The grasshopper campaigns of 1917-1924 : entomology at war
by Richard Wojtowicz

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts in History
Montana State University

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Signature Richard J. Wojtowicz

Date 18 July 1989

To Dianna, my spouse of infinite patience;
Lottie and Joseph, my parents;
John, my entomologist brother;
Pierce Mullen, Billy G. Smith, and Robert Rydell,
my Graduate Committee.

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ABSTRACT

Montana experienced the most destructive grasshopper outbreaks since 1903 during the period 1917 through 1924. Intervening years of agriculturally favorable weather, cheap land, good market prices, and few insect and disease problems encouraged many would be farmers to move into the state.

From 1917 through 1924, the Montana State Entomologist and associates in entomology at the federal level intervened decisively to stave off ruin for many Montana farmers. Deploying a variety of techniques they were able to prevent losses which would have driven some farmers into economic ruin. Data indicate that without their efforts greater economic loss would have occurred. Calculations of savings versus expenditures consistently established a positive balance in favor of scientific entomology. In this period efforts on the part of the Montana State entomological team made an important difference and contributed to the survival of state agriculture.

CHAPTER 1

INTRODUCTION

The consequences of Sarajevo affected the United States in various ways, though most Americans could not even pronounce the city's name or point it out on a map. For three years American business, industry, and agriculture had profited from the carnage along the shifting fronts of Europe and Asia Minor. Food and hardware had to come from somewhere and the isolationist U.S. served as a horn of plenty for armies and nations preoccupied with killing. But 1917 brought America into a struggle no longer confined to "over there." The United States now became the arsenal of democracy, and the cornucopia for a starving world.

At the same time an ancient enemy, quiescent for nearly a decade and a half, suddenly multiplied its numbers and again began ravishing the fruits of field and range. This enemy spoke no decipherable language and held no arguable ideologies. Evolutionally, they lived closer to the genesis of life on earth than their adversary, Homo sapiens, and possessed a less adaptive intelligence. In spite of occupying this lower rung on the chain of being, the humble grasshopper proved its mettle in the Montana

resurgent outbreaks between 1917 and 1924. Years of setbacks and partial victories faced the state entomological forces headquartered in Bozeman, Montana, under the overall supervision and direction of the State Entomologist, Robert A. Cooley.[1]

From 1917 through 1924, Montana agriculture experienced its worst grasshopper infestations since the turn of the century. Mild weather had encouraged the settlement of marginal lands in the state and engendered hopes for prosperity. But when drought conditions returned, beginning in 1917, many farmers confronted decreased productivity, low profits, high prices for goods, and spreading grasshopper outbreaks. Marginal lands also meant a tenuous chance for economic survival. Banks and other businesses, dependent on Montana agriculture, failed along with the farms. Grasshopper destruction grew steadily worse from 1917 through 1920, but paled in comparison with its intensities from 1921 through 1924. An individualist and often non-cooperative spirit among many Montana farmers gave way to the dictates of a situation which no person could hope to fight alone.

Cooley had developed an organization to meet insect pest crises and responded to the grasshopper outbreaks by putting it into action. He nurtured his organization to meet the call for efficient control of insect depredations on Montana agriculture. Financial, political, social, and

scientific obstacles sometimes constrained and set back the evolution of the entomology organization. But as the scientific basis of insect control allowed them to provide increasingly reliable control measures, Cooley and his compatriots created a social, political, and scientific mechanism to accomplish their goals. The grasshopper outbreaks of 1917 through 1924 provided a stimulus for further maturation of this entomology organization.[2]

About 160 species of grasshoppers occupied the various habitats of Montana. However, only a half dozen of these species caused significant agricultural damage to range and croplands during outbreak years. Four of this half dozen predominated in reports of the Montana Experiment Station and the State Entomologist's Office. In order to appreciate some of the various actors in this drama, one must first examine pertinent facts concerning the general biology and ethology of grasshoppers and several specific points about the handful of harmful Montana species.[3]

The climate of Montana generally allows grasshoppers only one complete life cycle (generation) per year. This cycle passes from the egg, through four to six nymphal stages (depending on the species), to the adult, then full circle again to the egg. This limited lifespan still provides sufficient time for the gradual growth of successive grasshopper generations until ideal weather, food

availability and other environmental factors enable them to reach outbreak proportions.

Adult grasshoppers deposit their eggs from midsummer through early fall at a depth of from one to two inches in the soil. A secretion, accompanying egg laying, glues these egg clusters and particles of soil together to form egg pods, providing protection from some predation and inclement weather. The various grasshopper species lay different numbers of eggs per pod and "choose" different types of egg laying sites. The majority of females lay from 200 to 400 eggs in areas which evolutionally have ensured high nymphal survival rates, usually around grass root zones and in undisturbed soils. Undisturbed, and usually weedy, areas like roadsides, headlands, rangeland and field margins provide ideal conditions for the success of grasshopper reproduction.[4]

During the autumn, eggs begin their initial development, but soon the chill of winter checks their progress as the cold soil imposes a state of suspended animation upon them. Protected by their pod structure and the insulating soil during the winter, the eggs hatch over a four-to-six-week spring period after the soil warms to 60° F. and precipitation stimulates egg growth. Larvae often hatch en masse after a soaking rain, although the rate and time of hatching depends in large part on the particular species involved. The stage of development reached during the fall

influences the variability in the time of hatching as well. Most eggs hatch between mid-May and mid-June.[5]

When the nymphs emerge, they begin consuming nearby green vegetation. However, grasshoppers eat plants selectively (again falling out according to species)--unless scarcity of their preferred diet leads them to feed on less desirable flora. Undeveloped wings, called wing pads, and a smaller overall body size distinguish nymphs from adult grasshoppers. As noted earlier, nymphs pass through four to six instars or stages, the length of which depends on weather conditions, food availability and other factors for growth. The most rapid development occurs under warm but dry conditions. Molting enables nymphs to pass from instar to instar as they grow and develop. During molting, the cuticle or outer skin splits along suture lines on the head and thorax, allowing the nymph to wriggle out of the old shell and expand its replacement skin.[6]

