3-15-1944

Second Report of the Committee on Grasshopper Research Appointed by the American Association of Economoic Entomologists. Part 1, Work Conducted by State Agencies of the United States.

Agricultural Experiment Station, South Dakota State College

Entomology
Pamphlet No.. 7

March 15, 1944

Second 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 S tates

Not for Publication

Agricultural Experiment Station
South Dakota State College
Brookings, South Dakota

This is the second report of the Committee on Grasshopper Research. The appointment of such a committee was first authorized at the San Francisco meeting of the American Association of Economic Entomologists in 1942 and was appointed by President Harry B. Weiss. Dr. P. N. Annand, who succeeded Dr. Weiss as president of the American Association of Economic Entomologists in 1943, requested that the entire personnel of the committee appointed by Dr. Weiss continue to function for another year. The committee members agreed to do this.

Since it was impossible for the entire committee to meet in a conference in order to discuss and plan the work of the committee for 1943, itseemed advisable to continue the plans agreed upon during the preceeding year.

Consequently, the report will again appear in three parts following the plan of the first report. 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, Entomologist of the 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 of Canada as well as by the Provincial workers of Canada. This part will be prepared and edited by R. D. Bird, Dominion Entomological Laboratory, Brandon, Manitoba. For copies of parts one, two, or three of this report the interested individual should write to the editor of that part.

The information which is included in parts one, two, or three of this report is prepared for the confidential information of workers or individuals who are interested in grasshopper problems, especially such as deal with the economic, embryological, taxonomic, ecologic and morphologic aspects. It was not intended, however, to exclude other phases of research work dealing with grasshoppers. The material in this report is not to be used for publication and should not be quoted or otherwise used without specific permission of the agency which furnished it.

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

Dr. G. A. Dean of Manhattan, Kansas and Dr. F. A. Fenton of Stillwater, Oklahoma assisted materially in gathering the basic material included in part one of this report. It was agreed that Dr. Dean and Dr. Fenton should contact all research agencies or workers doing investigational work with grasshoppers in certain states, obtain summaries or progress reports of the work done during 1943 and submit this material to H. C. Severin. Mr. Severin assumed a like responsibility for a group of states. The states assigned to each of these three committee members were the following:

To Mr. Dean:

Arkansas	Nebraska
Indiana	Colorado
Illinois	Idaho
Missouri	Nevada
Kansas	California
Iowa	Oregon
	Washington

To Mr. Fenton:

Oklahoma	Maryland
New Mexico	Virginia
Louisiana	West Virginia
Mississippi	New Hampshire
South Carolina	Vermont
North Carolina	Maine
Tennessee	Rhode Island

To Mr. Severin:

Alabama	Montana
Arizona	New Jersey
Connecticut	New York
Delaware	North Dakota
Florida	Ohio
Georgia	Pennsylvania
Kentucky	South Dakota
Massachusetts	Texas
Michigan	Utah
Minnesota	Wisconsin
	Wyoming

Mr. Severin agreed to edit the summaries and progress reports which he received, to have this material mimeographed and to arrange and bind it so that it might be sent out as Part one of the Second Report of the Committee on Grasshopper Research.

H. C. Severin

Arkansas

Wm. R. Horsfall: Arkansas Agr. Exp. Sta., Fayetteville, Arkansas

Biology and control of common blister beetles in Arkansas. Arkansas Agr. Exp. Sta., Bulletin 436, 1943. pp. 55, figs. 1-11.

The life histories and habits of seven blister beetles, the striped, squash, ash-gray, margined, gray, ebony, and black, have been studied. Adults of the first four are present throughout June, July, August, September, and part of October; the other three are fall species. The striped blister beetle is consistently the most important species, while the others are important less regularly. Soybeans, Irish potatoes, tomatoes, alfalfa, and beans are so severely injured at times that blister beetles are considered their primary insect enemies. They do not limit production of these crops over wide areas, but injury by the beetles often represents considerable loss to individual growers.

All species studied have a similar developmental history. Their larvae live as predators on the eggs of various species of grasshoppers. The seasonal histories of the several species are synchronized with those of the differential and two-striped grasshoppers. The seasonal histories of various species are adapted to those of the grasshoppers, as follows: Adults of the striped blister beetle occur in greatest abundance in late July, and their larvae are most numerous during early September. A long egg stage bridges the time between maximum adult abundance of the ash-gray blister beetle and the time the grasshoppers lay their eggs. The margined blister beetle has a long preoviposition period and an egg stage that is longer than average, so its larvae are most abundant during September and October. The ebony, gray, and black blister beetles, which occur late in the season, have a short preoviposition interval and egg stages of average duration, so their primary larvae are abundant during part of September, October, and even part of November. Only the squash blister beetle seems less specifically adapted to the egg-laying habits of these two grasshoppers. Early larvae of this species doubtless feed on eggs of several grasshoppers early in the season. Late larvae are common predators on eggs of the differential grasshopper as are the others.

Since the larvae of these blister beetles are dependent upon grasshopper eggs for food, killing the host grasshoppers before they deposit eggs will reduce most important species of blister beetles to a position of little importance in Arkansas. However, the gregarious habit of the striped blister beetle might enable that species to develop destructive swarms because the beetles come from scattered sources.

Fluosilicate dusts diluted with some inert material are most commonly used as emergency control measures. Barium fluosilicate or sodium fluosilicate is usually effective when the mixture is dusted on the beetles directly. A dust containing 2 per cent rotenone, made by combining equal parts of talc and powdered derris root containing 4 per cent rotenone, is effective as a means of destroying striped blister beetles on garden crops. Other control practices may be effective in varying degrees, but their value is uncertain.

Connecticut

Isabelle Weed Pfeiffer: Osborn Zoological Laboratory, Yale Univ. , New Haven, Conn.

Summary of studies of the endocrine function of the corpora allata in the grasshopper, Melanoplus differentialis.

The grasshopper Melanoplus differentialis has proven extremely favorable material for study of the function of the corpora allata, both because this species is hardy and easily raised under laboratory conditions (for rearing methods see Carothers '23) and because the large size of the head and the position of the corpora allata in the head make removal of these glands by surgical means readily possible. Unlike many insect species, where there is a single corpus allatum which may be located close to the brain, Melanoplus contains two of these glands, one located at each side of the gut near the junction of the oesophagus to the crop (see fig. 249, p. 479, Snodgrass '35). In this location the corpora allata are a considerable distance from the brain, aorta and corpora cardiaca, and, being discrete bodies without attachment to the gut, are also well separated from this organ. Thus, they may be removed without injury to any organ which could be supposed to have an effect on the physiological processes which the corpora allata have been found to influence. This species also lends itself readily to castration and grafting experiments. The methods by which allatectomy and castration are performed is described in an earlier report (Pfeiffer '39).

The corpora allata have been shown (Weed (Pfeiffer) '36a, '37; Pfeiffer '39) to be necessary for the production of ripe eggs in Melanoplus by the fact that removal of these glands from adult females causes the oocytes to stop development and begin to degenerate when they have reached the stage at which yolk deposition is to begin. The oocytes can, however, develop up to the yolk deposition stage without the corpora allata. Similar effects have been found to result from absence of the corpora allata in the bug Rhodnius prolixus (Wigglesworth '35, '36), the flies Calliphora erythrocephala (Thomsen '40,'42) and Sarcophaga securifera (Day '43) and in the roach Leucophaea maderae (Scharrer '43). Removal of the corpora allata from females of Melanoplus also prevents the production by the oviducts of the secretion which fastens the eggs together when they are laid (Weed (Pfeiffer) '36a, '37; Pfeiffer '39). This effect was shown not to result secondarily from suppression of the ovaries, by the fact that when the corpora allata are present removal of the ovaries does not prevent the production of secretion in the posterior portions of the oviducts which are left at castration (Pfeiffer '39).

