideration outbreaks of such insects as sugar beet webworms, blister beetles, army cutworms, pale western cutworms, etc. Further, many insects such as the codling moth and cabbage butterfly are with us constantly. *Insect control, then, must enter into any long-time planning for the agriculture of Montana*, along with soil conservation and rebuilding, water conservation, and other factors of major importance to the agriculture of the State.

Where does the responsibility for financing insect control campaigns lie?—The insect pests which have been receiving the most attention from the control standpoint during the past few years are grasshoppers and Mormon crickets. Both of these pests are migratory and may travel many miles during the season, and both will eat almost any vegetation. Control, then,

is not an individual problem. Mormon crickets notoriously migrate on foot in large bands from one farm to another, one county to another, and even from one state to another. Grasshoppers commonly migrate locally every year, and occasionally, as in 1938, they fly in large hordes for great distances.

Responsibility for assistance in control lies with all owners of agricultural or other lands upon which they may breed. These owners include the Federal Government, the State, the counties, corporations, farmers, etc. All of these groups have a responsibility, and all have been meeting it to a greater or lesser extent. The proportion of land ownership might be a logical basis from which to figure proportionate responsibility. Of the 92,737,869 acres in the State, the following are the percentages of ownership:¹

<i>Groups</i>	<i>Per-Cent</i>
Federal	35.64
State	5.67
County	2.72
Miscellaneous07
Corporate groups	14.25
Non-resident individuals	10.89
Resident individuals	30.75

Responsibility, then, would fall in the following order: individual, Federal Government, corporate groups, State, and county. The actual distribution of responsibility during the past two years has been: individual (including labor involved), Federal, county, State, and corporations. The State is not giving its proper proportion of assistance in insect control, and land-owning corporations are contributing very little. The problem of obtaining assistance from these corporations and from non-resident land owners deserves considerable attention. Non-resident land owners represent the most difficult group from which to obtain assistance. The logical procedure would be to assess a percentage of the cost of control work carried on on their lands, or of benefit to their lands, as taxes. Corporate owners are fewer in number and their assistance might be more easily obtained. The State's contribution could be cared for easily by

¹Renne, R. R., Montana Land Ownership, Mont. Agr. Exp. Sta. Bul. 322, 1936.

increased appropriation to the office of the State Entomologist and by some form of repayment to the counties for a part of their expenditures in insect control.



Figure 2.—Migratory hoppers on wheat, Garfield County, July, 1938.
Courtesy U. S. Bureau of Entomology and Plant Quarantine.

The State Entomologist is the responsible agent for the prosecution of insect control campaigns in the State. His primary work is with the Montana Agricultural Experiment Station and the Montana State College. However, this contact between control work and investigation is highly desirable, because for the methods used control is wholly dependent on investigation, if it is to be in any measure successful. For the field work the State Entomologist must have sufficient assistance to

properly carry out the duties required of the office.

The appropriation provided by the last session of the Montana Legislature made possible the employment of two full-time assistants, Mr. O. B. Hitchcock, who has been working on Mormon cricket control activities, and Mr. H. R. Willis, for the grasshopper campaign. It also made possible the hiring of temporary help, the purchase of a limited amount of equipment and the rental of district warehouses for the storage of materials purchased by the Federal Government. In addition a small amount of investigation into the effect of Mormon crickets on the range, and an extension of the annual grasshopper survey was carried on.

Further research is necessary because, while it is true that a measure of control has been developed for the great majority of harmful insects, there are few if any for which these methods cannot be refined in effectiveness and cost or new ones discovered. One line of research of extreme importance, but not yet receiving its proportionate share of attention, is that of forecasting increases in insect populations. Certain insects seem to do best in dry weather, others in wet. For the majority of them, however, the factors governing their increase or decrease are not known. In 1936 there were serious outbreaks of the false chinch bug (*Nysius ericae* Schil.) and the forest tent caterpillar (*Malacosoma disstria* Hbn.). The next year they were absent in any numbers and the lined sphinx moth (*Celerio lineata* Fab.) was abundant. In 1932 the Say's grain bug (*Chlorochroa sayi* Stal.), which had been observed in small numbers in the State since 1901, appeared in large numbers and caused considerable injury to wheat in the Triangle Area north of Great Falls. It has remained in injurious numbers up to the present time. When its period of high populations will end is not known. This past summer the common field cricket (*Gryllus assimilis* Fabr.) has been extraordinarily abundant in many areas in the northern tier of counties, and in some places farther south. It is not known whether or not it will increase to injurious numbers next season. Until information is available concerning the factors governing these increases in insect populations, the actual control work will be greatly handicapped.

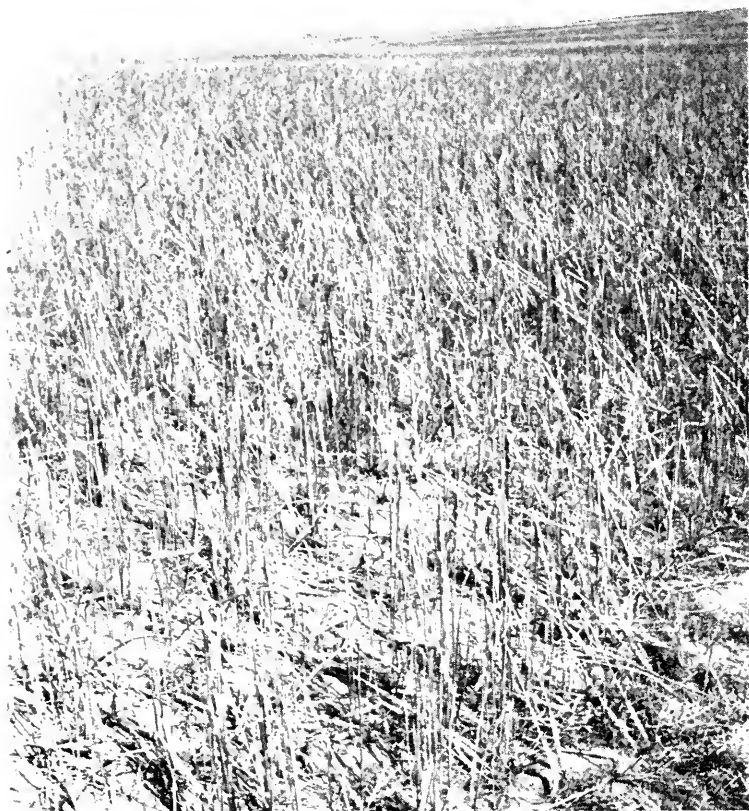


Figure 3.—Wheat field destroyed by lesser migratory locust, Garfield County, July, 1938. Courtesy U. S. Bureau of Entomology and Plant Quarantine.