The grasshopper reaches its adult stage upon completion of the final molt. From late July through October adult grasshoppers emerge with fully developed wings and attain sexual maturity within two weeks. After mating, the females lay eggs for about three weeks. Adults feed ravenously and may migrate in search of food when population pressures mount and food supplies decline at their present location. Both nymphal and adult populations move about from field margins into fields and between fields. The

adult stage, with its greater mobility, represents an opportunity for increased crop invasion and destruction. Additionally, the mature grasshopper better withstands the onslaughts of disease, predation, weather, and chemical treatments.[7]

Grasshoppers particularly savor small grains, although they consume corn, alfalfa, clover, soybeans, flax, and other crops. Grasshoppers cause damage mainly through seedling destruction and progressive defoliation of older vegetation. They may injure crops beyond the estimations set by merely counting the numbers of invading pests by feeding on particularly susceptible parts of a plant. Shattered kernels and severed heads of small grains testify to such attacks. The failure of vegetable and legume seed crops demonstrates the grasshoppers taste for plant blossoms. Vegetation which provides grazing for domestic and wild animals suffers similar depredations during grasshopper outbreaks. Defoliation damage or immediate feeding destruction of the plant makes it unavailable for other feeders. Twenty-five to 75 grasshoppers per square yard, considered a heavy infestation, may result in the removal of all vegetation in an area as the grasshoppers indulge in a feeding frenzy, compounded by sheer numbers. Wind and water erosion may soon follow the complete denudation of the soil surface, bringing about "dust bowl" conditions similar to those in the U.S. during the 1930s.[8]

Predators and parasites serve major roles in controlling the populations of grasshoppers and moderating or ending serious outbreaks. Currently many entomologists believe that grasshoppers reach crisis proportions due more to the conjunction of favorable weather and bountiful food supplies than the failure of moderators of the ecosystem to fulfill their "missions."[9] However, once grasshoppers reach numbers well beyond the capacities of predators and parasites to control them, these elements of the ecosystem have little impact on controlling an outbreak.

While avoiding the technicalities of a detailed morphological description of the four major species of grasshoppers involved in the Montana outbreaks between 1917 and 1924, some points about each species require a brief review. The importance of these selected biological and ethological facts will become more evident as the grasshopper control campaigns and the entomologists' forays into predictive science for the years following major infestations are considered.

The adult Camnula pellucida (Scudder)--known commonly as the Roadside, Warrior, Yellow-Winged, or Clear-Winged grasshopper--sports a yellow to brown body and front wings. Large brown spots further differentiate this insect from the other three grasshoppers under consideration. The entomologists and agriculturalists of British Columbia referred to C. pellucida as the Roadside grasshopper due to

its habit of ovipositing (egg-laying) in the undisturbed soils of bare, dry roadsides. This grasshopper also commonly uses exposed, particularly overgrazed open ranges. Thus, human actions producing near ideal reproductive environments largely contributes to the rise of invasive populations of C. pellucida.[10]

C. pellucida congregates in limited areas if hatching occurs in critical threshold numbers. This concentration elicits changes in behavior during the first two instars, whereby the insect becomes increasingly gregarious and demonstrates migratory tendencies. C. pellucida also may exhibit the effects of these population pressures on behavior during later stages of development. The change from their normal solitary demeanor, when individuals tend not to wander, inspired some western states, including Montana, to refer to C. pellucida as the "warrior grasshopper." Under the aforementioned influence of overcrowding on their behavior, the adults may fly in diffuse swarms for short distances and females may travel long distances to communally oviposit in sod to create egg beds. Entomologists consider C. pellucida partly gregarious. As "hoppers" or nymphs this species prefers feeding on Gramineae (Poaceae), which include grain crops. C. pellucida is the major pest of pasture and rangeland.[11]

A second major grasshopper pest of the early twentieth century in Montana, the greenish yellow or olive Melanoplus

bivittatus (Say) or the Two-Striped grasshopper, receives its name from two yellow stripes extending from its head to wing tips. Assuring a sufficient food supply for its progeny and itself, the female regularly lays its eggs in sod or weedy terrain adjacent to favored crops. Confined mainly to the arid West, M. bivittatus concentrates on irrigated lands. Seeking humidity, the Two-Striped grasshopper frequents lowlands, woodland margins, and shaded mountain slopes.[12]

Cultivated habitats also attract M. bivittatus. They tend to select land which the agriculturalist has cultivated and then abandoned for several seasons. Like C. pellucida, the Two-Striped grasshopper prefers ovipositing in compacted soils. On the other hand, M. bivittatus often lays eggs in stubble which farmers leave after harvesting grain crops. Rapidly increasing in numbers when the conjunction of favorable circumstances permit it, the Two-Striped grasshopper devours cereal and other crops, including alfalfa.[13]

Melanoplus mexicanus atlanis (Riley),[14] the Lesser Migratory grasshopper, thrives in bunch-grass prairie and in open grasslands of short grass and compact sandy soils--a favorite environment for egg laying. However, the adaptability of M. m. atlanis enables it to exploit a wide variety of habitats. Adults characteristically possess reddish-brown, or dark olivaceous bodies with a black

pattern. Hoppers and adults tend to display solitary behavior. If overcrowding occurs, the adults may form loose swarms and migrate when the swarms reach a critical density. Females oviposit in grain stubble, alfalfa, weedy idle land and rangeland.[15]

Considered extremely dangerous to the health of agriculture due to its migratory behavior under outbreak conditions, the Lesser Migratory grasshopper repeatedly bore comparison to Melanoplus spretus (Walsh), the Rocky Mountain Locust. During the 1880's M. spretus devastated the farmlands of the West and mid-West, exceeding anything settlers had experienced in the Eastern United States or Europe. Only the locust plagues of Africa and the Middle East provided points for analogy. American and European entomologists speculated upon M. m. atlanis as an environmentally induced disguise for M. spretus. Physical differences appeared "small and relative" and observers demonstrated the instability of some characteristics. Systematists felt that M. spretus, like the locust found elsewhere in the world, represented the swarming phase of the same insect of which M. m. atlanis embodied the solitary state. According to the continued argument, drastic changes in the environment brought about by more extensive agricultural development furnished the major explanation for M. m. atlanis no longer emerging in the M. spretus migratory phase. Regularly in the midst of another M. m. atlanis

outbreak, speculation proliferated as to the interchangeability of the Rocky Mountain Locust and the Lesser Migratory grasshopper as species.[16]

Aulocara elliotti (Thomas), the Bigheaded grasshopper, caused much less grief and destruction between 1917 and 1924 then did the three previously described grasshoppers. However, it materialized often enough in contemporary documents to deserve mention. With a general grayish brown body shade, A. elliotti adults display a flash of deep blue on the hind tibia as they propel themselves forward. The disproportionately large head relative to the rest of its body accounts for the common name, Bigheaded grasshopper. The female oviposits between range plants in bare spaces. Normally feeding on rangeland grasses, A. elliotti sometimes attacks small grains and enters the fray with the other more persistent species.[17]

These enemies of agriculture reduced the independence of farmers both financially and intellectually. Rugged individualism in the face of such destructive forces invariably led only to failure, despair and abandonment of a life's work. It did little good to fight the pests in one's own field if neighbors did nothing in theirs, since grasshoppers moved so easily from field to field, especially at the adult winged stage. Proper organization and treatment required outside expertise.[18] Montana's entomo-

logical organization served this purpose for the state's agricultural community.