The fact that the corpora allata are ductless glands located in the head yet exert a control over organs and tissues in other parts of the body leads one to assume that they perform their functions through the agency of a hormone, or hormones, released to the blood. Wigglesworth ('34, '36, '40) has confirmed this assumption by the demonstration from blood transfusion experiments that the effects of the corpus allatum of Rhodnius are transmitted by the blood. Also indicative of endocrine function of the corpora allata is the finding that, in Melanoplus and Calliphora, adult corpora allata from either males or females grafted into the heads (Pfeiffer '39, '40) or abdomens (Pfeiffer '39, '40; Thomsen '42) of allatectomized females counteract the effects of allatectomy on egg development, thus demonstrating that the corpora allata do not transmit

their effects through the nervous system. This finding also indicates that the effect of allatectomy on the production of ripe eggs and oviducal secretion is due to absence of reactions induced by the corpora allata rather than to wound effects, a fact which has also been demonstrated by the finding that the production of ripe eggs and oviducal secretion in Melanoplus is not prevented when the operation is performed without removing the corpora allata or with removal of only one of these glands or of all but a fragment of corpus allatum tissue (Pfeiffer '39). When a fragment is left, however, it evidently regenerates before becoming capable of supporting production of eggs and oviducal secretion (Pfeiffer '39). Similarly, when a single corpus allatum is left, it may hypertrophy (Weed (Pfeiffer) '37).

Since the corpora allata are essential to egg development only during the time yolk is being deposited, it appeared that their influence in this respect might involve control of metabolic processes related to yolk production. This possibility seemed further suggested by the fact that the corpora allata are apparently not necessary for sperm production (Wigglesworth '36; Weed '37; Thomsen '42) and, more specifically, by the finding that the fat bodies of allatectomized females of Melanoplus usually become greatly hypertrophied (Pfeiffer '39). To investigate this possibility, quantitative determinations were made (Pfeiffer '41 and unpublished) of the fatty acid, residual dry matter and water content of chronologically graded series of adult normal, allatectomized, castrated and allatectomized castrated females of Melanoplus. Similar series of adult normal and test females were observed qualitatively in regard to the size of the fat body and the quantity of blood. For comparative purposes a series of adult males was also analyzed quantitatively in regard to water and dry matter content.

These studies furnished evidence that the corpora allata do not begin to function in a manner which will support egg production until several days after the beginning of the adult stage. At about the same time that the corpora allata become functional the group of oocytes which will finish development first completes the period of growth which precedes yolk deposition. Completion of this growth is evidently necessary to make the oocytes responsive to the effects of activity of the corpora allata, and both responsiveness of the oocytes and activity of the corpora allata are required to permit yolk deposition to begin. However, these two factors are apparently entirely independent of each other. Usually they come into effect at about the same time, but sometimes they may fail to be properly synchronized, with the result that conditions resembling allatectomy or castration may exist temporarily. During the period preceding the assumption of activity by the corpora allata the weight of water and dry matter increases in both males and females but in such changing proportions that the percentage of water decreases. These changes are evidently in part associated with development of the exoskeleton and further growth of the body tissues in general.

When the corpora allata are absent or non-functional regarding egg development (as during the early part of the adult stage) fat is stored progressively and the weights of residual dry matter and water remain at the levels reached at the close of the period during which the exoskeleton develops. Activity of the corpora allata, on the other hand, results in maintenance of the fat content at or below the levels reached by the time the corpora allata became active and causes increases in the weights of residue and water beyond those occurring during the early period of the adult stage. These effects of allatectomy and of activity of the corpora allata occur in castrated females as well as in females which re-

tain their ovaries. Activity of the corpora allata was also found to be responsible for certain increases in blood volume which in castrated females become so excessive as to cause extreme distention of the abdomen. In contrast to the conditions in normal females, the weights of water and dry matter in males remain stabilized at the levels reached at the close of the early period of the adult stage.

The nature of the effects of allatectomy and of activity of the corpora allata in adult females of Melanoplus and the ways in which these effects are related to egg production (to be discussed in more detail in a paper now in manuscript) seem to justify a number of conclusions concerning the control of egg production and the role of the corpora allata in this process. In the first place the findings in these respects indicate that activity of the corpora allata induces the mobilization of certain materials having a chemical nature such that they do not respond to the fatty acid extraction technique employed. They suggest further that these materials are utilized in connection with egg production, that they are produced in the body of the female at some site other than the ovaries and that their production, as well as the production of yolk, is responsible for the maintenance of the fat content at low levels. The evidence also suggests that these materials are transported to the ovaries by the blood, that their presence in the blood gives rise to corresponding increases in blood volume and that their accumulation together with a possible increased rate of production is responsible for the tremendous blood volume increases seen in castrated females.

The production of the materials described above seems to be part of a special mechanism controlling yolk production which, though stimulated and maintained in operation by the corpora allata, is also subject to control by the ovaries and nutrient supply. Immediately following the assumption of activity by the corpora allata the interrelated metabolic reactions of which this mechanism appears to be made up seem to be out of balance, with the result that the fat stores acquired before the corpora allata became active are rapidly reduced and at the same time the blood volume may increase. However, ultimately these reactions come into balance in such a way that successive groups of ripe eggs are produced without great changes in the quantity of fat in the fat body or in the blood volume. The fact that absence of the ovaries drastically upsets this balance, as evidenced by the blood volume increases and also by effects on fat metabolism, not only demonstrates the importance of the ovaries to the mechanism but also suggests an interraction between the ovaries and the corpora allata. More conclusive evidence that the ovaries may exert a reciprocal control over the corpora allata is furnished, however, by the finding that the corpora allata become hypertrophied when the ovaries are absent (Pfeiffer '40; Thomsen '40; Day '43).

In connection with the study just discussed records were made of the color of the blood of the normal and test females. From these observations it was found that activity of adult female corpora allata in Melanoplus causes the blood to contain some green color, the amount varying from traces which are just discernible in the otherwise yellow color of the blood to amounts sufficient to give the blood a bright grass green color. When the corpora allata are absent and before they become active regarding egg development the blood is always yellow. That this effect is in some way related to the mechanism controlling yolk production is indicated both by the fact that females in which yolk deposition is actively in progress usually contain some amount of green color in the blood and by the fact that at the close of yolk deposition the blood gradually loses its green color and becomes bright yellow again. The intensity of the green color is affected by

the temperature at which the grasshoppers are raised, the blood tending to be greener at lower and yellower at higher temperatures. However, low temperatures were never found to cause the green color to appear in the blood of allatectomized females.

A study of factors affecting the development and function of the ovaries and oviducts as well as a study of testicular development was also made by means of a series of gonad grafting experiments in which transplants of portions of ovary with attached oviduct or of portions of testis were made from males and females of a variety of nymphal and adult ages into hosts of a similar diversity. In most cases the host gonad was first removed, but in a number of cases it was not. From these studies it was found that the conditions necessary for the production of oviducal secretion are present as early as the fourth nymphal stage (Pfeiffer '40), but only oviducts which have acquired the proper maturity can respond to these conditions. Thus, adult oviducts grafted into nymphs were able to produce oviducal secretion when the host oviducts could not. The nymphal environment would not, however, support the production of yolk even when the grafts had been taken from donors which were nearly ready to begin yolk production. In all cases the production of yolk in the graft was suppressed until the host became the proper age for yolk deposition to begin (Pfeiffer '40). Preliminary investigation suggests that this suppression results from the fact that the mechanism which affects yolk production does not come into effect until several days after the beginning of the adult stage. In contrast to these findings, younger ovaries grafted into older hosts were accelerated so that, if the age difference between host and donor was not too great, again yolk would be produced in the graft at the time the host became the proper age for yolk deposition to begin (Pfeiffer '40). This effect was apparently related to some mechanism controlling nymphal development which is at present not well understood. Testis grafts appeared to be unaffected by the host environment, since, within the limits of the experiments made in this regard, spermatogenesis was found to proceed in the grafts at normal rates regardless of the age of the host.