GRASSHOPPER CONTROL

General Conditions During 1937-1938

The 1937 season was similar to several preceding seasons in that drought conditions prevailed in many parts of the State. The hatching of grasshoppers started approximately the middle of May and was rather local in its occurrence. In the mountainous western third of the State there was a great mixture of species including *Camnula pellucida* (clear winged locust), *Melanoplus mexicanus* (lesser migratory locust), *M. packardi*, *M. infantilis*, *Chorthippus*, and others. Throughout the eastern

two-thirds of the State, *M. mexicanus* was the dominant form. In the southern half of this area *Aulocara elliotti* (big-headed locust) occurred in considerable numbers, and *M. packardi* and *M. bivittatus* to a less extent. Conditions in the north half of this area were similar, but *M. packardi* was possibly more abundant in many areas than *A. elliotti*. For the first time, at least in many years, the eastern *M. differentialis* (differential locust) was a dominant species. In some of the irrigated sections of Richland County the species was present in large numbers and laid many eggs.

No critical injuries to humans were reported as a result of the 1937 campaign. Thirty-two domestic animals died as a result of careless exposure of bait or bait materials.

The 1938 season was characterized by a definite break in the drought period, and both cultivated and wild vegetation grew luxuriantly throughout practically all of the State. Hatching of grasshoppers was from 4 to 6 weeks late, not being well under way until after the first week in June. Small numbers continued to hatch throughout the season. Rankness of vegetation doubtless contributed to this late and long-continued hatch. In fact on ranches near Wilsall, in Park County, there was practically no hatch until the first cutting of alfalfa was removed. The hatch became general on these fields as the soil warmed up.

In the western third of the State there was again a great variety of species, the most of the damage to crops being attributed to *Camnula pellucida*, *Melanoplus mexicanus*, and *M. packardi*. In the central third of the State *M. bivittatus*, *M. packardi*, *C. pellucida*, and *A. elliotti*, were dominant. In the eastern third *M. mexicanus* was dominant, with local concentrations of *M. bivittatus*, *M. femur-rubrum*, and *M. differentialis* in injurious numbers up the Yellowstone Valley into Custer County.

The increase of cool damp weather over the State was doubtless an important factor in reducing grasshopper populations in 1938. Locally, fungus was efficient in keeping numbers down, and, although Sarcophagid flies were not observed to be present in excessive numbers, there was a constant reduction in grasshopper numbers due to parasitism caused by maggots. It is

TABLE 1.—LOSSES FROM GRASSHOPPERS AND SAVINGS FROM CONTROL WORK IN DOLLARS

County	1937		1938	
	Loss	Savings	Loss	Savings
Beaverhead	9,000	20,000	700	—
Big Horn	2,000	8,250	700	1,000
Blaine	99,000	125,000	2,000	1,500
Lewis and Clark and Broadwater	34,400	27,000	—	—
Carbon	20,910	30,455	2,405	5,900
Carter and Fallon	2,300	14,300	5,300	6,500
Cascade	175,000	42,900	129,450	64,000
Cascade	1,150	7,100	—	—
Chouteau	10,000	5,000	1,500	1,000
Custer and Powder River	—	—	37,405	8,450
Daniels	—	1,000	326,000	17,000
Dawson	110,000	26,000	805,000	10,500
Deer Lodge	—	—	—	—
Fergus	117,200	141,200	6,175	3,350
Flathead	—	—	—	—
Gallatin	29,300	12,580	22,500	7,900
Garfield	3,200	4,000	168,500	2,000
Glacier	—	2,000	—	2,530
Golden Valley and Musselshell	242,500	105,800	33,000	96,000
Hill	6,000	5,000	60,750	187,200
Jefferson and Madison	—	2,745	2,405	5,900
Judith Basin	9,860	7,700	4,980	25
Lake	9,500	4,700	3,900	15,800
Liberty	7,200	74,000	3,862	880
McCone	—	—	1,021,491	176,199
Meagher	18,960	6,880	3,440	425
Missoula	—	—	—	—
Park	74,500	25,000	12,500	2,000
Petroleum	2,150	3,700	13,200	3,500
Phillips	2,500	12,000	27,150	1,300
Pondera	—	159,307	—	0
Powder River and Custer	—	—	37,405	8,450
Powell	2,250	2,800	—	—
Prairie	270,000	—	805,000	0
Richland	—	50,000	1,359,000	0
Roosevelt	—	—	277,500	30,000
Rosebud	19,500	67,900	92,000	24,500
Sanders	—	—	—	—
Sheridan	6,500	4,300	933,000	27,000
Stillwater	15,000	51,000	2,100	1,100
Sweet Grass	638,800	145,500	9,450	2,120
Teton	15,000	—	3,000	700
Toole	5,000	15,000	6,700	9,000
Treasure	—	—	—	—
Valley	890	12,100	50,100	9,000
Wheatland	5,800	3,000	—	0
Wibaux	182,000	50,000	430,000	283,500
Yellowstone	11,050	35,500	—	0
Totals	2,158,420	1,311,017	6,661,114	1,015,229

highly probable that they were the primary agent in the decimation of the 'hoppers which moved into the State in July.