This organization consisted of Montana State College's Department of Entomology and Zoology (hereafter referred to as the Department of Entomology), the Experiment Station, and the State Entomologist's Office--all headquartered in Bozeman. The Eighth Montana Legislative Assembly appointed Cooley, as Experiment Station entomologist and head of the Department of Zoology and Entomology, the State Entomologist in 1903.[19] This network involved the Extension Service through its communication with and use of the Service's county agents.[20] The Montana Experiment Station developed insect control methods through research and experimentation carried on within the scope of the Department of Entomology's duties--information which the State Entomologist supplied to agents, farmers, and the general public. After collecting information on conditions around the state, the State Entomologist communicated with county agents and other leaders to organize campaigns for battling insect outbreaks and keep them abreast of prices for and sources of necessary supplies. Cooley assigned most of these duties to the Assistant State Entomologist. The organization also cooperated closely with the newly instituted State Department of Agriculture as per the Session Laws of 1921.[21]

The State Entomologist's Office encompassed many duties. Cooley confronted emergency insect situations and assisted in the prevention of a large number of less important losses." As the sounding board for problems in Montana, he kept the Department of Entomology informed as to the needs for particular lines of research. By 1911, the State Entomologist served on the State Board of Entomology as a member and secretary. This State Board oversaw anything affecting "the health of man and domestic animals." Neither the State Entomologist nor the State Board of Entomology positions provided compensation beyond Cooley's salary in the Department of Entomology, except for traveling, laboratory, and office expenses, and the salary of an assistant. The County Insect Pest Law of 1921 further required the State Entomologist to investigate any reported insect infestations to determine if a county should organize a campaign and use the law as a funding mechanism. The Insecticide and Fungicide Act of the same year required Cooley to check agricultural poison shipments for adulteration and mislabeling while the Pest and Plant Quarantine Law placed additional burdens on the office. Finally, the State Entomologist published an annual report covering insect problems of the year, including new insects found in Montana.[22] When an insect crisis struck--like the grasshopper outbreaks--Cooley neglected many of his less immediate responsibilities.

Cooley took great pride in this entomological organization. He pointed out that other states had separated the State Entomologist's Office from other duties and educational institutions. But in Montana, for the sake of efficiency and economy, the State Entomologist spread his duties among the Experiment Station, the Department of Entomology, and his own office. This arrangement avoided the duplication of the Entomology Department's 2,000 volume library, its 90,000 specimen insect collection, microscopes, cameras, various other equipment, and office spaces.[23] In his final report for the 1917-1924 grasshopper period, Cooley reflected on this organization, concluding that,

> The triangular combination of a centralized state office, a county pest act, and a system of county agents, provides an effective organization for this service and has resulted in the saving of millions of dollars to the farmers of the state of Montana.[24]

These "millions of dollars" would mean salvation for many Montana farmers.

The state entomological organization of Montana--led by R. A. Cooley in his capacities as State Entomologist, head of the Entomology and Zoology Department of Montana State College and its division in the Montana Experiment Station at Bozeman, and including the U.S.D.A. Bureau of Entomology in Billings and the Extension Service--played the primary role in the control and final eradication of grasshoppers in Montana between 1917 and 1924. Natural

controls, including weather, parasites, predators, and disease, rapidly lost their dominance over the grasshoppers and left the tasks of grasshopper population limitation to human interventions. As natural controls reached a point of negligibility during these years, the state entomological organization stepped into the breach to assure the ascendancy of Montana agriculture. Furthermore, through these interventions, Montana's entomological organization ensured the survival of many Montana farmers who otherwise would have failed.

The thesis is organized in a chronological fashion. The next chapter describes the slow increase in grasshopper troubles from 1917 through 1920 and the gradual dominance of human intervention over the grasshoppers as natural controls failed. The first inklings of major trouble appeared in 1917, followed by 1918, a year of respite. But 1919 produced another reversal and increased problems. By 1920 Cooley and his organization planned for continued problems and the need for a strengthened and fully funded effort.

Chapter 3 deals with the clear failure of natural controls to keep grasshopper populations within bounds during 1921. Though predators and parasites appeared in abundance, they could not deal with the abnormal masses of grasshoppers. In response, the State Entomologist's Office turned increasingly to the poison bait method of control,

improving the formula and the timing of treatments for greater efficiencies. When the difficulties of funding became apparent, passage of the County Insect Pest Law of 1921 provided a mechanism for purchasing supplies and equipment for the grasshopper campaigns. The State Entomologist began pressing for increased funding when levels were too low to meet insect emergencies and gain maximum savings for farmers.

Chapter 4 considers 1922--the worst of the eight-year period. With increased pressures on personnel and funds, counties faced legal spending limitations. Meanwhile, Cooley stressed the inadequacies in funding for personnel, office expenses, and traveling necessary for his own office. Counties decried the weaknesses in the funding procedures of the County Insect Pest Law and joined with Cooley in advocating changes. The State Entomologist's Office expanded the scope of survey work to provide information to farmers and the legislature of 1923.

Chapter 5 discusses the mixed news for state entomology forces. The 1923 state legislature slashed the State Entomologist's Fund from $3900 to $450 because of a technicality in the 1903 law which originally had authorized the allocations. As a result, Cooley freed A. L. Strand of his duties as Assistant State Entomologist and depended on correspondence and federal personnel to control the outbreaks. Though still a bad year, 1923 had fewer and less

extensive outbreaks than 1922. The year ended with the Grasshopper Conference held in Great Falls during August. Its resolution committee developed plans to approach the federal government for assistance.