Many transplants of nymphal ovaries into male or female hosts of the same nymphal stage were made and examined after the hosts had reached ages at which yolk could be expected in the grafts. It was found that the female hosts would readily support yolk production in the grafts but the male hosts would not (Pfeiffer '40). This was surprising in view of the fact that male corpora allata grafted into allatectomized females will maintain yolk production in the host ovaries. The most plausible explanation found for this discrepancy is that the male corpora allata have the functional capacity for maintaining yolk production, but some inadequacy in the male physiology prevents the mechanism necessary for yolk production from operating effectively. This interpretation is supported by the finding that the oocytes of the grafts can develop further in the male environment than can the oocytes of allatectomized females, but they stop development at the time the proteinaceous yolk granules are to appear.

Of interest in connection with the gonad grafting studies is the fact that the presence of a gonad of the opposite sex had no effect on the secondary sexual characters even when the host gonad was absent or when the transplantation had occurred as early as the second nymphal stage. Castration at equally early ages also failed to affect the secondary sexual characters.

In an attempt to determine whether the corpora allata have an influence over molting, grasshoppers which had just entered the last nymphal stage (the sixth in

this species) were deprived of their corpora allata. These experiments failed to show any effect on either molting or metamorphosis (Weed (Pfeiffer) '36b, '37; Pfeiffer '39), but an influence of the corpora allata in this regard was later demonstrated by grafting adult corpora allata into fifth instar nymphs which had recently molted (Pfeiffer '42). No effect of this operation was observed throughout the remainder of the fifth stage, but shortly after the beginning of the sixth stage the blood of the hosts became green, in extreme cases intensely blue green. This effect was striking because, due to the character of the nymphal exoskeleton, the blood color showed through, causing the nymphs to be green in color. Normally nymphs of this species contain yellow blood and hence, if there is not a large amount of black pigment present, are bright yellow in color. The fact that reactions leading to metamorphosis were interfered with became apparent when the nymphs molted at the end of the sixth stage. At this molt metamorphosis normally occurs; the nymphal color pattern and type of exoskeleton is lost, the long wings characteristic of adults of this species are acquired, and no further molts occur. The grafted animals, however, retained the nymphal type of exoskeleton (in gross appearance at least) and the nymphal color pattern, although they achieved adult size. They also showed wing characteristics which ranged from large wing buds to the adult type of wing. Moreover, several of these animals molted again, and in one case two supernumerary molts occurred. At each of these molts the animals increased in size correspondingly, with the result that they became considerably larger than adult size. These characteristics indicate that the grafted corpora allata had to varying extents prevented the physiological changes which lead to metamorphosis, there having evidently been less effect in this respect in the cases where the adult type of wing was present and more where wing buds had again developed. The effect of the grafted corpora allata was evidently accomplished through release of a hormone, evidenced in other insects (see reviews by Wigglesworth '39; Scharrer '41; Bodenstein '42), which has been termed both "metamorphosis inhibiting hormone" (Wigglesworth '34, '36, '39, '40) and "molting hormone" (Bodenstein '42) because it operates to prevent metamorphosis and induce continuance of molting. The principal significance of the findings in this connection on Melanoplus is the evidence they present that the corpora allata may not lose, during the last nymphal stage, their capacity to produce this hormone, as there has been reason to suppose they might (see discussion of this by Wigglesworth and Bodenstein), but instead either continue to produce it into the adult stage or are capable of secreting it again if they receive the proper stimulus.

It is not known whether the green blood color caused by the grafted corpora allata in the nymphs of Melanoplus is of significance regarding metamorphosis or whether this effect is a result of the performance of an adult function by these glands. The fact that the green blood color did not render the nymphal environment more capable of supporting yolk production is indicated, however, by the finding that adult ovaries which were in some of the cases transplanted with the corpora allata did not begin to produce yolk until the effects of the corpora allata in preventing metamorphosis had worn off.

Florida

J. R. Watson: University of Florida, Gainesville, Florida.

Studies have been made of the life cycle, economic importance, ecology and control of the lubberly locust, Romalea microptera. An experiment station bulletin is being prepared on this project which is now discontinued.

Illinois

J. H. Bigger, Illinois Experiment Station, Urbana, Illinois

A report was submitted by J. H. Bigger which indicated that grasshoppers did but little damage to crops in Illinois during 1943. At least ten counties carried on some control through baiting but in no county was this extensive.

Iowa

G. C. Decker and C. J. Drake: Iowa State College, Ames, Iowa

Preliminary studies on the use of dinitro-o-cresol dusts in grasshopper control. Iowa State College Journal of Science, Vol.XIV, No. 4, July, 1940, pp. 345-351.

The experimental data in Iowa suggest the possibility of obtaining good kills of grasshoppers in a comparatively short time with a 10 per cent 3,5-dinitro-o-cresol dust applied at the rate of 10 to 15 pounds per acre.

Although the practical use of dinitro-o-cresol as a dust for grasshopper control remains to be estableshed by further study, the results reported in this paper are not inconsistent with data presented by numerous European workers, mostly in Germany, who, in the last few years, have reported varying degrees of success attending the use of dusts containing dinitro-o-cresol for the control of aphids, geometrids, nunmoth, and May beetles. Experimental work for the control of locusts and grasshoppers has been conducted also in Argentina and Africa.

Although 3,5-dinitro-o-cresol is quite insoluble, it reportedly burns considerably some types of foliage. Marcus (1937) reported spruce, larch, beech and birch moderately scorched but meadow grass uninjured. Thiem (1938) says, "Owing to injury to leaves dusting and spraying is not recommended in orchards." Schwerdtfeger (1939) observed, "Dinitro-cresol not only destroys all adults (cockchafers) with which it comes in contact, but as it also kills the young foliage the surviving adults die." Other workers present conflicting views on the degree of burning produced possibly because of differences in the tolerance of the plants and conditions under which they worked. The sodium salt of 3,5-dinitro-o-cresol which is water soluble is used as a selective weed killer. Westgate and Raynor (1940) report success in controlling mustard, wild lettuce and other broad-leaved weeds without damage to small grains, corn, onions, alfalfa and flax. The same authors point out that the applications recommended (which are higher than would be used in insect control) have no injurious action upon the soil.

Until much more information on the plant tolerance of these chemicals becomes available, their possible usefulness may be restricted largely to the treatment of mass populations of gregarious grasshoppers and other insects where plant-burning would be of secondary consideration. At the same time, if plant tolerance will permit its use, the susceptibility of the chinch bug and many other field crop insects to this material would indicate a possible wide use for 3,5-dinitro-o-cresol on small grain or corn and even in temporary barrier construction.

The dinitro-cresol and phenol compounds are known to be powerful reducing agents and to induce increased rates of metabolism in mammals but there seems to

be no agreement in the literature on the probable effect of small concentrations of these materials on man and other vertebrate animals. For the present, they should be used in field experiments only with masks and protective clothing.

Although 3,5-dinitro-o-cresol was the most toxic compound included in this study, dinitrophenol, 2,4-dinitro-6-cyclohexylphenol and the salts of these compounds also need further study because they produced a high mortality but acted more slowly than the former compound.

Dr. Carl Drake: Iowa State College, Ames, Iowa

Three papers on grasshoppers are being prepared. One is almost ready to be sent to press, the other two will be published a little later. The first paper will deal with the egg-laying potential of our three most destructive species of grasshoppers in Iowa, namely: M. bivittatus, M. differentialis and M. mexicanus. The second paper is along physiological lines and deals with special foods in relation to egg deposition. The third paper will deal with the hatching of the eggs in the spring of these same three species of grasshoppers.

Theodore Newton Tahmisian: Iowa State Univ., Iowa City Iowa.

Enzymes in ontogenesis: choline-esterase in developing Melanoplus differentialis eggs. Journal of Experimental Zoology. Vol. 92, No. 2, Mar.1943, pp.199-213.

Extracts of Melanoplus differentialis eggs were tested daily for their choline-esterase content throughout their embryonic life.

The pH and temperature optima of choline-esterase from grasshopper eggs are similar to optima reported from other sources.

Enzymogenesis begins on the seventh day of pre-diapause and continues until the onset of diapause at which time it stops only to be resumed during post-diapause.

Choline-esterase in the grasshopper eggs is of embryonic origin.

A close correlation between enzymogenesis and neuroblast differentiation exists.