Twenty-one domestic animals died as a result of eating carelessly exposed bait or bait materials. No serious injury to humans resulted from the campaign.

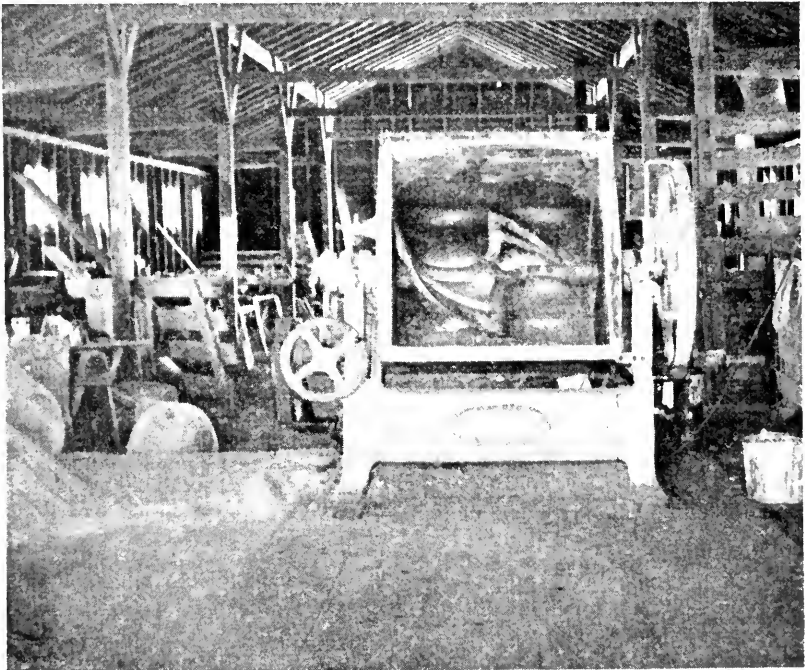


Figure 4.—Discarded bread mixer converted into bait mixer, Sheridan County.

Grasshopper Situation for 1937-1938

FOR 1937.—The grasshopper survey, carried on in collaboration with the Bureau of Entomology and Plant Quarantine during the autumn of 1936, allowed for the prediction of a moderately heavy infestation over most of the plains area of the State with still heavier infestations along the Continental Divide and in the Yellowstone Valley. Fortunately, the infestation along the divide was held in check by natural factors. The worst affected counties were Blaine, Carter and Fallon, Dawson, Fergus, Golden Valley and Musselshell, Park, Prairie, Sweet Grass, and Wibaux. Drought

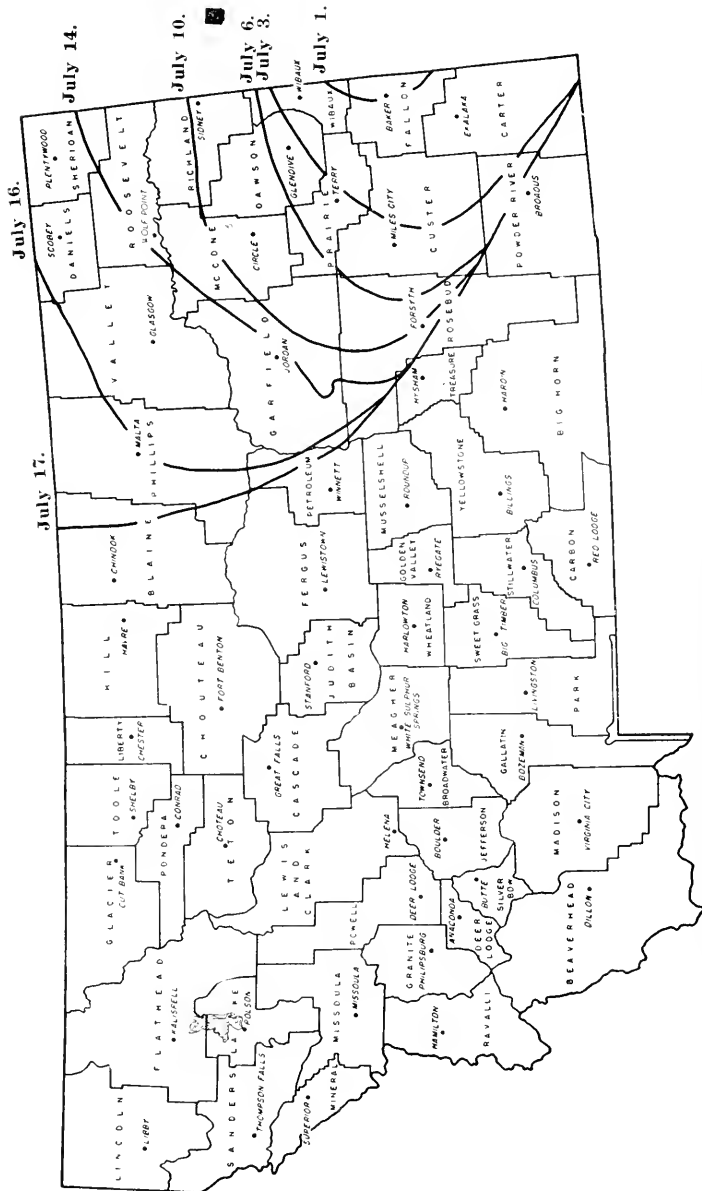


Figure 5.—Map showing the spread of the lesser migratory locust in Montana during the immigration of 1938.

conditions in the northeastern corner of the State seriously affected the campaign in that area. Most of the State suffered from lack of rainfall throughout May, reducing crop prospects and delaying control work. Total losses attributable to grasshoppers in 1937 amounted to \$2,196,420.00. Savings, nevertheless, amounted to \$1,385,642. The campaign cost \$62,753.37, and the savings per dollar spent were \$22.08.