The final chapter addresses 1924, the last year of the grasshopper outbreak. With inadequate allocations from the legislature, Cooley turned to the private sector for assistance. Montana banks supplied a revolving fund for his office to be repaid by legislative allocations during each session. Railroads allowed a half-rate for grasshopper bait supplies shipped along their lines. Still, no one would accept the position of Assistant State Entomologist because of the precarious nature of funding. Despite these and other difficulties, Montana's entomologists helped many farmers to survive the insect plague.

NOTES

1. Robert A. Cooley received his degree from Massachusetts State College. His official positions at Montana State College included: Professor, Zoology and Entomology, 1899-1923; Experiment Station Zoology and Entomology, 1899-1906; Experiment Station Entomologist, 1906-1937; Professor, Entomology, 1923-1931; and Consulting Professor, Entomology, 1931-1937. He also served as the head of the Zoology and Entomology Department, the Entomology and Zoology Department, and the Entomology Department until 1930, and as a member of the State Board of Entomology and the State Entomologist during the period 1917 to 1924.

2. A. Hunter Dupree, Science in the Federal Government: A History of Policies and Activities (Baltimore: The Johns Hopkins University Press, 1985), p. 158; A detailed description of what the state entomology entailed follows particulars on the major grasshopper species involved in the outbreaks.

3. Bob Gillespie and Ron Wight, Crop & Rangeland Grasshopper Management Guide, Tech Bulletin 85-2 (Helena, MT: Montana Department of Agriculture, [n.d.], p. 3.

4. Gillespie and Wight, Grasshopper Management Guide, p. 6; Robert E. Pfadt, "Insect Pests of Small Grains," in Robert E. Pfadt, ed., Fundamentals of Applied Entomology, 4th ed. (New York: Macmillan Publishing Company, 1985), p. 257.

5. Gillespie and Wight, Grasshopper Management Guide, pp. 6-7; Pfadt, "Insect Pests," in Pfadt, ed., Fundamentals, p. 259; B. P. Uvarov, Locusts and Grasshoppers: A Handbook for Their Study and Control (London: The Imperial Bureau of Entomology, 1928), p. 39.

6. Pfadt, "Insect Pests," in Pfadt, ed., Fundamentals, p. 259; Gillespie and Wight, Grasshopper Management Guide, p. 4.

7. Gillespie and Wight, Grasshopper Management Guide, p. 4; Pfadt, "Insect Pests," in Pfadt, ed., Fundamentals, p. 259.

8. Pfadt, "Insect Pests," in Pfadt, ed., Fundamentals, p. 255.

9. Ibid., p. 260.

10. Ibid., p. 258; Uvarov, Locusts and Grasshoppers, p. 293.

11. Uvarov, Locusts and Grasshoppers, p. 293; Pfadt, "Insect Pests," p. 259.

12. Pfadt, "Insect Pests," pp. 258, 259; Uvarov, Locusts and Grasshoppers, pp. 299-300.

13. Uvarov, Locusts and Grasshoppers, pp. 299-300.

14. Entomologists often shortened this trinomial designation for the Lesser Migratory grasshopper to Melanoplus atlanis.

15. Uvarov, Locusts and Grasshoppers, pp. 294-297; Pfadt, "Insect Pests," in Pfadt, ed., Fundamentals, pp. 257, 259.

16. Uvarov, Locusts and Grasshoppers, pp. 294-297.

17. Pfadt, "Insect Pests," in Pfadt, ed., Fundamentals, pp. 257-259.

18. John T. Schlebecker, "Grasshoppers in American Agricultural History," Agricultural History 27, no. 3 (July 1953): pp. 92-93.

19. In 1917 the Zoology and Entomology Department entered its eight year stint as the Entomology and Zoology Department. When this aggregate of academics occupied Lewis Hall upon its completion in 1924, Entomology and Zoology split asunder. R. A. Cooley headed the new Department of Entomology and Professor Spaulding took charge of Zoology. These years coincide with the grasshopper outbreak. See "History of the Department of Zoology & Entomology, Montana State University," pp. 5-6, File "Entomology and Zoology Research," Drawer "Departmental Histories," Montana State University Archives, Bozeman, Montana.

20. The Department of Entomology had no division within the Extension Service as it did in the Experiment Station. See "Experiment Station Report of the Entomology Department," [n.d.], File "Summary of Work Reports, 1920-1925," Acc. 00016, Box 1 of 15, Montana State University Archives, Bozeman, Montana.

21. F. B. Linfield, "Twenty-Fifth Annual Report For the Fiscal Year Ending June 30th, 1918," February 1919, p. 159, in Agricultural Experiment Station, Montana: Bulletins and Circulars, vol. 18, Montana State University Archives, Bozeman, Montana; "State Organization for the Control of Insect Pests," in "Report of Grasshopper Conference Held at Great Falls, Montana, August 32, 1923," File "Grasshopper Conference, Great Falls, 1923," Acc. 00016, Box 6 of 15, Montana State University Archives, Bozeman, Montana; A. L. Strand to Dorothy Lampen, 26 February 1921, File "Insect Control (General) 1921-1922, 1930-1949," Acc. 00016, Box 4 of 15, Montana State University Archives, Bozeman, Montana; "Experiment Station Report of the Entomology Department," [n.d.]; R. A. Cooley, "Montana Insect Pests for 1923 and 1924: Being the Twentieth Report of the State Entomologist of Montana," January 1925, Bulletin 170, p. 10, in Agricultural Experiment Station, Montana: Bulletins and Circulars, vol. 21, Montana State University Archives, Bozeman, Montana.

22. Cooley, "Montana Insect Pests for 1923 and 1924," Bulletin 170, pp. 7-10; R. A. Cooley, "Fourteenth Annual Report of the State Entomologist of Montana," December 1916, Bulletin 112, p. 61, 62, in Agricultural Experiment Station, Montana: Bulletins and Circulars, vol. 16, Montana State University Archives, Bozeman, Montana; Linfield, "Twenty-Fifth Annual Report," pp. 134, 162; R. A. Cooley, "Eighteenth Annual Report of the State Entomologist of Montana," January 1921, Bulletin 139, pp. 11-12, in Agricultural Experiment Station, Montana: Bulletins and Circulars, vol. 19, Montana State University Archives, Bozeman, Montana.

