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First Report of the committee on Grasshopper Research Appointed by the American Association of Economic Entomologists

Agricultural Experiment Station, South Dakota State College

Entomology
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First Report of the Committee on Grasshopper Research Appointed by the American Association of Economic Entomologists

Part 1

Work Conducted by State Agencies of the United States

Not for Publication

Agricultural Experiment Station
South Dakota State College
Brookings, South Dakota

This is the first report of the Committee on Grasshopper Research, which was authorized at the San Francisco meeting of the American Association of Economic Entomologists in 1942 and was appointed by President Harry B. Weiss. The information, which is included in this report, is prepared for the confidential information of workers who are interested in grasshopper problems, especially such problems as deal with the taxonomic, ecologic, and economic phases of grasshoppers. It was not intended, however, to exclude other phases of research work dealing with grasshoppers. The material in this report is not for publication and, therefore, should not be quoted or otherwise used without specific permission from the agency which has furnished it.

This, the first report of the Committee on Grasshopper Research will appear in three parts. Part one will include a report of the work done principally by the State Agencies of the United States and will be prepared and edited by H. C. Severin, State Agricultural Experiment Station, Brookings, South Dakota. Part two will include the work done by the United States Bureau of Entomology and Plant Quarantine and will be prepared and edited by J. R. Parker, Bozeman, Montana . Part three will include a report of the work done by the Dominion as well as the Provincial Workers. This work will be prepared and edited by R. D. Bird, Dominion Entomological Laboratory, Brandon, Manitoba. For copies of parts 1, 2, or 3 of this report, the interested individual should write to the editor whose name and address are given above.

F. A. Fenton, Stillwater, Oklahoma
K. M. King, Saskatoon, Saskatchewan, Canada
G. A. Dean, Manhattan, Kansas
R. D. Bird, Brandon, Manitoba, Canada
J. R. Parker, Bozeman, Montana
Chairman H. C. Severin, Brookings, South Dakota

Alabama

J. M. Robinson, Alabama Polytechnic Institute, Auburn

We do not have a grasshopper control project. Occasionally in the fall it is necessary to control grasshoppers in the fields planted to vetch. It may be of interest to know that a large acreage of Rami, on one of the State Prison Farms proved to be a breeding place for the bird grasshoppers, Schistocerca americana. The past summer (1942) some 600 acres of corn were planted near the Rami. The grasshoppers emerged in enormous numbers in July and destroyed some 300 acres of corn before control measures were applied.

Arizona

C. T. Vorhies, Arizona Agricultural Experiment Station, Tuscon, Arizona.

A long-time project on Orthoptera in Arizona, which was carried on by E. D. Ball until he became ill, has at last been completed through the publication of Technical Bulletin 93, "The Grasshopper and Other Orthoptera of Arizona" by E. D. Ball, E. R. Tinkham, Robert Flock and C. T. Vorhies.

Florida

Theodore H. Hubbell, University of Florida, Gainesville

J. R. Watson and Homer Bratley have carried on investigations on the life history and control of the lubber locust Romalea microptera. Some of the results have been published in the Florida Entomologist Vol. 23 (1): pp. 7-10 (1940), and Vol. 23 (2): pp. 40-42 (1940). An experiment station bulletin on the subject is contemplated.

J. J. Friauf spent about 18 months working on the Orthoptera and Orthopteran habitats of the University of Florida Conservation Reserve at Welaka on the east bank of the St. Johns River in Putnam County, Florida. This constitutes the most thorough, detailed and comprehensive ecological study yet made of the Orthoptera of any part of the state of Florida. The Ph. D. thesis resulting from this work, consisting of some 475 pages, is still unpublished and probably will remain so until after the war. In the work referred to Friauf paid particular attention to the Acrididae of the area studied and obtained much information on their habitats, life history, food habits, seasonal population shifts, etc. The work was done under the direction of T. H. Hubbell.

Florida (Con't.)

T. H. Hubbell and J. J. Friauf spent the entire summer of 1938 studying the Orthoptera of the Florida Scrub. Some 15000 to 20,000 specimens were collected, mounted and labelled and were deposited in the University of Michigan museum of Zoology awaiting study and the preparation of a paper. Undescribed species of Melanoplus were obtained and much distributional and ecological data were collected.

T. H. Hubbell has in preparation two papers,--one on the furcatus group of Melanoplus,--the other on the puer group based almost wholly on Florida material collected by Hubbell and Friauf during the past four years. Additional species and races will be described and the evolution of the two groups discussed.

T. H. Hubbell is also working on the taxonomic status of the Schistocercas of the alutacea-lineata complex, including Florida as well as other parts of the range of the complex.

T. H. Hubbell has in preparation an index to the literature of the Orthoptera of North, Central and South America. He and his associates have been working on this project for two years but the work is far from complete.

T. H. Hubbell and Morgan Hebard are preparing a checklist of North American Orthoptera and Dermaptera. They hope to have this work ready for publication sometime in 1943.