FOR 1938.—The autumn survey in 1937 indicated a general reduction in potential injury throughout the State with the exception of the eastern border counties and a few small areas in the center of the State. This prediction was borne out by the resulting populations which appeared during the first half of the season. One bad area in the west, involving parts of Lake, Sanders, and Missoula counties, developed without warning, and a considerable amount of control work was carried on in the northeastern counties bordering North Dakota. The bad areas were reasonably well under control by the first of July, and at that time it appeared that there would be less injury from these pests than for several years past. The final picture, however, was very different.

The Migrations of July, 1938

On the first of July, crop prospects throughout the most of Montana were better than they had been for a decade. On that day, however, Wibaux, Carter, and Fallon counties were invaded by hordes of grasshoppers from the southeast. The species involved was the lesser migratory locust, *Melanoplus mexicanus* Sauss. Where the "native" grasshoppers had been from 2 to 15 per square yard, the migrants increased the population without warning to from 40 to 500 per square yard. By the third of July, they covered all or a part of Carter, Powder River, Custer, Prairie, Dawson, Wibaux, and Fallon counties. From the 4th to the 9th temperatures were generally below 80° and there was little migration. By the 10th, parts of Rosebud, Garfield, McCone, and Richland counties were invaded. Winds were from the northwest on the 12th and 13th, but by the 16th they had continued into parts of Treasure, Petroleum, Phillips, Valley, Daniels, Roosevelt, and Sheridan counties, and on the 17th they appeared in the vicinity of Turner in Blaine County.

This large flight apparently originated in north-central South Dakota and south-central North Dakota. Some of the grasshoppers flew through Montana and far into Saskatchewan. The large migrations took place when the temperature was above 80° and a southerly wind was blowing. Interesting information bearing on this point is recorded by Munro and Saugstad in the Bimonthly Bulletin of the North Dakota Agricultural Experiment Station, Volume 1, Number 1, 1938:

"The direction of dispersal has ranged from north to northwest from the point of release. A possible explanation of this may be that winds from the south and southeast, being warmer than those from other directions, were more effective in promoting sustained flights of the insects. Records of the United States Weather Bureau reveal that for 15 days of the 29-day period, beginning July 17, winds from the south and southeast prevailed with an average daily maximum temperature of 88.9° F. For the remaining 11 days, which included 7 in July and 4 in August, the winds from the north and northwest prevailed with an average daily maximum temperature of 79° F.—a difference of 9.9° F. lower than the warmer winds from the south. The velocity of the southern winds averaged 7.04 miles per hour while those from the northerly direction averaged 8.1 miles. The heavy flights were generally observed to be travelling with the prevailing winds from the south."

While this temperature difference is doubtless of much importance, it was noticed on several occasions on July 12th and 13th in eastern Montana, that occasional 'hoppers rose some distance into the air and attempted to fly to the northwest, against the wind.

The flights in eastern Montana during the height of the invasion did not appear to be general over the whole area but took the form of large irregular clouds. The maximum elevation at which the migrating grasshoppers flew was not determined, but the following excerpt from a letter received from Mr. M. B. Freeburg, Superintendent of the Eastern Division of the Northwest Airlines, and dated September 1, 1938, is of interest:

"On July 27, I encountered a large concentrated flight of 'hoppers immediately east of Billings at approximately 7000 feet. It was approximately three miles through the flight Mr. Peterson at Billings reports that our Flight 2 of the 26th encountered a flight of 'hoppers at 11,000 feet between Helena and Billings. This is the only accurate and exact information I can give you at the moment, although I might mention that over a period of years 'hopper flights have been

encountered at all elevations up to and including 13,000 feet by various flights through the summer months."

CROP LOSSES AS A RESULT OF THE MIGRATION.—The 17 counties definitely affected by the immigration were Carter, Custer, Daniels, Dawson, Fallon, Garfield, McCone, Petroleum, Phillips, Prairie, Powder River, Richland, Roosevelt, Rosebud, Sheridan, Valley and Wibaux. The aggregate loss for all of these counties was \$6,474,191.00 or an average of \$380,835.00 per county.

Thirty-four counties which were affected slightly or not at all by the flight, reported on the grasshopper campaign. The total loss in these counties amounted to \$186,923.00 or an average of \$5,498.00 per county.

On the basis of the average loss for these 34 counties, a loss of \$280,398.00 might have been expected for the State as a whole had not the July immigration occurred. Actually, however, the total loss for the State amounted to \$6,661,114.00. Therefore, the loss which theoretically could be charged against the flight was \$6,380,716.00. The loss in the counties affected by the flight was 97.2 per cent of the total loss experienced in Montana during 1938.

Crop Savings During 1938

In spite of the large amount of crop damage suffered in 1938, savings attributable to the campaign were comparatively high. A total of \$1,007,174.00 worth of crops was saved through the expenditure of \$31,004.21, or a savings of \$32.49 per dollar spent, as compared with the \$22.08 saved per dollar spent in 1937.

TABLE 2.—SUMMARY OF GRASSHOPPER CAMPAIGNS FOR 1937-1938

	1937	1938
Tons of bait used (dry basis)	2,313	1,574
Mixing stations	34	39
Cost of mixing per ton (average)	\$4.70	\$4.30
Farmers using bait	4,602	3,086
Acres baited	582,904	0
Injury to humans	0	0
Livestock losses	32	21
Federal expenditure	\$45,620.25	\$24,433.68
State, county, and local expense (exclusive of field labor)	\$17,133.12	\$ 6,570.53
Total expenditure	\$62,753.37	\$31,004.21
Savings	\$1,385,642.00	\$1,007,174.00
Savings per dollar spent	\$22.08	\$32.49
Losses	\$2,196,420.00	\$6,661,114.00
Loss per acre injured	\$2.01	\$2.63

This increase in savings resulted from factors such as the small hatch of grasshoppers, the better growing conditions which may have encouraged better application of the control methods, the more vigorous crops which were able to withstand injury better than in previous seasons, and the allotment of more supervisors to the State by the Federal Government through the Bureau of Entomology and Plant Quarantine.