It is suggested that choline-esterase may be an inductor of nervous tissue.

Acetylcholine in the grasshopper egg occurs during post-diapause development but is absent earlier.

Joseph Hall Bodine & Theodore Newton Tahmisian: Iowa State Univ. Iowa City, Iowa

The development of an enzyme (tyrosinase) in the parthenogenetic egg of the grasshopper, Melanoplus differentialis. Biological Bulletin, Vol. 85, No. 2, 1943, pp. 157-163.

Development and rate of growth of the enzyme tyrosinase have been studied in the parthenogenetic egg of the grasshopper, Melanoplus differentialis.

A marked lag in the appearance of the enzyme in the parthenogenetic egg occurs.

Total amount of enzyme found in the parthenogenetic egg is approximately 50% of that found in the normal fertilized egg.

Parthenogenetic eggs subjected to x-irradiation on the fifth day of development show no change in the amount and rate of production of the enzyme--suggesting as in normal eggs, the production of the enzyme by the serosa cells.

Results of experiments are presented which tend to show that arrested development, or killing of eggs, by low temperature do not produce lowered amounts of enzyme in eggs thus treated.

Possible explanation for the production by parthenogenetic eggs of lowered amounts of enzyme are given.

Thomas Hunter Allen, Arthur B. Otis and Joseph Hall Bodine: Iowa State Univ. Iowa City, Iowa.
Changes in properties of protyrosinase due to shaking. Archives of Biochemistry. Vol. 1, No. 3, 1943, pp. 354-364.

As a result of shaking above a critical rate, a solution of protyrosinase changes irreversibly at characteristic velocities and order into a mixture of definite proportions of protyrosinase, tyrosinase, and inactive products. Perhaps these changes proceed as a branching, consecutive reaction. If inactive products are insoluble and capable of combining with both protyrosinase and tyrosinase, then the reactions halt, because neither of these are dispersed in solution and available for reaction at a surface.

Grasshopper egg protyrosinase was used in these experiments.

Joseph Hall Bodine and Wilbur A. Robbie: Iowa State Univ., Iowa City, Iowa
Physiological characteristics of the diapause grasshopper egg. Physiological Zoology, Vol. XVI, No. 3, 1943, pp. 279-287.

A rapid method for measuring the densities of large numbers of grasshopper eggs is reported, and a study of the accuracy of the method is given.

Constant values for weight determinations of eggs may be secured by allowing the eggs to dry in the air for twenty minutes before drying.

The density of the egg decreases and the weight increases during the prediapause period.

A weight increase during diapause was observed, but the average change in density was not statistically significant.

Density decreases and weight increases for eight days postdiapause. After that neither of these properties change appreciably.

The distribution of diapause eggs according to density follows a bell-shaped curve. The eggs of lowest density have the biggest respiration.

It is possible to sort a group of eggs, by means of sodium chloride solutions, to give a fraction which is remarkably uniform is respect to size and stage of development.

Joseph Hall Bodine and Theodore Newton Tahmisian: Iowa State Univ., Iowa City, Iowa
The effect of heavy metals on the activation and injury of the enzyme tyrosinase. Archives of Biochemistry, Vol. 2, No. 2, No. 3, 1943, pp. 405-411.

The effect of salts of the heavy metals--mercury, gold, palladium, iron, platinum, nickel, cobalt, zinc, manganese, aluminum, cadmium and copper--on the activation and toxicity for protyrosinase and tyrosinase have been studied.

Activation of protyrosinase occurs within definite concentration of Hg, Au, Pt, and Pd.

Below toxic concentrations of all salts no injury to the protyrosinase was evidenced since the addition of a known activator of protyrosinase, aerosol OT, produced 100% activation.

All salts in higher concentrations are toxic for tyrosinase, the order of toxicity being, Au-Pd-Hg-Fe-Pt-Ni-Zu-Mn-Al-Cd-Cu.

The possible relation of the toxicity of the salts and their position in the electromotive series are discussed.

H. E. Jaques: Iowa Wesleyan College, Mount Pleasant, Iowa
During the past year, we have added to our previous knowledge of the distribution of the grasshoppers of Iowa. This research is being done, as a phase of the Iowa Insect Survey.

Kansas

Roger C. Smith: Kansas State College, Manhattan, Kansas

Report of grasshopper investigations in 1943.

The annual survey of grasshopper populations was made by score card type questionnaires and personal observations as has been done in this state since 1930. Apparently grasshoppers were less numerous and less destructive in Kansas during 1943 than in 1942 and below normal in both respects. The cool, wet months of May and June were unfavorable to the young grasshoppers especially in eastern Kansas where a gradual increase appeared to be taking place in 1942. Grasshoppers were of importance only in the drier, western half of the state but injuries were confined to foliage damage of outside rows and ends of fields of crops. The

heavy growth of weeds supplied sufficient food for them so that the migration to to crops was slow and scattered. The fall survey showed them to be present in greatest numbers in the western two or three tiers of counties in Kansas except in the extreme south.

Grasshoppers damaged for the first time in the state the seed pods of cowpeas and soybeans somewhat seriously during the summer and fall. They ate the foliage and petals of cowpeas but the greater damage was done by eating into the mature cowpea pods and destroying the peas (Negative 1A3526) causing an appreciable loss. The damage to soybean pods consisted of eating into the ends or less commonly from the edge of the pods (Negative 1A3525) but this damage was far less important than on cowpeas. The species of grasshoppers present were the differential, two-lined, migratory and two species of Schistocerca. No control measures were attempted for this damage but prompt harvesting is apparently necessary where these conditions occur.

The work on the book "The Common Insects of Kansas" was completed by the five co-operating authors in 1943 and will be ready for distribution to the public in 1944. Most of the common economic species of grasshoppers have been described and illustrated in the book. It should result in better reports on grasshoppers in the state by the public and probably stir up some interest in school and individual collections of grasshoppers. Control of these insects is also described sufficiently so control programs by the public may be aided somewhat.

Michigan

Irving J. Cantrall: University of Michigan, Ann Arbor, Michigan.

The Ecology of the Orthoptera and Dermaptera of the George Reserve, Michigan. Univ. Mich. Press, Ann Arbor, Michigan. Jan. 1943, pp. 1-182, x plates, 2 maps.

A three-year study was made of the Orthoptera of the Edwin S. George Reserve, a tract of approximately two square miles situated on the edge of an interlobate moraine region in Livingston County, Michigan. This study was designed to form a part of the general program of investigation of the biota of the Reserve which is being undertaken under the auspices of the University of Michigan Museum of Zoology. The major purposes of my work were: (1) to obtain a complete list of the Orthoptera present on the Reserve; (2) to determine the habitats of the species and to analyze their occurrence in terms of established correlations with environmental features; (3) to develop a satisfactory classification of the orthopteran habitats of the area; (4) to determine the seasonal relations of the species present; and (5) to obtain as much incidental information on the natural history of these forms as could be gathered without interfering with the attainment of the other objectives.

One species of Dermaptera and seventy-five species and races of Orthoptera were found to inhabit the area. (The total list for Michigan is one hundred and thirty seven species and races.) Four of the forms taken on the Reserve had not previously been recorded from Michigan, and the first definite state records for two others were obtained. The absence of a number of species that occur in neighboring territory is attributed to the absence or poor development of their characteristic habitats on the Reserve.

The habitat relations of all of the species were studied in detail, and a classification of their occurrence in different situations was worked out, based on the concepts of "characteristic," "sporadic," and "erratic" occupancy of habitats. The environments of the Reserve were studied in terms of physiographic, pedologic, and phytologic characteristics and were correlated with the ecological distribution of the orthopteran species. From these data the classification of orthopteran habitats presented in this paper was derived. This classification recognizes the presence on the Reserve of three major types of environment, each with its own series of orthopteran habitats--a xeric series that includes two grassland habitats of the uplands; a mesoxeric series that includes two forest habitats of the uplands; and a hydric series that includes eight marsh, swamp, and bog habitats. It was necessary to bring into the habitat classification the concept of strata, some confined to a single major habitat and others extending through several habitats; the occurrence of the orthopteran species proves in some instances to be correlated with the major habitats, in other instances with particular strata wherever they may occur.