Illinois

W. P. Flint, Agr. Exp. Sta., Urbana

Only routine work was done with grasshoppers in Illinois last year. General observations were made on the abundance of grasshoppers in Illinois and some check surveys were made in the fall to learn the number of eggs deposited in the most favored situations.

Iowa

Carl J. Drake, Iowa State College, Ames

All our efforts dealing with grasshoppers in 1942 were devoted to the preparation for publication of the data obtained from experiments and observations carried on during the past few seasons. The data obtained dealt largely with egg-laying and hatching of certain species of grasshoppers, and particularly with the development of hatching curves for the past several summers. Some work was also done on parasites of the eggs of grasshoppers. This work was largely done by Dr. Decker and Dr. Drake.

Kansas

George Dean, Kansas State College, Manhattan

Brief Statements of Recent Work on Grasshoppers of Experiment Station Project 115 of the Kansas Experiment Station.

By Roger C. Smith

1. Grasshopper egg identifications

The study by J. B. Tuck on identification of grasshopper eggs by the sculpturing on the chorion was completed and published. Slides were made of one fourth sections of the eggs of known identity of 48 species of midwestern grasshoppers. A characteristic section of each egg was described and photographed.

It was found that every species of egg studied had a different pattern of sculpturing. In some cases these patterns differed very widely, while in others they were so similar that the eggs could be differentiated only on minute characters. These characters, however, were consistent and sufficient. In no case was any variation in the pattern within a species discovered. The key for the identification of the eggs is based on the presence or absence of a cap on the posterior end of the egg, the shape of the cells on the body and cap if present, and the variation in the development of the cell boundaries on different areas of the cap and body. Quite unexpectedly the study has revealed some interesting possibilities in species relationships. It was found that females of two species which can not be distinguished morphologically can be identified by removing eggs from their abdomens and identifying them. This study is already proving helpful in grasshopper surveys and control programs. The student is extending this study to other species.

2. Studies on the grasshopper mite.

The outbreaks of grasshoppers during the summers of 1936 and 1937 were utilized for control experiments, a study of parasites, and life history studies of hoppers. Sarcophagid flies and larvae were plentiful in May 1936 and from August to frost during both years. They were mostly inactive during the hot season. Over 300 flies were reared from larvae and puparia in 1936 from the hopper catcher used at the agronomy farm. Of 60 grasshoppers collected in the field near the laboratory, 33 were parasitized by red mites with an average of 1.6 mites per grasshopper. The grasshopper mite, Eutrombidium locustarum, was exceptionally abundant during the two years of the biennium and was reared in the field laboratory. The mite winters as an adult, lays large numbers of eggs in the spring which hatch in 4 to 6 weeks. The mites crawl upon the hoppers and attach to the wings generally at the base. The mites feed to completion and drop off from mid-July to September. They molt and transform to adult mites in the soil and overwinter. The mites feed upon grasshopper eggs both in the early spring and late summer. The wings are frequently frayed but not as a result of the mite infestation. A study lasting through July gave indications that mites do not cause breaking of the wings, does not affect the size or number of egg pods laid but do shorten the lives of hoppers having 2 to 4 mites on the wings.

Many adults in the fall of 1937 failed to develop eggs or the ovaries were undeveloped. There is a possibility that poor nutritional conditions during the extreme heat of the summer was responsible for this.

3. Onion bait.

Tests the latter part of July 1937 involving two sets of field sowings and one of cage sowing each with a check of the standard Kansas grasshopper bait formula with and without onions to test the attractiveness of onions gave the following results:

Per cent killed after 24 hours in cages of 50-100 grasshoppers collected from areas 2 to 4 hours after sowing.

Kind of test	With Onions	Without Onions	Check
Cage test	47%	53%	10%
Cage test	71%	63%	18%
Field test	16%	26%	.089%
Field test	81%	75%	13%
Field test	50%	16%	12%
Field test	60%	85%	22%

The average net kill with onions was 54% while without onions was 53%. The addition of the onions, therefore, contributed little or nothing to the value of the bait.

4. Reprints of articles on the relation of grasshoppers to castor beans and epsom salt in baits have been published.

5. Annual Grasshopper Summary records.

These are published in the annual summaries, copies of which have been sent out to entomologists.

6. Summary of grasshopper populations in Kansas since 1850.

A summary report using information from all available sources on "grasshopper populations in Kansas from 1850 to date" is in process of preparation and some progress has been made in analyzing the data with reference to weather. There is less agreement between large or small numbers of grasshoppers in any part of the state and rainfall and average temperatures both during and for the year preceding outbreaks than was expected. It is thought this report should be prepared and published now in order to incorporate the experience of Professor Dean and Dr. Kelly who are co-operating on the study.

7. Summary report on Mr. Charles Brett's studies for doctor's thesis problem.

Mr. Charles Brett, Nebraska City, Nebraska is making a careful study of the life histories of the migratory and differential grasshoppers under rigidly controlled conditions of temperature, humidity and food. He has been unusually clever in devising automatic control equipment at small cost using old refrigerator cabinets in the basement of his home. He now has life history data, colored photographs, measurements and weights of more than 500 individually reared grasshoppers under controlled conditions. His most recent summary report follows:

THE EFFECT OF THREE FOODS ON THE DEVELOPMENT OF MELANOPLUS MEXICANUS (SAUSSURE) WHEN REARED UNDER DIFFERENT RELATIVE HUMIDITIES AT A TEMPERATURE OF 75°F.