MORMON CRICKET CONTROL

Mormon Cricket Situation for 1937-1938

FOR 1937.—The Mormon cricket situation in Montana during 1937 was the most serious ever experienced in this State, and probably any other. Forty-five per cent of the infested acreage reported for the nation was in Montana. The infestation affected 976,563 cultivated acres and 6,511,132 acres of range, representing an increase of 59.9 per cent over 1936. The first large-scale control program against these insects was inaugurated in 1937 through the allocation of W. P. A. funds which were administered generally by the Bureau of Entomology, the U. S. Department of Agriculture, and in Montana by the State Entomologist. Large infestations occurred throughout the southern part of the State from Park to Powder River counties. Others appeared in practically all of the mountains east of the divide, and a critical condition developed west of the divide in Lake and Sanders counties. It is doubtful if a single county in the State was without some cricket population in 1937.

This campaign was predominantly successful. While the infestation increased 59.9 per cent and involved much more crop land, the injury sustained increased only 13.8 per cent over the preceding year. The savings amounted to \$5,166,098. This figure plus the loss should give the probable loss which would have been sustained had there been no control campaign, or a loss for the State of \$5,666,640. The savings plus the losses in 1936 probably amounted to around \$500,000. When these two figures are compared, the increase in jeopardized crop acreage is seen to be immense.

Seventeen counties participated in the 1937 campaign: Big Horn, Carbon, Cascade, Chouteau, Fergus, Golden Valley, Judith Basin, Lake, Lewis and Clark, Liberty, Meagher, Park, Sanders,

Stillwater, Sweet Grass, Toole, and Yellowstone.. Besides this, three Federal agencies participated on lands within the State but under their jurisdiction. These were the Custer National Forest, the Crow, and the Tongue River Indian Agencies.

That the campaign was appreciated was evidenced in various parts of the State. In his final report for Cascade County, County Agent D. P. Thurber stated:

"It is interesting to note that practically every farmer in the area is fully convinced that the cricket program was directly responsible for all of the crop that was harvested. In other words they said that if there had been no program they would have had no crop. There was not a single man who thought we should not continue with the program next year."

A wheat farmer with extensive holdings in Big Horn County wrote as follows:

"We believe on our job . . . we have successfully battled crickets this season, and we estimate our loss from crickets at less than one per cent. Owing to the location of our farms . . . it is generally conceded that we have successfully combatted the crickets on an area representing two hundred fifty to three thousand acres. In fact, the farmers between our job and Hardin, representing many thousands of acres, did not get into the campaign at all, as our barriers prevented their (the crickets') progress."

FOR 1938.—Control work in 1937 was almost entirely for the protection of crops, and therefore most of the control operations were limited to crop land or areas immediately adjacent to crop land. This affected control work in 1938 extensively, for it was evident throughout the State that where crickets were fought late in the season in 1937 there was a great reduction in the 1938 population. In some areas where control work was not extensive in 1937 there was a reduction from a moderately heavy to a light infestation, indicating that other factors were also at work. In Lake and Sanders counties there was an increase over 1937, and there is evidence of an increase in the extreme north-east counties of the State.

The increase in rainfall of 1938 over 1937 reduced the actual time which could be spent in the fields by the crews, and may have affected the movement of the crickets also.

There were several important changes in the organization and the prosecution of the 1938 campaign. Federal assistance

came from a direct appropriation administered through the medium of the Bureau of Entomology and Plant Quarantine. This allowed a change in the method of obtaining labor. The most costly item in cricket control is the labor involved, and stress was placed on increasing the use of barriers and power dusters. Hand dusters in use decreased from 1,298 in 1937 to 984 in 1938, power dusters increased from 11 to 100, and metal barrier from 54.8 miles to 156. Savings during the 1938 campaign were estimated at \$979,345. and losses at \$96,304.

It is much more difficult to anticipate possible cricket damage for the next year than is the case with grasshoppers. We are, however, better prepared for a campaign next year than in the past. The following equipment is being carried over for next year's campaign: 40 tons sodium arsenite, 88 tons diatomaceous earth, 4 tons hydrated lime, 110 tons mixed dust, 48,407.5 gallons crude oil, 1,296 usable hand guns, 103 power dusters, and 159 miles of metal barrier. The Federally owned part of this material has been concentrated in a warehouse in Billings and will be reissued to the counties in the spring according to their needs.

TABLE 3.—SUMMARY OF MORMON CRICKET CAMPAIGNS 1937-1938

	1937	1938
Crop savings	\$5,166,098	\$ 979,345
Crop losses	\$ 500,550	\$ 96,304
Acres protected	829,930	545,075
Acres injured	211,770	81,836
Crop acres infested	976,563	2,209,078 ¹
Range acres infested	6,511,132	5,542,407
Total infested acres	7,487,695	7,751,485
Materials used		
Hand dusters	1,298	984
Power dusters	11	100
Burners	193	—
Mixed dust (tons)	495.35	350.58
Oil (barrels)	1,950.7	4,027
Oil barrier (miles)	135	164
Furrow barrier (miles)	117	3
Metal barrier (miles)	54.8	156
Bait (tons)	771.75	—
Federal appropriation	—	\$ 151,578.79
W. P. A. allotment	\$ 332,075.20	—
Other Federal agencies	\$ 23,652.00	—
State, county, and local	\$ 81,154.22	\$ 105,652.82 ²
Total expenditures	\$ 436,881.42	\$ 257,231.61

¹Includes all land within five miles of crops.

²Includes volunteer contributions of \$60,905.71.