Some of the species of Orthoptera were found to be at all times restricted to particular habitats or strata, while others exhibit a changing relationship to habitat as the seasons progress. Spread of certain species as erratics into noncharacteristic habitats was a common occurrence, particularly in the autumn. Among the grouse locusts a hitherto undescribed phenomenon of seasonal aggregation was discovered, most of the species forming breeding assemblies in restricted areas during the spring, followed by dispersal later in the season.

Critical consideration of the various methods that have been proposed for determining relative abundance of populations of Orthoptera led to their being discarded as highly inaccurate and misleading; it was concluded that estimates based on long-continued observation of the species in the field, detailed knowledge of their individual peculiarities of behavior, and experience with the results of different collecting methods gave the closest approach to accuracy obtainable at present. This method of estimate was therefore adopted in this study.

A review of the literature on the species occurring on the Reserve showed that little of value had been recorded concerning the habitat relations and habits of most of them; such relevant information as there was has been summarized in the treatments of the individual species.

A large amount of data on the life history, seasonal relations, breeding habits, songs and other features of the species dealt with was obtained, and has been incorporated in the Annotated List.

Minnesota

Mykola H. Haydak: Rearing grasshoppers under laboratory conditions. Science, June 26, 1942, pp. 657-658.

The rearing of grasshoppers in the laboratory requires considerable care and attention. The food must be grown and supplied daily to the insects, the cages must be cleaned at least once a week, dampness must be avoided, etc.

The present paper describes a simple method for rearing grasshoppers which is being used in the Division of Entomology and Economic Zoology of the University of Minnesota.

Two types of cages are used, a smaller, for the hatching of the eggs and as living quarters for the first instars, and a larger one for growth and reproduction.

Inside dimensions of the smaller cage are 6x3½x3½ inches. The sides and one of the ends are of wooden boards, the other end is left open for the attachment of a cheesecloth sleeve. The top and the bottom of the cage are made of screen wire cloth, 16 to an inch mesh. The bottom is elevated a quarter of an inch above the surface of the table.

The larger cage is of 12x12x12 inches inside dimensions. The cage is made of wire cloth 12 to an inch mesh, nailed to the wooden framework. The bottom is elevated a half of an inch above the surface of the table. The lower third of one side is left open for a cheesecloth sleeve as in the smaller cage.

Food consists of a dry mixture of dried brewers' yeast, 1 part; skim milk powder, 2 parts; and dried alfalfa meal, 2 parts by weight. Water is given in shell vials plugged with cotton and laid on the bottom of the cage. Food can be supplied to the newly emerged insects in "Coca Cola" or similar caps from which cork has been removed. It is advisable to put 2 to 3 receptacles with food in the cage as well as 2 or 3 vials of water in order to avoid overcrowding and consequent undernourishment of some insects. One ounce ointment boxes are satisfactory for food containers in the bigger cage.

Grasshoppers are allowed to emerge from the eggs in the small cage. Water and food should already be present before hatching starts. Constant light is provided by bending an ordinary table lamp over the cage--about 3 to 4 inches from the top screen. The insects find the food and water without difficulty. It is important, however, to have the insects reared from eggs in the cage and not to introduce them from the outside after they will already have started feeding on their natural food. After all the insects enter their second instar, they may be transferred to a larger cage, the dimensions of which depend on the number of grasshoppers maintained for use in the laboratory.

The insects do not require any special attention, provided they always have food and water available. Feces which accumulate under the screen bottom may be removed from time to time.

In our experiment, hatching of overwintering eggs of Melanoplus differentialis started on May 27 and next molt occurred 5 days later. June 7, when all the grasshoppers had molted, they were transferred to the larger cage. There was no mortality. The time of appearance of the nymphs of the third instar was not noted, but June 9 the nymphs of the fourth instar began to appear, and succeeding molts occurred on June 13 and 20. The first adults appeared on June 24, the total developmental period being 28 days after hatching, during which 6 molts occurred. July 11, the last nymph molted 31 days after hatching started. The insects were mostly segregated in a circle around the light where the temperature was about 34° C.

First death of adults occurred on July 12, 45 days after hatching, and 43 days later half of the adults were dead. The last adult, a male, died on October 26 at the approximate age of 152 days. Until July 21 the insects were kept in a basement laboratory having only artificial light available day and night. On that day the cage was taken to the greenhouse, where it remained till the end of the experiment. The insects behaved normally. They mated and thefemales oviposited in sod which had been placed on the floor of the cage.

The advantages of this method are obvious. The experimenter needs only to fill the dishes with food when necessary, provide water and occasionally remove the paper with feces from under the cages.

Missouri

L. Haseman: Missouri Experiment Station, Columbia, Missouri

During 1943, there were no heavy outbreaks of grasshoppers in Missouri, though there was a general sprinkle of hoppers over much of the better farming section. There were some losses in the state from the work of grasshoppers, but nowhere was this loss extensive. As a result there was little poison bait mixed and used.

A small amount of collecting of grasshoppers was done during the year. It is planned to work out a complete taxonomic study of the Orthoptera of Missouri in the future. All other work with grasshoppers in Missouri was temporarily abandoned because of lack of man power.

Montana

J. H. Pepper and Ellsworth Hastings: Bozeman, Montana.

Studies on the body fluids of several species of grasshoppers and their possible effect on the solubility of sodium fluosilicate.

The preliminary work on this project was started in 1939. At that time it was decided to investigate the pH and buffereing capacity of the digestive juices and the blood of several economically important species of grasshoppers to see if any marked differences were evident among them. Following this the solubilities of fractionated arsenicals were determined in the digestive juices of Brachystola magna and that of fractionated sodium fluosilicate in the digestive juices of M. bivittatus. The results of these investigations did appear in the December issue of the Journal of Economic Entomology, 1943.

The above investigations which were conducted on both grasshoppers and the Mormon cricket (Anabrus simplex) brought out the fact that some factor or factors, other than the pH of the juices, was responsible for the differences in their solvent powers toward sodium fluosilicate. Similar studies, which were conducted at the same time, on the solubility of sodium fluosilicate in distilled water showed the latter to have much greater solvent powers than the digestive juices. Since the sodium fluosilicate must go into solution before it can become effective as a toxic agent, it was decided that the rate of solution in the insect and hence its effectiveness may be governed in a large measure by the free water content of the digestive juices. This factor may be expressed inversely as the total solid content of the juices and may be quantitatively determined by evaporating a sample of the juice at 100° C. to constant weight or by means of a calibrated Abbe' refractometer.

During the past season studies were made to determine the variation in solid content of the digestive juices of grasshoppers under their natural conditions in

the field. Variations in composite samples of from 21.7% to 31.2% in solid content of the juice were found in 'hoppers taken in a wheat field during the hours from 8: 15 a.m. to 9:30 p.m. on the same day. Juices collected from 'hoppers in other habitats such as irrigated alfalfa fields, dry land alfalfa, weed patches, etc. differed considerably, the outside limits being from 12.6 to 36.4% total solids. It was considered that the variation in solid content of the juices could be brought about by feeding on plants of different moisture content, amount of such feeding, continuous feeding as against sporadic, the length of time that elapsed after feeding had stopped, the physiological state of the insect, etc. The next problem was to determine what effect such changes in solid content of the juices would have on the rate of solution of sodium fluosilicate. This rate of solution was determined under a standard set of conditions, that is, 10 ml. of juice, 100 mg. of sodium fluosilicate, temperature 25°C. and time 48 hours. Fluorine was determined by a modification of the Willard-Winter method.

Cricket and grasshopper juices were collected in the field and stored at 2°C. until the determinations could be made. Most of the determinations reported herein were made using cricket juices as these were much easier to collect in quantities adequate for analysis. Previous determinations have shown that both cricket and grasshopper digestive juices react in the same way with respect to solvent powers, the only difference being in rate of solution, so that data obtained from one of them can be used to predict what the situation will be with respect to the other.