The temperature in all cases being a constant 75°F. will not be further designated in this summary.

Nymphs of Melanoplus mexicanus (Saussure) immediately upon hatching were placed upon head lettuce and they fed readily. In atmospheres of different constant relative humidities ranging from 20% to 65%, it was found that as the humidity was increased the length of time required to complete nyuphal development was also increased. The size of the imago decreased. There were no significant differences in measurements of the head, thorax and wing length under the extremes of humidity. The greater weight at low humidity was due to an increase in the deposition of fat in the abdomen. At a lower humidity the insects fed more constantly. The greater loss of body moisture at low humidities no doubt necessitated the taking in of more food in order to replace this loss. None of the grasshoppers died during their nymphal development when reared under a humidity of 20%. At higher humidities the mortality increased because of bacterial action. Fungus was not observed at 75°F.

Twenty-nine newly hatched nymphs placed upon fresh alfalfa plants in an atmosphere of 20% did not feed readily. All of them died before reaching the imago. They survived from 2 to 84 days with an average of 12.2 days. 50% humidity was the most favorable for them as has also been found true at other higher temperatures. At this humidity 48.5% died in the nymphal stage. At 65% humidity 69.5% of them died. These grasshoppers were smaller than those raised on head lettuce and the males failed to develop normal wings. The tegmina averaged about 6.5 mm in length as compared to a normal length of about 18 mm. Previously at higher temperatures they developed normal wings when raised on alfalfa.

Information concerning the rearings on corn seedlings was not considered adequate because so few individuals were available from the hatching incubator, however, it was indicated that at 50% the humidity was most favorable. At this condition it took them about 72 days to complete nymphal development as compared with 62 days when reared on alfalfa and 52 days when reared on lettuce.

From these results it may be generally concluded that this grasshopper when raised on alfalfa is very susceptible to bacteria at a temperature of 75°F. and a relative humidity of 50% or above. Below 50% humidity there is an increase in mortality because of desiccation. Dry air, however, is most favorable if succulent food is available, especially if the food is low in protein. Under such conditions the adults which develop are heavier, consume more food, are more active and suffer less mortality.

Project 211 of the Kansas Agricultural Experiment Station

By D. A. Wilbur and Roy F. Fritz

Name of Project: The effects of different systems of management of grasslands and conservation areas upon grasshopper, cutworm and other insect populations.

Subproject 1: The effects of different systems of management of grasslands and conservation areas upon grasshopper populations.

This project is cooperative between the departments of Entomology and Agronomy and informally with the Bureau of Entomology and the Soil Conservation Service, U. S. D. A.

Most of the work of the past year is included under the following headings:

a. Study of ecology and behavior of grasshoppers in the "Permanent Area for Intensive Grasshopper Study" near Garden City.
b. Survey of grasshopper and other insect populations in selected types of grasslands representative of Flint Hills section of Kansas.
c. Laboratory tests of foods and feeding habits of the thistle hopper and migratory hopper.
d. Observations on an epizootic which virtually eliminated the thistle hopper during the early summer.

Observations on the "Permanent Area" were carried on for the third consecutive year and have been standarized with similar work conducted by the Bureau of Entomology at Hays, Kansas, and in other states where grasshoppers present a perennial problem. The abundance based on square yard estimates of 25 specimens of hoppers in 11 crops or ecological units was determined. A spectacular shift in the population of Melanoplus mexicanus from 5,000,000 of 1940 to 76,700,000 in 1941 took place on the "Area", while the virtual elimination of Aeolcplus t. bruneri from a population of 65,000,000 occurred.

Extensive tests of foods and feeding habits of the thistle hopper were arranged at Garden City but due to the disease affecting this species, M. mexicanus was substituted. Another series of feeding experiments on this latter species was carried on in the greenhouse at Manhattan during the winter. These data have not been summarized.

The epizootic which nearly eliminated the thistle hopper during late June and early July was observed, but the causative agent was not determined. This species has for the past few years been the dominant hopper in western Kansas from the point of numbers, but was so reduced by midsummer 1941 that specimens could only be found after extended search. The hoppers died as though attacked by the grasshoppers fungus but the specificity of the disease to one species of hopper, its extreme virulence and certain other factors pointed to a bacterial or virus agent.

Publications:

Wilbur, D. A., R. F. Fritz, and R. H. Painter
Grasshopper problems associated with strip cropping in western Kansas. Jour. Amer. Soc. Agron. 34 (1): 16-29, 1942

Wilbur, D. A. and R. F. Fritz
An epizootic among the thistle hoppers, Aeoloplus turnbulli bruneri, Caud. in Kansas. Jour. Econ. Ent. 35 (1): 109, 1942

Louisiana

C. O. Eddy, Experiment Station, Agricultural and Mechanical College, Baton Rouge

No research work has been done with grasshoppers in Louisiana during the past year. However, the grasshopper population in North and North Eastern Louisiana is becoming greater each year and it is believed that it will be necessary to take some control measures in this area before long. The principal crops affected in this area are soy beans and corn, and to a less extent cotton.