Effect of Mormon Crickets on Range

No definite information has been available as to the effect of Mormon crickets on the range. Through the increase in funds made available during the past biennium, and with the cooperation of the Bureau of Entomology and Plant Quarantine, and the Forest Service, it was possible to employ Mr. Nolan Keil who made a study of the relationship between Mormon crickets and range plants. The work was carried on in the drainage of Slim Sam Creek, Twp. 6N, R. 1W, above Radersburg. All of these observations were made where precipitation was abundant and the crickets were not forced to eat certain plants because of drought. Further, the crickets migrated to higher elevations before some of the later plants of the lower elevations appeared.

The entire area in which observations were made was between 5000 and 6000 feet in elevation and on a general south and east slope of an open range nature with occasional patches of trees. The trees were both deciduous and evergreen. The most common deciduous trees were *Populus* (cottonwood), *Salix* (willow), and some *Alnus* (alder). The most common evergreens were *Pseudotsuga* (Douglas fir), *Pinus* (pine), and *Picea* (spruce).

The excellent moisture conditions persisting throughout April, May, June and the first half of July increased the normal length of life for many of the more succulent plants. As the crickets preferred many of these to the grasses, this may explain to some extent the small damage to grasses this year.

A collection of 203 species of range plants was made, of which 55 were fed upon by Mormon crickets. Injury to these plants was divided into feeding on leaves and feeding on flowers and seeds.

The 10 plants showing greatest injury to leaves, in order of damage suffered, were: wild onion (*Allium nuttallii*), nodding onion (*Allium cernuum*), larkspur (*Delphinium bicolor*), bitterroot (*Lewisia rediviva*), mouse ear (*Cerastium arvense*), shooting star (*Dodocatheon conjugens*), violet (*Viola nuttallii*), dandelion (*Taraxacum officinale*), yellowbell (*Fritillaria pudica*), and yarrow (*Achillea millefolium*). The first grass to appear in this series was fifteenth in order of injury sustained.

The 10 plants showing greatest injury to flowers and seeds

were, in order: shooting star (*Dodocatheon conjugens*), looseleaf lupine (*Lupinus laxiflora*), mouse ear (*Cerastium arvense*), bluebell (*Mertensia lanceolata*), yellowbell (*Fritillaria pudica*), pussytoes (*Antennaria imbricata*), larkspur (*Delphinium bicolor*), littleleaf alumroot (*Henckera parviflora*), blue bunch wheatgrass (*Agropyron spicatum*), and sedge (*Carex douglasii*).

It may be noted that of the 10 plants showing greatest foliage damage only 4 appear among the 10 showing greatest flower and seed damage. Many of the plants heavily damaged early in the season lived to produce flowers and seeds. Only one species, *Dodocatheon conjugens*, showed more than 38 per cent damage, this occurring early in the season before the crickets had reached the seventh instar. It may be noted also that of the first 10 plants most heavily damaged, only 2, *Agropyron spicatum* and *Carex douglasii*, are especially valuable as forage plants, *A. spicatum* being especially valuable because of its high palatability to all classes of livestock and its resistance to grazing. As for some of the other injured plants, in regard to economic value it may be said that *Allium* (onion) furnishes green succulent herbage early in the spring, which is eaten readily by cattle and sheep. *Delphinium* (larkspur) is palatable to most stock but is known to be poisonous to cattle and is considered objectional to a range. The fleshy leaves of *Lewisia* (bitterroot) were fed upon quite extensively by crickets; in heavily infested areas nearly every plant showed more or less damage. The bitterroot has little or no forage value. *Cerastium* (mouse ear) although heavily fed upon was scarce in this range and of little importance. *Fritillaria* (yellowbell), *Dodocatheon* (shooting star), and *Viola* (violet) are short lived and have practically no forage value. *Mertensia* (bluebell) has little forage value to most livestock but is highly palatable to sheep. *Antennaria* (pussytoes) is slightly eaten by sheep but is almost worthless as forage.

The most common forms of damage were for the crickets to either eat on the leaves leaving the larger veins, which in the grasses gave a shredded appearance, or to cut the flower stem off causing the head to fall and then eat down the cut stems.

OTHER IMPORTANT INSECTS OF THE YEARS 1937-1938

PALE WESTERN CUTWORM*(Agrotis orthogonia Morr.)*

It has been pointed out in previous reports that the abundance of this pest is directly correlated with the rainfall in May and June of the preceding year. Annually an examination of the weather records for the State is made and the possibility of outbreaks of this pest is ascertained. With this information available it is possible to alter farming practices so as to practically eliminate injury the following year.

The pale western cutworm lays its eggs, approximately between August 15th and September 15th, in worked soil which is without a crust. Therefore, a field which is to be planted to wheat the following season should not be worked between these two dates. Further, Seamans¹ has shown that there is a possibility of eliminating these insects in the spring from infested fields. He has shown that the newly hatched larvae feed on the surface for a period in the spring before going into the ground. They are dependent on green food. Further, they may live for some time without food provided they have not eaten, but once they have taken food they starve quickly when it is not available to them. On the basis of these observations he suggests that fields, in which infestations are expected to appear, be allowed to green slightly in the spring so that the newly hatched larvae may have a chance to feed. The fields then should be cultivated in such a way that no growing plants appear above the surface of the soil for *at least 5 days*. Seeding may then follow and there is a high probability that most of the little larvae will have starved before green vegetation again appears.

Fortunately the weather experienced during the spring of 1938 indicates that injury from pale western cutworm is not likely to occur anywhere in Montana in 1939.

ARMY WORM*(Cirphis unipunctata Haw.)*

True army worms have been taken in Montana at Hardin, Havre, Hamilton, Waterloo, Malta, Miles City, Bozeman, Three

¹Seamans, H. L., Scientific Agriculture, Vol. 17, No. 10: 612-615, June, 1937.

Forks, and Sidney, indicating a general distribution throughout the State. They have appeared in outbreak numbers, however, only twice, first in Big Horn County in 1915, and second in an area centering about Sidney in 1937.