Solubility Experiments.

Commercial (98% pure) $Na_2Si\ F_6$ was fractionated by means of screening into fairly uniform samples having average particle diameters of 21, 93, 167, and 218 microns. The equilibrium solubilities of these fractions were determined by placing an excess of the material in boiling water, refluxing it for 24 hours and then cooling the solution to 25°C. at which temperature it was held for several days to make sure that equilibrium was established. An aliquot was then drawn off and the $Na_2Si\ F_6$ content determined. There was no significant difference in their solubilities the average value being 0.8343%. This value was considered as the true solubility of the material.

The solubility of these fractions in distilled water at 25°C. for 48 hours was then determined. The 48-hour period was selected as this was considered to be the average time that the material would be held within the digestive tract of the insect. The results are shown in Table I. They should be interpreted as rate of solubility, as, if enough time were allowed the true solubility would be reached.

Table I

Ave. particle Diam. in Microns	Gms. in solution per 100 c.c. H_2O	Percentage of true Solubility
20	.8237	98.7
93	.7628	91.4
167	.7280	87.2
218	.7076	84.7

Rate of solution in a composite sample of Mormon cricket juice solid content of which was 16.8%. The temperature was held at 25°C. and samples taken off at the times noted in Table II. Commercial $Na_2Si\ F_6$ was used.

Table II.

Time in hours	% solubility	% of solubility at 96 hrs.
24	.031	16.5
48	.175	92.5
72	.185	97.8
96	.189	100.0

It will be seen that the greatest rate change took place during the first 48 hour period. Following this the rate of solution was very slow indicating that when a percentage solubility of approximately .17% is reached the rate of change becomes insignificant as far as building up a reserve of soluble material is concerned.

Solubility and Solid Content of the Juices

The solid content of a composite sample of M. bivittatus digestive juices was adjusted by dilution and evaporation to the desired percentage solids. The temperature was maintained at 25°C. and solution allowed to proceed for 48 hours. The results are shown in Table 3. For comparison the percentage of the amount dissolved at 12% total solids is also shown. Commercial Na_2SiF_6 was used in these determinations.

Table III

% solids in juice	% solubility	% of solubility at 12% total solids
12	.159	100.0
18	.069	43.3
24	.051	32.0
30	.034	21.3
36	.034	21.3

A series of M. bivittatus were fed entirely on wild lettuce and their juices collected. They had a solid content of 23.6%. The solubility of the Na_2SiF_6 in this material, under conditions similar to those above was only 0.024% showing that the type of food may have some effect.

Rate of solution and temperature

In these experiments a composit sample of cricket juice having a solid content of 16.8% and commercial Na_2SiF_6 were used. The time allowed for solution was 48 hours. The results are shown in Table 4. For comparison the percentage increase with temperature is also shown.

The 1943 fall survey showed the grasshopper population at the lowest level since the early 1930's. Threatening populations are present in a few small areas in central and western Nebraska. State workers are cooperating with Federal workers in an effort to put into effect a concentrated control program in 1944 with the idea of preventing increase and spread from these foci of infestation. It is hoped that this program will demonstrate the value of preventive measures in grasshopper control.

Ohio

F. M. Semaus: Ohio State University, Columbus, Ohio and Youngstown College, Youngstown, Ohio.

Protozoan Parasites of the Orthoptera, with special reference to those of Ohio, I-IV. Ohio Journal of Science, 36(1936), No. 6, pp. 315-320; 39(1939), No. 3, pp. 157-181, illus. 44; 41(1941), No. 6, pp. 457-464; 43(1943), No. 5, pp. 221-234; No. 6, pp. 271-276.

The purpose of this study was to determine the distribution of protozoan parasites in all available species of Orthoptera in a given region and to learn something of the relationship between life history and ecology of parasite and life history and ecology of host. Excluded are the domestic cockroaches and the wood eating roach. In addition, a classified annotated list of the protozoan parasites of the world, attacking this group was compiled from the literature, a key for their identification was constructed, and a complete bibliography was assembled. The following contributions are included: Parts 1, Introduction and methods; 2, description of the protozoan parasites recognized in this study; 3, protozoan parasites in relation to the hosts and to host ecology; and 4, classified list of the protozoan parasites of the Orthoptera of the world--Classes Mastigophora, Sarcodina, Sporozoa, and Ciliata. There are four pages of references.

Pennsylvania

James A. G. Rehn and John W. H. Rehn: The North American locust genus, Paratylotropidia(Orthoptera: Acrididae: Crytacauthacridinae). Am. Ent. Soc. Vol. 69, no. 1, 1943, pp.33-60, pl. IV-V.

An historical account of the genus, Paratylotropidia, a description of the species, and discussion of the range and the habits of each species.

James A. G. Rehn: The Aucacres, a new group of South American locusts (Orthoptera: Acrididae, Crytacanthacridinae). Proc. Acad. Nat. Sci. Phil. Vol. 95, 1943, pp. 33-51, pl 8-10. This work constitutes a critical study of the three South America genera, Cumainocloidus, Aucacris and Neuquenia.

James A. G. Rehn: The bird locusts of the African genus, Arnithacris (Orthoptera: Acrididae, Crytacanthacridinae). Proc. Acad. Nat. Sci. Phil. Vol. 95, 1943, pp. 111-137, pl. 13-18.

Dr. James A. G. Rehn informed H. C. Severin that work was now under way on several revisionary studies dealing with the genera Bradynotus and Asemoplus and and at present unrecognized related generic entities of western North America.

Table IV

Temperature, C°	% solubility	% of Solubility at 31°C.
11.0	.010	4.2
16.0	.041	17.2
25.0	.181	76.6
31.0	.236	100.0

On an average the rate of solubility increases approximately 0.01% for each degree rise in temperature.

Solubility and Amount of Sodium Fluosilicate

In order to determine the effect of ingesting different amounts of bait the following experiments were performed. In each case the volume of cricket juice was kept constant at 10 ml., the temperature at 25°C. and the period of solution 48 hours. The cricket juice had a solid content of 16.8%. Varying quantities of Na_2SiF_6 were added to the juice and the amount dissolved in 48 hours determined. The smallest amount added was in excess of the amount required to saturate the water solution for the given temperature and time. The results are shown in Table 5, where a comparison is made with distilled water.

Table V

Amount of Na_2SiF_6	% solubility in water	% solubility in cricket juice
25 mgs.	.256	.011
50 "	.463	.042
100 "	.716	.175
150 "	.753	.376
200 "	.754	.416

A considerable increase in rate of solution is noted with increase of sodium fluosilicate.

While the above experiments are only relative and cannot be correlated quantitatively to actual field conditions they do, nevertheless, serve to point out the factors which are known to vary under actual control operations which may account for many of the discrepancies in kill which are normally encountered.

Nebraska

H. Douglas Tate: Nebraska Agricultural Experiment Station, Lincoln, Nebraska.

Work on grasshoppers in 1943 consisted of routine observations made in connection with field control operations. Records were made on abundance, extent of damage, and seasonal development of the more important economic species. Damage to crops was relatively minor. Approximately 450 tons of dry bait were used.

He stated that these studies will also analyze the relationship of certain of these genera to Palearctic ones, with which no suggestion of relationship has been previously advanced in print. These papers will appear as joint presentations of John W. H. Rehn and James A. G. Rehn.

South Dakota

G. B. Spawn: South Dakota Agr. Exp. Sta., Brookings, S. Dak.
Tillage methods in grasshopper control. Entomology, Pamphlet 6,So. Dak. Agr. Sta. Brookings, S. Dak. Nov. 1943, pp. 1-2.

The eyes of the world are turned toward the American farmer as the individual to whom they must look for the production of a plentiful supply of food for our fighting forces, our Allies and for the hungry millions as they are liberated from Nazi rule and devastation. Grasshoppers have done much to defeat the Great Plains farmers in their effort to produce this food.

In the central part of our State many fields of corn, badly needed for feed, were planted during the past year from which not one bushel of grain was harvested. Numerous fields of flax, very important as an oil crop, remained uncut. Many fields of small grain, also badly needed for feed and the manufacture of food products, had the yield per acre very seriously reduced. This damage was done by grasshoppers and under moisture conditions which otherwise could have permitted a good harvest.