Michigan

Irving Cantrall made a thorough and detailed ecological study of the E. S. George Reserve in Livingston County, Michigan. In this survey he worked up the Orthoptera of the region and studied their habitats, food habits, etc. His paper is in press and will be published as a Miscellaneous Publication of the University of Michigan, Museum of Zoology.

Missouri

L. Haseman. Agr. Exp. Sta., Columbia

Four outlying grasshopper study areas were laid out and a fifth one was set aside at Columbia. In these areas, it is intended to carry on a long-time study of grasshoppers including their abundance, species involved, effects of climates, conditions, parasites, crop schedules, and other environmental influences. The work was begun during the past year.

During 1942, except for a few counties in the southeast quarter of the state, grasshoppers were not abundant enough to warrant baiting. Only a few tons of bait were used all told in the southeast part of the state last year. Missouri, really, is on the eastern fringe of the grasshopper danger zone, but it is intended, nevertheless, to continue tabulating ecological and other records as they affect grasshoppers in our designated outlying study areas.

Montana

Harlow B. Mills, Montana State College, Agr. Exp. Station, Bozeman

The work at Montana State College involves the study of the body fluids of grasshoppers and related insects and is continuing at the present time.

J. H. Popper, F. T. Donaldson and Ellsworth Hastings, all of Montana State College are the authors of an article, "Buffering Capacity and Composition of the Blood Serum and Regurgitated Digestive Juices of the Mormon Cricket (Anabrus simplex Hald.) published in Physiological Zoology, Vol. XIV, No. 4, Oct. 1941 pp. 470-475.

Nebraska

H. Douglas Tate, University of Nebraska, Lincoln.

Work in Nebraska concerned with grasshoppers was curtailed considerably during 1942 partly because of shortages in personnel and partly because of the fact that the grasshopper population in areas where the work could be conveniently conducted was low. As in previous years, however, observations and records were made by staff members on the numbers of grasshoppers in various parts of the state, the amount of damage to different crops, general biology and the extent to which parasites occurred. These records are kept from year to year and looked upon as being of considerable importance especially when viewed from a long-time standpoint. Plans are being made to undertake a more extensive program as soon as circumstances will permit.

Grasshopper development was retarded about two weeks by frequent rains and relatively cool weather in the early spring. A comparatively low population combined with an abundance of vegetation resulted in relatively minor grasshopper injury in 1942, except for local areas. Parasites were of considerable importance. Fungus disease caused from 15 to 25 per cent mortality of Melanoplus bivittatus and M. differentialis in some localities of eastern Nebraska in early July.

Because of cool moist weather, conditions were unfavorable for egg laying in the fall. The infestation is only about one-half that present at the same time in 1941. A high degree of parasitism was evident at the time of the fall egg survey, largely by blister beetles, ground beetles and ground beetle larvae. In a number of counties more than 50 per cent of the egg pods were affected.

Myron H. Swenk and Charles H. Pratt are the authors of Research Bulletin 122, Neb. Agr. Exp. Sta. Nov. 1941. This bulletin discusses, "The Relation of Temperature to the Embryonic and Nymphal Development of the Differential Grasshopper, Melanoplus differentialis Thomas."

Nevada

George G. Schweis, Department of Agriculture, Reno

At the present time, the department is taking field notes from time to time on the habits and life history of Melanoplus occidentalis. This grasshopper has increased enormously in numbers in Nevada during the past few years, but as yet has failed to attack any cultivated crops except incidentally. The feeding habits of this grasshopper are confined primarily to range shrubs and grasses, but we are conducting our observations with the ultimate idea of finding out whether or not this species of grasshopper can adapt itself in such a way as to feed on cultivated plants, when the nymphs hatched from egg beds situated adjacent to or in cultivated areas. At the present time, several such egg beds have been located.

Nevada

E. W. Lawrance, University of Nevada, Reno

A general insect survey of Nevada has been started. As the survey progresses, the species of grasshoppers occuring in Nevada will become known. No progress report has been published as yet of this survey.

North Carolina

Z. P. Metcalf, North Carolina State College, Raleigh

The work done with grasshoppers in North Carolina is largely taxonomic. The collection of the Orthoptera of North Carolina, largely made by Dr. B. B. Fulton is fairly complete for the state.

North Dakota

J. A. Munro, North Dakota Agricultural Experiment Station, Fargo, North Dakota

Castor Bean Fails as a Grasshopper Poison

During 1937 and 1938 much unwarranted publicity was given the castor bean as a grasshopper poison, the popular belief being that the plant was particularly attractive and toxic to the grasshopper. Grasshoppers at the rate of about 50 per square yard were enclosed in large screen wire cages with castor beans growing alongside of wheat. The species involved were mainly M. mexicanus with occasional specimens of M. bivittatus and M. differentialis. The grasshoppers preferred the wheat to the castor beans and would only feed upon the latter when forced by hunger. Those which fed upon castor beans apparently suffered no ill effect.