The pest was noticed first in the Sidney area on about the 5th of July, 1937. Some time before, the adults had been seen flying in considerable numbers. The caterpillars hide during the most of the day beneath clods, matted vegetation, and other pro-



Figure 8.—Army worms (*Cirphis unipunctata* Haw.) at the edge of an irrigation ditch, Richland County, 1937.

tection, coming out toward the middle of the afternoon. They take bait readily in the afternoon when they start to feed.

The methods of control used in the Sidney area in 1937 were:

1. Poison bait spread about 4 p. m. This bait consisted of the following ingredients:

Bran	100 lbs.
Water	12 gals.
Cane molasses	8 qts.
Sodium arsenite	4 lbs.

Comparative tests were run to discover whether the addition of molasses was essential. Although the experiments were insufficient to furnish definite conclusions, the indications were that the addition of molasses was desirable.

2. Where irrigation water was available, a small stream of water running through the ditches served as an excellent barrier.
3. Where water was not available, steep-sided ditches which were kept dusty by dragging a log through them proved good barriers, largely stopping migrations of worms.

SAY'S PLANT BUG

(*Chlorochroa sayi* Stal.)

While not so abundant this past season as in some previous years, this pest continued to injure wheat more or less in the Triangle Area north of Great Falls. Information is not available as to the total loss suffered in the State during the past biennium. It was estimated that there was a 3 per cent injury to wheat kernels on one farm near Big Sandy. Say's plant bugs were extremely abundant at the North Montana Branch Experiment Station at Havre the last week in July. An examination of range areas was made in the vicinity of the Station at that time and a few bugs were found in areas where the range was poor and Russian thistles and tumbling mustard were invaders. They were extremely rare in these situations, however.

Say's plant bug is most abundant in the spring in weedy fields where the nymphs feed to a large extent on the above weeds. Later in the season they migrate into wheat fields. The present infestation in Montana has just passed its sixth year and shows little tendency to disappear—in fact, large populations have been encountered as far east as Rosebud County and the vicinity of Fallon in Prairie County. It may be that the continuance of the pest in the State is in part at least the result of large acreages of abandoned crop land.

Investigations are under way at the North Montana Branch Station to discover if the shortening of the Russian thistle-tumbling mustard period of the reversion cycle by the planting of abandoned crop land to crested wheatgrass will affect plant bug populations.

SUGAR BEET WEBWORM
(*Loxostege sticticalis* L.)

The outbreak of sugar beet webworms in 1938 was the heaviest since the state-wide infestation of 1932. In many respects it could be classified as a more severe outbreak than the one in 1932. While most of the damage this year was confined to the Flathead and Bitterroot valleys and an area around Great Falls, in many cases beets were entirely destroyed, which was

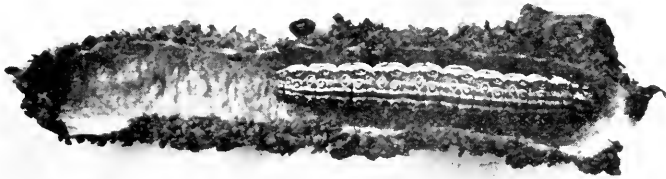


Figure 9.—Sugar beet webworm in case.

not the case in 1932. Usually in a moderate outbreak the beets are defoliated, but in time new leaves are produced; thus the damage is due to delaying the growth of the plant. In most cases a lighter crop of beets is produced following such an infestation. No data are available as yet to show the effect of feeding on the sugar content of the beet. In many cases this year both, in the Flathead and Bitterroot valleys the beets were entirely destroyed by the worms eating the crown out of the plant. In some fields entire areas were destroyed in this manner, while in others only occasional beets were entirely destroyed.

Contrary to the general rule, most of the eggs were deposited on the plants in the field rather than on bordering weed patches. This may be accounted for by the fact that the adults did not emerge until much later this year, and considerable foliage was present in the beet fields at the time they were

ready to lay eggs. There was a very light second generation.

None of the commonly recommended insecticides proved of much value in controlling the worms when they were present in large numbers.

As a rule only 2 to 5 per cent of the first generation enter the prepupal stage, but a survey made this year showed that from 45 to 50 per cent of the first generation entered this stage. The reason for this large percentage entering the prepupal stage is not known. However, many European workers have noted that such a condition generally precedes a severe outbreak. On this basis, providing conditions are favorable for the production of a high percentage of fertility among females in the spring of 1939, a rather severe outbreak of this insect may be expected.

CUCUMBER BEETLE

(*Diabrotica vittata* Fab.)

This species has long been recognized as the worst pest of cucurbits throughout America east of the Rocky Mountains. A few specimens were collected in 1932 from Custer County. During the 1938 season the beetles were very abundant in the truck-farming areas of Yellowstone County. They were also sent in for identification from Daniels and Roosevelt counties.

The adult beetles are about 1/5 inch long, with three black stripes down the back separated by wider stripes of bright yellow. They eat irregular holes in the leaves and flowers of cucumbers, squash, melons, and pumpkins. The larvae live in the soil and may damage the roots, although this type of injury has not been noted in the Montana infestations. In some parts of the country the adults carry a serious disease of cucurbits called bacterial wilt. Up to the present this disease has not appeared in association with the beetles in Montana.

Cucumber plants are attacked as soon as they appear above ground by beetles which have overwintered in trash. The most successful control is a repellent and poisonous dust consisting of one part calcium arsenate and twenty parts burned gypsum or land plaster which should be thoroughly mixed and dusted over the plants. The plants should be kept covered with this dust from the time they appear above ground in the spring until the first generation of beetles has disappeared.

CODLING MOTH*(Carpocapsa pomonella L.)*

For the past 2 years, bait traps have been used in the Bitterroot Valley for timing the sprays for the codling moth. During the 1937 season the moths were few throughout the most of the Valley, being most abundant northeast of Stevensville. Here the largest number collected from one trap at one inspection was 13. Cover sprays were timed by these trap collections by many of the growers. In 1938 there was a pronounced increase in trap collections. This increase was rather general, at least from west of Hamilton to Stevensville where the greatest



Figure 10.—Codling moth bait trap, Bitterroot Valley, 1937.

concentration again occurred. Here the maximum number of moths collected from one trap at one inspection was 54. Populations indicated by the magnitude of some of the collections of this year are of considerable importance to apple growers.