By the use of appropriate tillage methods, and using them at the proper time of the year, the damage which will otherwise be done by grasshoppers can be reduced considerably.

Based upon four years of experimentation the following tables give an evaluation of the effectiveness of various tillage implements for use in grasshopper control.

EXPERIMENTS IN THE WINNER-RELIANCE-CHAMBERLAIN AREA
Heavy soils----clay and clay loam
Fall Tillage under Field Conditions

Tillage Treatment		Average Percentage Control
Moldboard plowing		81.33
Single discing		76.34
Double discing		74.35
Narrow sweep sub-surface cultivation		59.93
Straight blade sub-surface cultivation		58.02
One-way discing (wheat land plow)		44.61
Listing	(one test)	26.85
Cut-away disc treatment	(one test)	20.70

EXPERIMENTS IN THE HECLA AREA
Light soil ---- sand and sandy loam
Fall Tillage under Field Conditions

Tillage Treatment		Average Percentage Control
Listing*	(one test)	100.00*
Tandem discing		97.40
Moldboard plowing		96.04
One-way discing plus drilling	(one test)	93.97
One-way discing (wheat land plow)		92.27
Wide sweep sub-surface cultivation	(one test)	91.49
Narrow sweep sub-surface cultivation		84.27
Plowing with moldboard removed		74.11
Double discing	(one test)	60.07
Single discing		44.51
Straight blade sub-surface cultivation		2.90

* It is the writer's belief that additional experiments with listing will without doubt lower this figure. All the above figures are subject to change as subsequent tests and emergence results may justify.

SUGGESTIONS FOR USE OF TILLAGE IN GRASSHOPPER CONTROL

1. Plan your control campaign in advance. The man who waits until the 'hoppers hatch has lost a major battle in grasshopper control, and with it a chance to reduce greatly the future damage to his crops.

2. Fall tillage is best but if no fall tillage was used then spring tillage can be used to advantage. Spring tillage should be done as early as possible with particular attention being given to outer edges (150 feet) of fields and to headlands. Both surface and sub-surface methods are good in that they disturb the soil for a depth of at least 2-3 inches.

3. In using the above tables as a guide in the choice of implement for 'hopper control one should note that the results differ with the different types of soil. Consult the table which most nearly matches the soil type of the land to be treated.

4. Consider soil erosion control recommendations as well as grasshopper control when choosing the implement to be used.

5. Deep plowing is recommended where it can be done without danger of soil blowing.

6. Cultivate with a spring tooth harrow early next spring to reduce hatching of grasshoppers in alfalfa fields.

7. (IMPORTANT) Use tillage following harvest to create unfavorable egg-laying conditions in fields. Leave untilled strips, 15 to 20 feet wide, every 15 to 20 rods in the field to function as egg concentration areas. These strips should be tillage treated when grasshopper egg-laying has been completed, late in the fall.

8. (IMPORTANT) Fields should be examined in the fall, if at all possible, to determine the amount of grasshopper egg deposition. Inexpensive egg screens can be constructed from 1 x 4 boards and ¼ inch mesh hardware cloth. Soil samples of approximately one-half square foot each, of the surface 2-inch layer of soil, should be taken at intervals over the field and field margins. The screening of egg pods from these individual samples gives a good estimate of the seriousness of the infestation. An egg pod count of one per square foot in a field on an average (or one pod per 2 samples) is an indication of a threatening grasshopper infestation. This may mean, depending upon weather and other factors, from 35 to 45 percent damage to crops, by Government and State Extension Service figures. The infestation does not necessarily have to be this heavy to warrant the use of tillage as a control measure.

9. In headlands and edges of pastures bordering cultivated land, where tillage cannot be used, the TIMELY use of poisoned bait is recommended. Poisoning is most effective while the 'hoppers are small and before they scatter out from their hatching grounds. Consult your County Agent.

H. C. Severin: South Dakota Agr. Exp. Sta., Brookings, S. Dak.
A study of a gynandromorph of Melanoplus mexicanus mexicanus (Sauss.). Jour. N. Y. Ent. Soc. Vol. 51 1943, pp. 179-183, pl 1.

In this paper, the author discusses briefly the frequency of occurrence of gynandromorphism in the Insecta and in the orders of the Insecta. This is followed by a description of a gynandromorphic specimen of Melanoplus mexicanus mexicanus (Sauss.). The specimen is typically male in structure in the dorsal half of the entire body (head, antennae, thorax, and abdomen) and in the left half of the ventral half of the body (including sternum of thorax, legs and genitalia). In the ventral right half of the body the gynandromorph is typically female in structure except for a few details. Three photographic figures of the abdomen are used to illustrate the characters of the abdomen which are of a sexual dimorphic nature.

H. C. Severin: South Dakota Agr. Exp. Sta., Brookings, S. Dak.
The grasshopper mite, Eutrombidium trigonum (Hermann) an important enemy of grasshoppers. South Dakota Experiment Station, Tech. Bul. 3, 1944, fig. 1-19.

The grasshopper mite, Eutrombidium trigonum (Herm.), is an important enemy of grasshoppers in South Dakota. In its larval stage it is parasitic on grasshoppers and in its nymphal and adult stages, it is predaceous on the eggs of grasshoppers.

The various stages in the life cycle of the mite have been described in detail in this publication.

A study of the life cycle of the mite has shown that it has one complete and a partial second generation a year in South Dakota. The winter may be passed in the soil as an adult mite or as a nymph. The eggs of the mite are usually laid in small 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 several egg-masses may be laidby a single female. The eggs hatch into six-legged larval mites usually within 2 to 4 weeks.

The larval mites are external parasites of adult and nymphal grasshoppers. All species and varieties of grasshoppers that occur in South Dakota are subject to attack by these mites. The larval mites remain attached to the body or to the appendages of a grasshopper for 8 to 14 days, if possible, and during this time they engorge themselves with the blood of the host. They then drop from the host, burrow into the soil and pupate.

The mites remain in this, the prenymphal pupal stage for 7 to 18 days and then emerge, as eight-legged nymphs. The duration of the non-hibernating nymphal stage averages about 27 days. During the nymphal stage, the mites prefer to feed upon grasshopper eggs, whose liquid contents the mites suck out through their mouth-parts. Towards the end of the nymphal stage, the mites burrow into the soil and transform into preimaginal pupae.

About two weeks are spent as preimaginal pupae and then the mites emerge as adults. The preferred food of the adults consists of the liquid contents of grasshopper eggs.

Under favorable conditions the entire life cycle of a grasshopper mite may by completed in 61 days. The seasonal history of the mite is indicated diagrammatically in Fig. 2, while the life cycle is outlined in skeleton form in Fig. 1.

The larval mites have little direct effect upon the health of the infested grasshoppers except to weaken them a trifle. They do not prevent nymphal grasshoppers from maturing and developing into seemingly normal adults. Even though the mites may be fastened to the wing pads of nymphal grasshoppers, such pads are not seriously damaged, for when the nymphs ultimately become adult grasshoppers, the wings seem to be normal in every way.

When an adult grasshopper becomes heavily infested with larval mites, the majority of the mites are attached to the hind wings and to the dorsum of the mesothorax and metathorax. When such mites become large, they may prevent the grasshopper from folding the wings properly. As a consequence, the tegmina and second pair of wings become much battered and broken and, at times, so badly as to be reduced to mere stubs. A severe infestation of mites upon the wings and at the base of the wings of grasshoppers may interfere seriously with efficient flight. A moderate infestation of adult grasshoppers does not seem to shorten the life of the insect materially nor does it seem to interfere with normal reproduction.