23. Cooley, "Fourteenth Annual Report," Bulletin 112, p. 61; Cooley, "Montana Insects for 1923 and 1924," Bulletin 170, p. 12; F. B. Linfield, "The Work of the Montana Experiment Station: Thirty-First Annual Report, July 1, 1923, to June 30, 1924," February 1925, p. 33, in Agricultural Experiment Station, Montana: Bulletins and Circulars, vol. 21, Montana State University Archives, Bozeman, Montana.

24. Cooley, "Montana Insects for 1923 and 1924," Bulletin 170, pp. 9-10.

CHAPTER 2

TRANSITION: NATURAL TO HUMAN CONTROLS

Events of the years 1917 to 1920 demonstrated the gradual shift from the natural suppression of grasshoppers in Montana with little active participation by state entomologists to the growing need for intervention by the State Entomologist's Office and its interwoven fabric of the state entomological organization. R. A. Cooley and his forces accepted the challenge of saving Montana agriculture from the swelling waves of voracious insects. But even after the first four protracted years of struggle, Montanans had not suffered the worst that grasshoppers could provide nor had Montana entomology won its greatest victories against this six-footed bane of farmers.

1917: Resurrection

In autumn 1916, county agents, agriculturalists, and other observers notified the State Entomologist's Office that abnormal numbers of grasshoppers had infested the Flathead Indian Reservation during the summer. Melanoplus atlanis did the most damage in scattered areas of the state "climbing the full-grown grain stalks and cutting off the heads" and slightly injuring "newly seeded winter wheat."

Montana's Assistant State Entomologist, H. L. Seamans, surveyed the area of the reports in mid-April of the following year.[1] He promptly discovered grasshopper eggs and physical remains of the previous season. Recognizing the potential for trouble, the State Entomologist's Office in Bozeman notified county agents in neighboring counties to prepare for an outbreak.[2] Cooley reconstituted the organizational machinery in 1917, which would fight the grasshoppers for the next eight years and ward off the total collapse of agriculture in Montana. Luckily, a combination of natural controls and artificial interventions directed by the State Entomologist's Office prevented major damage in 1917.

Western Montana witnessed the feared outbreak in 1917. In the opinions of farmers and the state's entomologists it suggested the grasshopper plagues of pioneer days. Below normal precipitation and abnormally high summer temperatures created ideal breeding conditions for grasshoppers. County agents reported large grasshopper concentrations in Flathead, Sanders, and Missoula Counties in a 70 mile area from Stevensville to Flathead Lake. The infestation soon spread to other parts of the state. Other large areas of trouble appeared in Cascade, Chouteau, Blaine, Phillips, Valley, Sheridan, and Richland Counties. Farmers and agents also reported damage through western Gallatin and southern Broadwater Counties. The pioneer outbreaks had

involved Melanoplus spretus, the extinct Rocky Mountain Locust, which scoured large areas clear of crops and native vegetation for a series of years in the latter half of the nineteenth century. But the twentieth-century visitation of other species, the most widespread and damaging in over twenty-five years, consumed crops and defoliated orchards and native trees. Urban dwellers also watched helplessly as vegetable plots and prized landscaping disappeared beneath hordes of hungry insects.[3]

In some areas of the infestation nearly all green vegetation served as nourishment for the armies of grasshoppers. Through the passing season and the pressures of crowding, these invaders attained their winged forms and flew to fresh feeding areas, generalizing the outbreak beyond its earlier locus. Immigration replenished the numbers of grasshoppers which control crews had not long before managed to destroy. It seemed that if only the agricultural community persevered and defeated this plague, most farmers would overcome this setback and prosper, but the weather failed to cooperate. Many crops saved by the insect control programs fell before the equally devastating drought.[4]

World food demands, exacerbated by World War I European manpower and cropland destruction, dictated increased attention to the wastage of agricultural products. As one of the guardians of agriculture in Montana, Cooley acknowl-

edged the role of entomology in general and of his office in particular in assuring the continuing supply of food and fiber. World food shortages and the fact that at least ten percent of agricultural yield fell to insect pests each year stressed the need to limit feasting by these uninvited guests.[5]

The county agents served as the major contacts for the State Entomologist's Office in accomplishing its duties in controlling insect pests. The daily field work necessary in implementing recommendations fell on the shoulders of these agents. Familiarity with conditions in their assigned areas and closer working relationships with local people positioned county agents better to assist farmers. The State Entomologist's Office sent assistants to give lectures and demonstrations of control techniques and provided current information on sources and prices of materials for poisons and other insect control supplies.[6]

Assistants from the State Entomologist's Office remained in the field for two months working with county agents and farmers. On May 30, Seamans resigned his position as Assistant State Entomologist to accept a field assistantship with the U.S. Bureau of Entomology. A. L. Strand, who graduated in the entomology curriculum of Montana State College in 1917, assumed Seamans's vacated post on June 1st.[7] To meet further demands for manpower during the crisis, Cooley employed two senior entomology

students, C. L. Corkins and Kenneth M. King. The State Entomologist Fund of $2,700 failed to meet the needs of the 1917 grasshopper outbreak and the Chancellor of the University furnished an additional $1,000 after Cooley appealed for additional funds.[8]

At the federal level, Montana enjoyed the cooperation and assistance of the Bureau of Entomology, a division of the U. S. Department of Agriculture. During June and July of 1917, C. W. Creel, the supervisor of the Forest Grove Entomological Station in Oregon, and his assistants helped the state entomological forces of Montana to battle the grasshopper menace. When farmers proved unwilling to treat their own property if vacant and public lands remained untreated, the Federal government funded treatment on some of the public lands. This action prevented much reinfestation by migrating grasshoppers.[9]

State entomologists failed to identify the species of grasshoppers in the 1917 outbreak beyond the point of the genus, Melanoplus. The Rocky Mountain Locust of fifty years earlier received the brunt of accusations since the 1917 species shared similar migratory habits and comparably large wings. Admitting to his bafflement, Cooley asserted that even if this species proved technically different from Melanoplus spretus, "there is [still] much reason to [fear] that it may be capable of quite as much damage as was done in the old days."[10]