Reference: J. A. Munro. Unpublished 1938 North Dakota Agricultural experiment Station Progress Report.

Wheat Varieties and Grasshopper Injury

To test the susceptibility of various wheat varieties to grasshopper attack six wheat varieties each replicated six times were grown in the plots. One plot was caged to confine the grasshoppers, mostly M. mexicanus, with a small percentage of M. bivittatus and M. differentialis. The other plot was protected from grasshoppers and served as a check. The experiment was conducted by the entomology department in cooperation with the agronomy department of the North Dakota Agricultural Experiment Station. The relative degree of susceptibility of each variety exposed to grasshoppers is expressed in percentage yield to the corresponding varieties in the protected plot as follows: Thatcher, 83.2%; Reward, 60.6%; Ceres, 58.2%; Rival, 54.9%; Rented, 53.4%, Minidak, 50.2%. From these data Thatcher appeared much more resistant to grasshopper attack than the other varieties tested.

Reference: J. A. Munro. Unpublished 1938 North Dakota Agricultural experiment Station Progress Report.

Pennsylvania

James A. G. Rehn, Academy of Natural Sciences of Philadelphia, Philadelphia

James A. G. Rehn and John W. H. Rehn issued the second section of their revision of the New World Gomphocerinae and also finished and turned in for early publication a revision of the North American locust genus, Paratylotropidia.

James A. G. Rehn also completed and published three locust studies, one dealing with the genera and species of the new world group, Tristirini, another a revision of the North American genus, Psoloessa, and a third treating most of the species of the African genus, Pyrgomorpha. He also completed and has ready for publication a revision of the African bird-locusts of the genus, Gymnotheoris and is now engaged in a study of certain Neotropical genera forming an as yet, unnamed group centering about the Chilean genus, Auntenia, and also a study of

Old World elements of the locust group, Euthymiae. In addition, a comprehensive study of Trinidad locusts is being given some attention by James A. G. Rehn.

Morgan Hebard is continuing his studies in the systematics and distribution of a number of North American generic groups, most of which is part of a long-range study which is not intended for early completion. Correlated with this is the continuation of his studies of the Orthoptera of Texas.

H. Radclyffe Roberts completed a study of Melanoplus differentialis and related species found in the United States and Mexico. His paper has been published. His very extensive studies on Mexican Acrididae, based on four seasons of field work in that country, have of necessity been discontinued for the duration of the war.

The papers mentioned above as intended for early publication have either already been accepted and positions given or will be so acted upon in a very few days. All will be published before the coming autumn. Other work mentioned as under way may or may not be completed and published this year. The papers mentioned as published have appeared in either the Proceedings of the Academy, or the Transactions of the American Entomological Society.

South Dakota

H. C. Severin, Experiment Station, Brookings

The Grasshopper Mite, Eutrombidium trigonum Hermann, An Important Enemy of Grasshoppers. By H. C. Severin

The grasshopper mite passes the winter in its adult state in the soil. As soon as the weather warms up in the following spring, the adult mites make their way to the surface of the ground. Here they run about, sun themselves, and seek grasshopper egg-masses. When a mite finds a mass, it burrows down into it and engorges itself with the contents of several eggs. In warm weather the engorged female mites begin egg-laying in 5 to 17 days after their first feeding. The eggs are laid by the mites in chambers in the soil, the average number of eggs laid by a single female being 4768. Egg-laying may be continued over several weeks and during this time, many egg-masses may be laid.

The eggs hatch in 15 to 28 days at temperatures varying from 65 to 75 degrees F. At higher or lower temperatures, the incubation period may be correspondingly shortened or lengthened. The larvae which hatch from the eggs are active six-legged mites. During favorable weather, these six-legged mites run over the surface of the soil and over plants or other materials and seek grasshoppers to which to attach themselves and from which to obtain their nourishment. A larva remains attached to the body or to the appendages of a grasshopper for 8 to 14 days, if possible, and engorges itself with the blood of the host. At the end of the feeding period the larva drops from its host, burrows into the soil, usually constructs a chamber and inside of this chamber it pupates. Pupation takes place usually within 3 days. The mite remains in this or the prenymphal pupal stage for 7 to 18 days, the variation in time being largely accounted for because of differences in temperature.

An eight-legged nymph emerges from the prenymphal pupa. The nymph, like the adult, prefers to feed upon the contents of grasshopper eggs. The duration of the nymphal stage varies from 13 to 50 days, with 27 days as the average.

At the end of its period of life, the nymph constructs a chamber in the soil and inside of this transforms into a preimaginal pupa. From 1 to 5 days or more are required for this transformation to take place. The duration of the preimaginal pupal stage under favorable conditions varies from 9 to 18 days, but this period may be considerably prolonged under adverse conditions such as colder temperatures.