By means of the traps it is not only possible to time cover sprays, but comparisons may be made, from year to year, as to the upward or downward trend in codling moth populations.

POTATO PSYLLID

(*Paratrioza cockerelli* Sulc.)

The Potato psyllid (also called the tomato psyllid) was generally present throughout Montana in 1938. This pest appeared on both tomatoes and potatoes, but on the latter a "purple-top" disease caused by the insects greatly increased the damage. Potatoes, especially early varieties, were seriously affected by



Figure 11.—Psyllid nymphs on tomato leaf. Notice the eggs on the edge of the leaf. Approximately 6 times natural size.

the "purple-top", and produced very small tubers which in many cases did not justify the cost of digging.

The adult potato psyllids are about 1/16 of an inch long and have stout hind legs which enable them to jump when disturbed. They are sometimes called "jumping plant-lice." The females lay tiny oval, orange eggs which are supported on short stalks. Each female may deposit 300 or more eggs. The eggs hatch into tiny, scale-like, wingless nymphs, which feed on the plants, moult five times at 3 or 4-day intervals, and emerge as winged adults. There may be several generations during the summer season.

Experiments carried on during the past season indicate that young psyllid nymphs are easily killed by a lime-sulphur spray, or by various sulphur dusts, but the older nymphs and the adults are more resistant to the action of these insecticides. The use of the standard lime-sulphur spray is therefore successful only when the following conditions are met:

- a) Spray must be of the proper strength (1 gal. 33° Baume' lime-sulphur to 40 gallons of water, or equivalent strength).
- b) Spray must be forcefully applied to the under surface of foliage.
- c) Plants must be sprayed early in the season, before the nymphs have had a chance to produce the "purple-top" disease.
- d) Most of the insects should be in the younger nymphal stages, since the older nymphs and adults are not easily killed.

Considerable spraying was carried out by growers in Yellowstone County, but the "purple-top" disease was already too far advanced to permit recovery of the plants.

GRASS PLANT BUGS

(*Labops hesperius* Uhl. and *Conostethus* n. sp.)

In the spring of 1936 two species of plant bugs were noticed attacking range grasses on the Crow Indian Reservation. In the spring of 1938 these pests were again abundant and some invasion of winter wheat occurred east of Crow Agency and south

of Hardin in Big Horn County. Specimens were collected and sent to Dr. H. H. Knight who identified them. The Labops was much more common in wheat than was the Conostethus. Injury was typical and consisted of mottling of the leaves. Where feeding was intense there was a tendency for the leaves to curl longitudinally and wither. The height of the injury to wheat occurred approximately May 24, 1938, after which time the number of bugs decreased and the wheat, which was growing vigorously, outstripped the injury.

Range grasses attacked were *Koeleria cristata* (L.) Pers., *Poa secunda* Presl., *Stipa comata* Trin. and Rupt., *Stipa* (?) *williamsi* Scribn. and a species which is probably a *Hordeum*.

LEAF FOLDING SAWFLY

(*Pontania bozemani* Cooley)

Larvae of this insect, prevalent in 1924, were again observed in numbers, folding the edges of cottonwood leaves. Similar damage has been noted as far north as Swift Current, Saskatchewan.

ALPINE ROCK CRAWLER

(*Grylloblatta campodeiformis* Walk.)

Several new collection records, all in Gallatin County, have accumulated for this alpine insect. The first Montana specimens were taken in the Gallatin Range (1936), in southern Gallatin County. Many more specimens have been found at several points in the Bridger Mountains, about 20 miles from Bozeman. Although formerly considered quite rare, this species is now readily found at certain seasons of the year in favorable localities. A recent intensive survey of one area covering 120 square yards yielded 64 specimens.

MAPLE TWIG BORER

(*Proteoteras aesculana* Riley)

Specimens of this insect, the first reported to the Montana Agricultural Experiment Station, were reared from specimens collected in Billings, in July, 1937. They were determined by J. McDunnough.

WOOLLY ELM APHIS

(*Eriosoma americanum* Riley)

This plant louse has been extremely abundant in Montana during the past 2 years. In some areas it has been the limiting factor in the planting of American elms as shade trees. It attacks the elms in the spring, curling and distorting the leaves, and producing honey dew in quantities. In June a winged generation appears and the insects leave the elm leaves and go to the roots of Juneberry. In the autumn they produce other winged forms which migrate back to elms and deposit the overwintering eggs. On September 15th and 16th, 1938, the returning migrants were clustering by the millions on the bark of elm trees in Terry and Malta.

Unless there are hosts other than the Juneberry, the elimination of this alternate host should control this pest. Practically, however, if not impossible, it certainly is not feasible to control this insect in this manner. A thorough dormant spray consisting of a 3 or 4 per cent oil emulsion has given fair results by destroying the overwintering eggs.

TOMATO WORM

(*Protoparce sexta* Johanssen)

It is probable that this pest of tomatoes has occurred in Montana for some time. The first authentic records for Montana, however, were obtained during the summer of 1938. One individual was received from Beaverhead County, and a number of the worms were collected from tomato vines at Three Forks on August 30, 1938.

In gardens, hand picking is the best means of control. In large plantings, dusting with lead arsenate at the rate of five pounds per acre has been recommended in other parts of the country. No dusting should be done for at least 10 days before the tomatoes start to ripen.

LITTLE EARWIG

(*Labia minor* Linnaeus)

This tiny earwig was first collected in Montana at Bozeman, on May 31, 1914. It was not collected again until September 7, 1938, when one specimen was taken in the North Cottonwood Canyon, Gallatin County, while sweeping for grasshoppers.

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