New and old methods of grasshopper control commingled in the 1917 campaign. Local conditions and the state of the art dictated the choice of particular techniques. Major factors determining the method included the extent of the infestation, the crop type, farmer cooperation, availability of materials, and accessibility of labor and time. Approaches to attacking the problem included grasshopper-catching machines, cultural controls, poisoned bran mash, and other minor methods.[11]

With grasshopper-catching machines farmers trapped live grasshoppers for later use as poultry feed. Farmers perceived the machines as less expensive than other techniques and providing a usable byproduct. The cheaply built cage-like device measured about sixteen feet in width. Farmers drew it with a pair of horses, one on either side, through a grasshopper infested field. As the disturbed insects leapt before the advancing machinery, they struck a tin sheet attached to the front, fell into a trough and collected in a large bin area at the rear. Usable in low-growing crops, it proved unacceptable in ripening grains, corn, and well developed seed alfalfa because of the damage it caused to the vulnerable plants. Rough terrain precluded its use in many other areas.[12]

The State Entomologist's Office touted the usefulness of the catching-machine's byproduct--tons of dead grasshoppers.[13] Basing recommendations on the experiments of J. S.

McHargue of the Kentucky Experiment Station, which demonstrated the 75 percent protein rating of dried grasshoppers, Cooley's office advised farmers to take advantage of a rich resource otherwise discarded. Such protein ration stimulated chicken "egg production to the highest degree." Since prolific egg laying depressed summer markets farmers could "collect and dry grasshoppers during the summer months and feed them to poultry during the winter," thereby earning higher egg prices. Thus the farmer "[paid] for his machine, [made] a good wage for himself and team, and [prevented] grasshoppers from destroying his crops." Through the aid of the State Entomologist's Office farmers sold surpluses of dried grasshoppers to others requiring winter feed. This apparatus faded in popularity with professional entomologists and agents as they acknowledged the greater efficiencies of other methods which killed more grasshoppers or prevented them from reproducing easily. For the moment, Cooley and his entomologists recommended a combination of the catching machines and poison baits.[14]

Cultural control methods comprised another method of battling grasshopper proposed to farmers by the State Entomologist and county agents. Plowing, harrowing, disking--all classified as cultural treatments--destroyed eggs before they developed and hatched. The Montana experiment station, on the advice of Cooley and others, recommended disking the ground or working it with a spring-tooth harrow

"lengthwise, crosswise, and cornerwise" three inches down in October or November. If plowing in the late fall or early in the spring, they increased the recommended depth to six inches. In this way, entomologists hoped that the egg pods suffered breakage, scattering, and exposure to surface weathering and predation.[15]

However, state entomologists also noted the impracticality and futility of the cultural method in many Montana situations. "Large areas of dry, hilly ground, open range, and unused private or government land" prevented the use of cultural controls due to jurisdiction problems and added expenses. They provided breeding grounds during grasshopper outbreaks from which they continuously migrated onto treated lands under the right conditions. Sparse settlement of Montana tracts dictated focusing on grasshoppers at the nymphal and adult stages rather than attempting to prevent outbreaks at the egg stage on a sufficiently broad scale.[16]

In the opinions of the State Entomologist's Office, the Experiment Station, and the Department of Entomology, poisoned baits provided the most successful and promising method for controlling grasshoppers at the nymphal and adult stages. The formula for the poisoned bran mash in 1917 consisted of bran, Paris green or white arsenic, salt, cheap molasses or syrup, lemons or oranges, and water. The poisoned bran killed nymphal and adult grasshoppers and

allowed the treatment of crops susceptible to damage by the catching-machinery. But at thirty-five to fifty cents per treated acre, many farmers found the treatment too expensive in hard times. Farmers often objected to the expense and care needed to apply the poison bran properly. To alleviate part of the cost complaints, the Bozeman office suggested subscription lists for donations to insect campaigns. However, a few contributors often paid the lion's share of costs.[17]

Farmers who could afford the costs found they could spread large amounts of the poisoned mash more quickly from the rear of wagons. Often lined up alongside one another in a spirit of cooperation, the workers overlapped the spread areas of adjacent fields and covered a greater area more completely in less time. Automobiles served the same purpose as the modern equivalent of the wagons. Even with such strategies, the State Entomologist's Office advised against attempting to treat all vacant lands. Instead, Cooley and his assistants counseled farmers to find and poison the grasshoppers when they concentrated in green areas during dry periods following the spring rains. This included areas along creeks, draws, and waterholes where the vegetation thrived in moister microclimates. Through observation of the behavior of grasshoppers during various parts of the day, the state entomological authorities suggested that workers distribute the poison from three to

five in the afternoon and between daylight to eight in the morning. They noted that grasshoppers fed best after the sun had warmed them in the morning and a few hours before evening. Entomologists thus increased the bait's efficacy by making sure farmers spread it at the proper feeding times.[18]

The demands for collective action against the grasshopper infestations--especially with the poison bait method--dictated the organization of farmers and communities. The State Entomologist's Office assigned an employee to enter a troubled area first to gather information on existing conditions, grasshopper abundance, and damage. At meetings called by the county agents, farmers and other concerned citizens learned from the agent and an entomologist sent from Montana State College about the grasshopper's life history, the area's present situation, and a comparison of conditions in other districts. Committees comprised of farmers and townspeople often arranged for the purchase, mixing, and distribution of the poisoned bait.[19]

Farmers and other applicators of the poison bran mash often doubted its efficacy when they could see no immediate results. Therefore, the State Entomology Office published details on what would happen after treating an area. The poison worked slowly, taking five or six days. By the second full day, grasshoppers usually stopped feeding but continued to move about for three or four days before

dying. Observers might not find large numbers of dead grasshoppers since the poisoned ones sought damp, shaded places before dying. Birds, other animals and insects also carried dead grasshoppers off for food. The farmer had to judge the success of poisoning by the numbers of living grasshoppers remaining, though grasshoppers from adjacent untreated areas might skew the numbers and convey a false perception that the initial treatment failed. Fifty to 75% of grasshoppers died from a proper first application. A second treatment after four or five days raised the fatality rate to 80 or 90%.[20] By providing more details about what farmers should expect, officials hoped to limit discouragement and to maintain support for the program by the public.