Most of the mites which become adult during the summer or early fall do not lay eggs during the same summer or fall, but they pass the remainder of the year, winter and early spring, in the adult state in the soil. However, a small percentage of the mites that become adult in the summer do mate and lay eggs. In such cases the preoviposition period of these adult mites is, at times, only 5 days. The eggs laid by these mites hatch and such mites under favorable circumstances have sufficient time to pass through their various stages and become adult before winter sets in.

Under the usual South Dakota conditions therefore, one complete and, in addition, one partial generation of grasshopper mites are produced during a year. Under favorable circumstances the entire life cycle of a grasshopper mite may be completed in 61 days.

The life cycle of the grasshopper mite may be outlined in skeleton form as follows:

1. Adult mite unengorged
2. Adult mite engorged
3. Egg
4. Active larva recently hatched
5. Active larva engorged and parasitic on a grasshopper
6. Active larva engorged and no longer on grasshopper
7. Inactive swollen larval mite
8. Pronymphal pupa
9. Active nymph
10. Inactive engorged nymph
11. Preimaginal pupa
12. Adult mite

The adult and nymphal mites feed by preferance upon the contents of the eggs of grasshoppers, while the larval mites feed upon the blood and body fluids of nymphal and adult grasshoppers. When the nymphal and adult mites are numerous, they destroy many eggs and thus serve as an important check upon the grasshoppers. The larval mites, on the other hand, are not very destructive to the grasshopper they infest, but undoubtedly the drain of blood by large numbers of the larval mites must have some influence upon such grasshoppers. When the larval mites are numerous on the wings of an adult grasshopper, they may prevent the proper neat folding of the wings and this in turn, often results in broken wings. The broken wings may in turn affect the grasshopper adversely in many ways.

The Life Cycle, Seasonal History and Habits of the Grasshopper, Boopedon nubilum Say in South Dakota. By H. C. Severin

The grasshopper, Boopedon nubilum Say produces one generation per year and winters over in the egg state in South Dakota.

Females of this species of grasshopper occur principally in two color phases, a black and a brown. These two color phases occur in approximately equal numbers in South Dakota. From the standpoint of wing length, the females may be classified again into two groups, a long and a short winged group, with the short winged group making up about 92 percent of the females. However, there is some variation within each group of females, both as to color and wing length.

The male Boopedons are melanistic with only slight variations in coloration. However, the wing lengths of the males are quite variable.

The eggs of Boopedon nubilum are laid in open places of compact soil. Since this grasshopper in South Dakota feeds principally on western wheat grass, Agropyron smithii Rhdb., the eggs are laid usually in open spots of compact soil of pure stands of western wheat grass or in mixed stands of western wheat grass, grama grass, Bouteloua gracilis (H. B. K.) Lag. and buffalo grass, Buchloe dactyloides (Nutt.) etc. Rarely are the eggs placed in soil containing a heavy matting of grass roots.

The egg masses are laid deeper beneath the surface of the ground than are those of most species of grasshoppers. The plug of each egg mass is usually directed vertically while the egg mass proper is directed at an angle to the plug or occasionally horizontally. The plug is usually placed so that its upper surface is located from $\frac{1}{2}$ to 1 inch beneath the surface of the ground.

The egg mass proper is cylindrical in shape and straight or slightly curved. Ten masses carefully measured varied from 4.5 to 7.5 mm. in width and from 10 to 26 mm. in length. The eggs in each mass are glued together by a secretion which is light grey, pink or brown in color. Very little of this secretion is to be found on the outside of the egg mass. While the number of eggs in a mass vary from a few to 75 or more, ten of such egg masses, containing from 24 to 64 eggs, averaged 42 + eggs.

Each female Boopedon is capable of laying at least two egg masses, though under favorable conditions this may be increased to three or even four.

When this species of grasshopper becomes abundant in an area, the same bare spots in fields of western wheat grass may be used for oviposition purposes by the same or different individual grasshoppers time and again during the egg-laying period. Under such conditions, a small area may contain numerous egg masses. It is not unusual to find a square foot of such soil to contain 40 or more egg masses or a total of more than 1600 eggs.

The date when hatching of the Boopedon eggs takes place varies with many factors, chief of which are temperatures and moisture. In general, it may be said that the eggs of this species of grasshopper, hatch somewhat later than do the eggs of many of our other species of grasshopper. Further, the hatching period in a comparatively small area may extend over a period of several weeks.

In 1942, South Dakota experienced an unusually wet and cold spring. As a consequence, the hatching period of the eggs of Boopedon was delayed, but in most areas of the state the majority of the eggs of this species had hatched by June 1 during this year.