Poisoned bran mash also served as the ideal solution to grasshopper attacks on orchards. The grasshoppers ate the leaves and bark, causing abnormal development and stunted growth. The department encouraged shaking the insects from young trees after broadcasting the poison mash on the ground. Consuming the mash before returning to the trees, the grasshoppers died within a day or two.[21]

County agents and the State Entomologist's Office constantly reminded people that the grasshopper bait contained poison--either arsenic or Paris green. During the 1917 campaign, many horses, hogs, and poultry consumed the bran mash and died. After investigation, the State Entomologist

decided that carelessness contributed to all the accidents. Seven hogs died because of a mixup in feed sacks on one farm. On others, horses nosed open tied sacks of poison mash and feasted on their last meals.[22]

Other methods, not requiring community organization or specialized equipment, served the needs of some agriculturalists. Grasshopper swarms in weed patches, vacant city lots, and along roadsides died in controlled burns. Young hoppers gathered beneath old straw after hatching also met death by flame. Grasshopper aversion to excessively wet areas suggested the use of irrigation as a control. Finally, the state agricultural authorities believed that large flocks of turkeys and chickens consumed many grasshoppers so they encouraged poultry raising as a hedge against undue damage.[23]

No single artificial intervention gained absolute favor from Bozeman entomologists. Each approach had its uses Poison bran mash provided the best results in ripening crops and under conditions where the grasshopper catching-machine could not physically operate or would damage maturing crops. But the poison bait proved less viable under wet, cool conditions when grasshoppers slowed and fed less readily and the poison lost its potency quickly. Fire treatments succeeded against grasshoppers only in their nymphal and adult stages since they normally oviposited too deeply for farmers to kill their eggs. Cultural methods

faced the same constraints as the catching machine; irregular topography and rocky soils prevented plowing, harrowing and disking in many areas of Montana. Dry land farmers normally had no access to irrigation, so they had to depend on the other approaches. Flocks of poultry might provide farmers an agricultural alarm clock, but they quickly satisfied their avian appetites in a major grasshopper outbreak without significantly limiting insect numbers. Thus, in 1917 Montana entomologists had not settled on any one primary method to battle an old foe of humanity.

Natural controls also played a role in the 1917 outbreak. Blister Beetles, Epicauta maculata (Say) and Epicauta pennsylvanica, fed on grasshopper eggs and appeared in large numbers with the grasshoppers. In and around the area of Flathead County, flesh flies, Sarchophaga, laid their young on the bodies of adult grasshoppers. After feeding on these adults, which died in the process, the young emerged as adult flesh flies. Numerous dead grasshoppers testified to the presence of this parasite.[24]

To predict the prospects for 1918, the entomologists of the state college advised farmers and county agents on methods of surveying for grasshopper eggs. Depending upon where grasshoppers had been numerous in the 1917 season, farmers should examine the soil around the roots of grass, clover, and alfalfa. In bare soil the observer scraped away the surface to a depth of two inches. If he or she

discovered one or more egg masses per square yard over an extensive area, the locale might expect grasshopper problems the following season. During May and June of the following year farmers watched for hoppers of around a quarter inch. If they found them in abundance, farmers prepared to battle them as they attained the injurious stage. In addition, the observer reported the presence of many eggs or hoppers to the State Entomologist in Bozeman. Cooley would then send someone to inspect the area and recommend appropriate control measures.[25]

As an added precaution, Cooley sent his assistants to the regions where significant damage had occurred during the year to survey for grasshopper egg-laying activity. On the basis of the species of grasshopper eggs and the extent of egg-deposition discovered, he could establish whether Montana should expect a repeat of grasshopper troubles in 1918. When no eggs materialized during the extensive survey, Cooley confidently predicted no major outbreak for 1918.[26] But, grasshoppers had played out only the first round of an eight-year struggle. Interventions in the outbreak areas by agents and other county leaders under direction from the State Entomologist's Office, natural parasites, and the arrival of colder weather all combined to control grasshoppers in 1917--not a particularly bad year in retrospect.

1918: Pause and Hope

Cooley and the state entomological organization learned quickly from the destructive grasshopper experiences of 1917. Early in 1918, they attended closely to evidence of mass hatching, especially in areas which had suffered the heaviest damage the previous year. The Entomology Department took advantage of the prior outbreaks by refining methods of control, particularly the use of poisoned bran. At the same time pressures and demands arising from the war dictated the general directions for national agriculture. The U.S. and Canada served as the breadbasket for Europe. This required an emphasis on practical results and left less time for basic research--maximization of food production over satisfaction of mere intellectual curiosity. Montana farmers tried to meet the increased market needs and take advantage of the higher food prices by increasing the acreage planted--acreage now increasingly threatened by the fellow travelers, grasshoppers and drought.[27] For the second year, the state entomological services worked in tandem with natural enemies of the grasshopper to control scattered outbreaks and head off losses and financial ruin for many Montana farmers.

Research lagged behind the pace of other years. Investigations bore only indirectly on the world war as the department focused entomological research and outreach

activities on methods of increasing agricultural production. The necessity of applying existing knowledge to increase crop yields and the shortage of staff personnel, as they received notice for war service, decreased support for long term studies. Student numbers dwindled as young Montanans answered the call of the "war to end all wars" and female students stayed home to fill in for military-bound brothers. In response, Montana State College temporarily furloughed faculty and reduced departmental budgets, further eroding the possibility of completing projects. In the autumn of 1918, the Spanish influenza struck station workers and necessitated the abandonment of offices and laboratories, and the transformation of the College agricultural building into a temporary hospital.[28]

Yet Montana entomologists managed to accomplish significant work despite these obstacles. They contributed to the life history studies of various insects in general and assembled disparate information on grasshoppers in particular. Field workers applied this knowledge in control measures to improve agricultural production and to contribute, in their own ways, to the war effort and the advancement of their science.[29]

Representatives from the State Entomologist's Office inspected areas reporting grasshopper damage, finding it less severe then the 1917 outbreak. Unlike other years between 1917 and 1924, Cooley compiled no outbreak map for

the 1918 season, emphasizing his perception of a lull or a probable end to the trouble. June, the hottest month of the year, provided low precipitation, warm winds, and dry days and promised grasshopper problems. However, July and August guaranteed a successful wheat crop with a return to normal precipitation. Some areas witnessed the return of the poorly identified Melanoplus, which the office again compared to the Rocky Mountain Locust. However, Camnula pellucida (Yellow-Winged or Warrior locust), Melanoplus bivittatus (Two-Striped locust), and Aulocara elliotti (the Bigheaded grasshopper) caused the majority of damage.[30] Although the Yellow-Winged grasshopper inflicted significant damage in the Bitter Root Valley of Ravalli County, it did not migrate. Observers also reported unidentified grasshopper species in Rosebud, Madison, Fergus, Sweetgrass, Meagher, and Cascade Counties. The unspecified Melanoplus reappeared in southern Broadwater and eastern Gallatin Counties, where it consumed thousands of wheat acres. J. R. Parker,[31] Assistant Station Staff Entomologist, and Cooley surveyed the area in September but found neither traces of the adult grasshoppers nor signs of egg-laying.[32]

The State Entomologist's Office compiled and distributed the looseleaf bound book, Standard Control Methods, Insect Pests of Montana, to county agent offices in order to impose some degree of uniformity on the advice of agents

to farmers and further increase the strength and efficiency of the state entomology organization. Through this book, the department also sought to assist agents in insect pest identification. Based on the collective experience of department entomologists, the book attempted to bridge the gaps in the county agents' knowledge of a specialized science. With occasional updates, the department retained its currency of information. According to Standard Control Methods, county agents should recommend the standard methods of treatment for the state as described in the text, after they positively identified an insect. The Department of Entomology would classify questionable insects, but they found it necessary to remind agents to "never send insects in letters." The Committee on Insect Pests, formed to deal with the increasing likelihood of trouble, expected the county agents to report any serious outbreaks to the College's department of entomology. When practical, the office sent one of its own men or a representative of the federal Bureau of Entomology to ascertain the situation and organize a campaign and demonstrations of control methods.[33]

The U.S.D.A. Bureau of Entomology continued its cooperation with Montana's entomological services in the second year of the grasshopper war. The Food Production Act provided funds for the Bureau to supply field extension entomologists in association with agricultural colleges and

experiment stations. Through this agreement, two Bureau entomologists specializing in insects of cereal and forage crops served in Montana under the direction of the State Entomologist.[34]

Personnel problems also plagued the grasshopper fight. Cooley found it necessary to recommend to F. B. Linfield, Director of the Experiment Station, that he not remove Parker from grasshopper work in the future.[35] Parker had left his research work from March through August, 1918, in order to conduct extension work in rodent control and entomology at the behest of F. B. Linfield. This included the critical period for insect damage. Much valuable time passed, since the spring months served as the best time for Parker to progress in his grasshopper experiments. He lost a month of this time anyway due to a bout with scarlet fever. On the other hand, Parker expressed his excitement at the prospects for proving himself in entomology and asked J. A. Hyslop, Extension Entomologist of the Bureau of Entomology in Washington, D.C., about promising projects he could pursue. Hyslop directed Parker's attention back to the needs of grasshopper control, based on the experiences of the previous year's outbreaks.[36]

The pressure on the State Entomologist's Fund, in no small part due to the grasshopper troubles, forced Cooley to accept an arrangement with the Bureau of Entomology. Through this agreement Strand, the Assistant State Entomol-

ogist, temporarily left his position and served as a field assistant with the Bureau out of Bozeman. Strand continued along lines of work similar to his duties as assistant to Cooley until the military inducted him in June, 1918. The loss of Strand and others had forced the movement of Parker out of his usual research work as assistant station entomologist during the crucial period in grasshopper troubles. As the war continued to draw away his staff, Cooley lamented that "before long Parker and I will be the only ones left here in the entomological force." Cooley even considered the prospect of enlisting some of his better entomology students in departmental work to fill the personnel vacuum. The department also looked upon women as a potential source of entomologists and workers. Thus, Cooley, as head of the Entomology-Zoology Department of the College, submitted articles to Montana newspapers outlining opportunities for women as scientists, biological illustrators, library researchers, and laboratory technicians--all with a strong focus on entomological science. The war-spawned personnel shortages had opened opportunities for women in entomology. These prospects ended with the war and the return of male staff members.[37]

Along with the continuing difficulty of maintaining staff in the entomological organization, Cooley foresaw no expansion in the scope of responsibilities for the coming two years. The events of each year determined the focus of

the office and the department and the spending from the State Entomologist's Fund. An outbreak of destructive insects triggered investigations in the field and work in the laboratories at Bozeman as the organization went into action to head off the worst of the damage.[38]

The State Entomologist credited parasitic flies (Sarcophaga spp.) with stemming the tide of the grasshopper outbreak of 1917 and even more so in 1918. As a result grasshoppers inflicted little damage in Flathead, Missoula, and Sanders Counties--the area which had received the brunt of the infestation and agricultural losses in the previous year. These flies also prevented a major outbreak in Gallatin and Broadwater Counties.[39]

However, entomologists did not leave the suppression of the 1918 grasshopper outbreak entirely to natural enemies. Under the supervision of county agents and others working though the office in Bozeman, farmers spread poison bran mash and crisscrossed fields with catching-machines in the most heavily infested sections of the state. Beyond crop damage, some farmers complained about grasshoppers eating their binder twine before hired hands could stack the grain. Bozeman advisors recommended a strong "Kreso Dip" to discourage the insects' omnivorous appetites.[40]

Noting the high cost for the ingredients in the poison bran, researchers at the college attempted to remedy the situation. Farmers viewed the expense as the major reason

for not using the poison method. Lemons sold for $12 per case in 1918--too expensive to waste for attracting insects. Amyl acetate (banana oil) seemed promising as a substitute. In field tests near McIntire, W. B. Mabee found amyl acetate equal to lemons, while H. L. Seamans thought it had failed to attract as well in his Fort Benton trials. In desperation, others tried vinegar without success. Beer had also crossed the entomologists' minds, but Cooley felt "it may be best to put the arsenic and beer together before we allow the latter out of our sight."[41]

By the end of 1918, the entomology department had collected valuable equipment and source materials to carry out its mission more efficiently. The insect collection, important in identification and teaching, contained 80,000 specimens, while the entomology library held 550 volumes and 800 pamphlets. Cooley made his 5,000 books and pamphlets available to the department for research. In addition, the department subscribed to twenty different zoology and entomology journals. Numerous drawings, prepared by departmental personnel, depicted "enlargements of insects and parts of insects" for the edification of students and farmers. Cooley worried that all this valuable material could vanish in a fire within twenty minutes. The collected knowledge of Montana insects, representing years of dedicated research, would instantly disappear with the firetrap that housed it. He added the need for a new home