Female specimens of Boopedon nubilum pass thru five nymphal instars, but the males pass through only four, a very exceptional phenomenon. In the first two instars, all of the nymphs, both male and female show no melanistic characteristics, but in the third instar an occasional male and an occasional female begin to show melanistic characters. However, the intensity and distribution of the blackness is not identical in all specimens. Even in the last or fourth nymphal instar, the majority of the male specimens show few melanistic characteristics, and yet they all are intensely melanistic as adult males. Melanism, then, begins to express itself in occasional males in the third instar, in a larger number in the fourth and in all of the males in the adult state. In the females, melanism begins to express itself in occasional specimens in the third instar, in larger numbers in the fourth, in still larger numbers in the fifth and in approximately fifty percent of the adults. If melanism begins to express itself in one of the earlier nymphal stages it is not an intense and uniform blackness that is present, but in such cases the melanism becomes more and more intense with each succeeding molt.

The length of the period devoted to nymphal development is largely dependent upon the temperatures that prevail during this period. Warm weather tends to shorten this period, while cool weather lengthens it. In 1942, 95 percent of the male Boopedons were adults by July 1, but only about 70 percent of the females were adult by July 8, fully a week later. In other words, most of the male Boopedons required only four weeks to pass through their nymphal development, while the females required 5 to 6 weeks to complete their nymphal development.

Description of the following stages of the life cycle of Boopedon nubilum have been prepared for publication and photographs have been prepared of all of these stages.

A. Adult females: long and short winged phases and melanistic and brown phases.
B. Adult males: long and short winged specimens.
C. Egg mass and plug: the soil covering of the egg mass has been removed to expose the eggs.
D. Eggs: natural size and magnified.
E. Chorion of egg magnified 50 times and magnified 220 times.
F. Dorsal and side views of male and female nymphs in the first instar.
G. Dorsal and side views of male and female nymphs in the second instar.
H. Dorsal and side views of male and female nymphs in the third instar.
I. Dorsal and side views of male and female nymphs in the fourth instar.
J. Dorsal and side views of female in the fifth instar.

While Boopedon nubilum feeds upon a variety of foods, the largest amount of damage that is done by this grasshopper occurs to western wheat grass. Not only are the leaves eaten and destroyed, but the stems are also damaged. Frequently the stems are only partially girdled, and this may cause the stems to break over. It is not unusual to find more than 70 percent of the stems of western wheat plants girdled and broken over in fields of western wheat grass that is heavily infested with Boopedons.

The only method of control of Boopedon nubilum which we found practical was to destroy them with poisoned bait. The standard bran and sawdust bait, with either liquid sodium arsenite or sodium fluosilicate as the poison gave us excellent kills. Excellent kills were obtained in uncut or cutover fields of western wheat grass, in alfalfa fields, and in fields of small grain and corn. Since in South Dakota most of the eggs are laid in compact soil in fields of western wheat grass, tillage methods of control are out of the question.

Tillage and Its Effect Upon Grasshopper Populations

By Gerald B. Spawn

This South Dakota Station project was undertaken in an attempt to evaluate various tillage methods from the standpoint of destruction of grasshopper eggs and the prevention of egg deposition. The work was started in 1939. An attempt has been made to evaluate the effect of tillage methods in different soil types because of a difference in the efficiency of the machines in various types of soil.

Because of the danger of creating soil erosion hazards, the methods of tillage to be used by farmers must be chosen with this point in mind. Deep plowing, for example, should not be used in an area which is subject to soil blowing.

Results of three years of study (the project is set up on a five year basis) are as follows:

Experiments in the Winner-Reliance area; soil type, Boyd Clay. Fall tillage methods under field conditions show the following average percentages of control: moldboard plowing, 83.50%; double discing, 74.10%; single discing, 58.76%; one-way discing (wheatland plow) 54.76%; sub-surface cultivation (straight blade type, 50.00%; sub-surface cultivation (small sweep type or duckfoot) 46.45%; regular listing, 40.24%; cut-away disc treatment, 35.25%.

Spring tillage under field conditions (basis one test only):

Sub-surface cultivation (small sweep type or duckfoot) 85.66% single discing, 79.12%; regular listing, no control. It is the leader's opinion that additional tests would probably necessitate changes in the spring tillage figures.

Experiments in the Hecla area; soil types, Valentine sand and Bearden sandy loam.

Fall tillage under field conditions show the following average percentages of control: regular listing (one test), 100.00%; moldboard plowing, 94.15%; tandem discing, 93.80%; one-way discing plus drilling (one test), 93.11%; sub-surface cultivation of the wide sweep type (one test), 90.52%; one-way discing, 86.28%; sub-surface cultivation (small sweep type or duckfoot), 81.64%; plowing with moldboard removed, 74.01%; double discing (one test), 54.44%; single discing, 39.34%; sub-surface cultivation of the straight blade type, no control.

Subsequent experimentation will probably necessitate changes in some of these figures.

Publications: Progress reports #1, 2 and 4, South Dakota Experiment Station, Entomology.

Tennessee

G. M. Bentley, College of Agriculture and the Agricultural Experiment Station, Knoxville.

S. Marcovitch and W. W. Stanley are the authors of Bulletin 182 of the Agricultural Experiment Station of Tennessee. This bulletin discusses the "Fluorine Compounds Useful in the Control of Insects". The authors state that the principal advantages of sodium fluosilicate in baits for the control of grasshoppers over arsenic are (a) the fluosilicate is less repellent to insects; (b) it is less toxic to livestock and higher animals; and (c) it is more toxic to insects. The authors further state that according to Shotwell, attractants are of little value in grasshopper baits and add unnecessaryily to their cost.

Texas.

F. B. Isely, Trinity University, San Antonio

My paper, "Correlation of Mandibles and Food Specificity of Grasshoppers" will appear in the Annals of The American Entomological Society perhaps in June, 1943. I am working now especially on the questions of Distribution of Orthoptera in Relation to Environment. I am also carrying on Further Studies Pertaining to Food Specificity and Habits as Revealed in Cage Studies.

Utah

Geo. F. Knowlton, Utah Agricultural Experiment Station, Logan

Range Lizards as Insect Predators by Geo. F. Knowlton

Fifty-nine sagebrush swifts, Sceloporus graciosus graciosus (B.-C.), were collected in south Cedar Valley, Tooele County, Utah, on May 29, 1941. They were taken among sagebrush, Artemisia tridentata and rabbit-brush, Chrysothamnus nauseosus and C. viscidiflorus, in a foot-hill area recently dusted for Mormon cricket control. The control program had been so effective that only an occasional living cricket was seen by the collectors, yet 23 of the stomachs (39 per cent) each contained a third or fourth instar Anabrus simplex Hald. nymph, or recognizable fragments. It was estimated that more than 500 lizards per acre were present, suggesting that this common swift undoubtedly is an important natural supplementary control factor. None of the approximately 20 smaller, immature lizard specimens taken at this time had recently eaten A. simplex, probably because Anabrus nymphs were large, and smaller insects could be more readily ingested.

Additional insect and plant foods found in the lizard stomachs are listed by Dr. Knowlton in this article. Journ. of Ec. Entomology 35 (4): 602 Nov. 10, 1942.

Dr. George F. Knowlton further reported, "In connection with my supervision of grasshopper control in Utah during the past season (1942) we estimated that better than three-fourths of a million dollars in crops were saved. In connection with this work during recent years, I have also endeavored to carry on some studies on the effect of birds and lizards feeding on grasshoppers in cultivated and range areas. This really amounted to bird food-habit studies, as we seldom were able to attempt an evaluation of the results of such feeding. However, where birds or lizards were abundant, and particularly in the case of the California gulls, definite aid to our farmers was evident. Minor attention was also given to the effect of certain other biological control factors in addition to the vertebrates listed above.

Dr. W. W. Henderson of the Utah experiment station has an experiment station project dealing with the ecology, habits and taxonomy of the grasshopper and their allies. During the past few years he has published the following articles:

The Genus Hesperotettix in Utah, Great Basin Naturalist Vol. II. No. 1, pp. 9-21, 1942.
The Genus Aeoloplides (Orthoptera) in Utah. Proc. of the Utah Acad. of Sci. Arts and Letters, Vol. 18 pp. 83-89, 1941.

Both of the above papers are largely taxonomic in nature.

Virginia

James McD. Grayson, Virginia Polytechnic Institute, Blacksburg

While a post-graduate student at Iowa State College, Dr. Grayson carried on some investigation work with Melanoplus bivittatus and the results of which he wrote up and submitted as his Doctoral thesis. Dr. Grayson has written an abstract of this thesis and this abstract is hereby reproduced.

A Study of Coloration in the Grasshopper Melanoplus bivittatus Say

Color variations of the grasshoppers, Melanoplus bivittatus say occur under similar environmental conditions. Percentages of each color type found in the field were: dark, 30.3 percent; light, 42.0 percent; and intermediate, 27.7 percent.

The color type of the adult grasshopper is largely determined by the presence, or absence, of carotin immediately beneath the cuticule. Carotin was found to be present in a concentration of 0.0406 mg. per gram of body weight in the females; of 0.0397 mg. per gram of body weight in the males (both determinations with the alimentary canal removed); and of 0.266 mg. per gram of tissue in the reproductive organs and surrounding fatty materials.

A study of the genetic relationship between the color types and the effects upon the coloration of the grasshopper of such factors as temperature, humidity, various colored lights, rearing one per cage versus many per cage, and rearing in darkness are being investigated. These experiments will be reported upon in detail at a future date.

Wyoming

Robert E. Pfadt, University of Wyoming, College of Agr., Exp. Sta., Laramie.

The following grasshopper project is being investigated:

"Control of Wyoming range grasshopper"

Investigations have been carried out upon range grasshoppers by the Wyoming Agricultural Experiment Station in cooperation with the Federal Bureau of Entomology and Plant Quarantine. The project has consisted of a study of food preferences, a study of the effect of diet upon survival and upon egg production, and a study of the selection of sites for oviposition. The species of grasshoppers which have received the greatest attention have been Aulocara elliotti, Ageneotettix deorum, Amphitornus coloradus, and Melanoplus mexicanus. Other species listed were Metator pardalinus, Cordillacris occipitalis, and Philbostroma quadrimaculatum.