Both the nymphal and adult grasshopper mites prefer to feed upon the liquid contents of grasshopper eggs. Eggs drained of their liquid contents so that the chorion is severely collapsed usually die, while eggs that are not so seriously damaged recover. A nymphal mite may collapse, in varying amounts, from 1 to 14 grasshopper eggs, but only a fraction of these eggs are actually destroyed. An average adult female mite, while it is in its preovipostion period, consumes the entire or only a portion of the liquid contents of 3 to 4 grasshopper eggs, and it may collapse from 2 to 16 additional eggs during the remainder of its life. However, not all of these eggs are actually destroyed. Those that are not, will give rise to seemingly normal grasshopper nymphs.

Grasshopper mites have been reported so abundant during some years in some sections of the United States as to actually control a severe outbreak of grasshoppers. The author has not encountered such conditions in his thirty years of

experience with grasshoppers in South Dakota. However, the red mite is consistently present in all sections of the state each year, and during years favorable to it, is one of the important checks of grasshoppers.

Utah

W. W. Henderson: Utah State College, Logan, Utah

Four devastating Melanopli found in Utah. To be submitted for publication to the Great Basin Naturalist.

The four species considered are highly destructive to Agriculture in Utah. They all belong to the genus Melanoplus and are listed in order of their destructiveness as follows: M. mexicanus mexicanus Sauss., M. packardii Scudd., M. bivittatus (Say), and M. femur-rubrum(DeGeer).

For each species there is given enough of synonymy to make clear the taxonomic history of each. This is followed by an abbreviated description of the species which makes use of the most striking and the most easily detected characters. Then follows a consideration of the known geographical distribution, the particular distribution in Utah, and the economic status of each species in North America. The final consideration is a list of citations which includes about sixty titles.

George F. Knowlton and F. C. Harmston

Grasshoppers and crickets eaten by Utah birds. The Auk Vol. 60, No. 4, 1943, PP. 589-591.

Many species of Utah birds are decidedly insectivorous. Studies of a large number of stomachs from such birds have indicated that the vast majority of insects eaten were injurious. The following report is based on laboratory examinations of the contents of bird stomachs collected throughout Utah from 1935 to 1940, inclusive. Birds are definitely important in reducing insect populations, especially when insects occur in large numbers, as is the case in insect outbreaks. Assuming 2.5birds per acre as an average for Utah (which is lower than many estimates would place the figure), an estimated population of 131,500,000 birds would exist in this state. Birds consume large amounts of food each day; they undoubtedly consume many billion injurious insects through the farm and range areas of Utah each year, with consequent benefit to farm crops, range forage and home gardens. While recognizing the benefits derived from the feeding of birds, it is difficult to estimate accurately the degree of control over a large area, which birds exert upon any particular insect pest. In general, the benefits derived from birds in the control of insects undoubtedly are many times the loss occasioned by the feeding of a few species which attack crops, fish or useful birds.

Brewster's Egret, Egretta thula brewsteri.--One stomach from a bird collected in the meadows at Logan, on September 6, 1940, contained twelve warrior grasshoppers, Camnula pellucida.

Pacific Nighthawk (Chordeiles minor hesperis).--Four stomachs were examined; one contained nine winged grasshoppers, of which two were Trimerotropus caeruleipennis, two were Disosteira carolina and one Melanoplus femur-rubrum.

Lewis's Woodpecker (Asyndesmus lewis).--Of five stomachs examined, one contained an adult grasshopper.

Eastern Kingbird (Tyrannus tyrannus).--Fourteen stomachs were examined, eight of which contained nine adult grasshoppers.

Arkansas Kingbird (Tyrannus verticalis).--An examination of 55 stomachs revealed that 48 of them contained 140 grasshoppers, of which 105 were adult; six stomachs contained eight field crickets.

Say's Phoebe (Sayornis saya).--Four of the seven stomachs examined contained nine adult grasshoppers.

Western Wood Pewee (Myiochanes richardsoni richardsoni).--Two of the three stomachs examined each contained one adult grasshopper.

Desert Horned Lark (Octocoris alpestris leucolaema).--Examination of 62 stomachs showed eight to contain 16 Orthoptera, 14 adult and one nymphal grasshopper and one sand cricket.

Barn Swallow (Hirundo erythrogaster).--Fifty-four stomachs examined contained two recognizable field crickets and one snowy tree-cricket.

American Magpie (Pica pica hudsonia).--Only one of 16 juvenile magpie stomachs examined contained a grasshopper.

American Raven (Corvus corax sinuatus).--Often seen to feed upon Mormon crickets in Tooele and Juab Counties during recent years.

Rock Wren (Salpinctes obsoletus obsoletus).--Of the seventy-four stomachs examined, thirty contained 59 grasshopper adults and one nymph.

Western Mockingbird (Mimus polyglottos leucopterus).--Two stomachs contained one nymphal and four adult grasshoppers.

Catbird (Dumetella carolinensis).--One of two stomachs collected at Hooper contained two grasshoppers.

Sage Thrasher (Oreoscoptes montanus).--Thirty-nine stomachs were examined, thirty-two of which contained 61 adult and six nymphal grasshoppers and five field crickets.

Western Robin (Turdus migratorius propinquus).--Eleven stomachs yielded three adult grasshoppers and one field cricket.

Mountain Bluebird (Sialia currucoides).--One hundred and fifty stomachs examined contained 142 Orthoptera; 92 adult and seven nymphal grasshoppers were in 62 stomachs; 43 field crickets in 20 stomachs.

American Pipit (Anthus spinoletta rubescens).--Twenty-one of the 78 stomachs examined contained 36 Orthoptera, all field crickets.

White-faced Glossy Ibis (Plegadis guarauna).--One specimen collected on meadows at Kanesville, July 23, 1940, contained two adult grasshoppers and one field cricket.

Western Red-tailed Hawk (Buteo borealis calurus).--Of seven stomachs examined four contained Orthoptera, totaling 56 adult grasshoppers and one sand cricket.

Northern Red-shouldered Hawk (Buteo lineatus lineatus).--One specimen, collected at Elgin, Utah, September 28, 1939, contained five adult grasshoppers. This is an unusual record for Utah.

Swainson's Hawk (Buteo swainsoni).--Four of the ten stomachs examined contained 77 adult grasshoppers; one bird collected at Benson, July 31, 1940, contained 68 of these.

Desert Sparrow Hawk (Falco sparverius phalaena).--This is the most abundant hawk occurring in Utah, more than a hundred having been observed in one day of field study on several occasions. An examination of 197 stomachs showed 2,699 Orthoptera still recognizable, besides large amounts of well-digested fragments consisting chiefly of grasshopper parts; 2,417 grasshoppers were still recognizable in 185 stomachs; 231 field crickets were contained in 49 stomachs; and 50 sand crickets in eight stomachs; one katydid also was present. Grasshopper counts were based on caudal ends of abdomens as more of these were recognized than were heads or other parts. Evidently this bird takes the abdomen from many grasshoppers not entirely consumed, especially in areas where grasshoppers are abundant and easily captured.

Sage Grouse (Centrocercus urophasianus).--Three were collected in Mormon cricket areas; one contained 35 and another four Mormon cricket eggs; the other contained one sand cricket.

Ring-necked Pheasant (Phasianus colchicus torquatus).--Of ten examined, eight contained grasshoppers in either crop or gizzard, the total number being 13; one was a nymph.

Killdeer (Oxyechus vociferus vociferus).--Of five stomachs examined, two contained a total of five adult grasshoppers.

Western Willet (Catoptrophorus semipalmatus inornatus).--The one specimen collected contained one grasshopper.

California Gull (Larus californicus).--One specimen was taken on Tintic Mountain in 1940 in an area where from a few hundred to an estimated 2,000 gulls frequently were observed to congregate and feed upon Mormon crickets; the stomach of this specimen contained twelve mature Mormon crickets which constituted 100 per cent of the contained food. This stomach was very large and distended, filling most of the abdominal cavity of the bird.

Road-runner (Geococcyx californianus).--One specimen was collected at St. George on September 18, 1935; it contained three adult grasshoppers.

Burrowing Owl (Speotyto cunicularia hypugaea).--One specimen collected at Midvale, Utah, October 11, 1936, contained one grasshopper and one mouse.

Nevada Shrike (Lanius ludovicianus nevadensis).--Twenty-six stomachs were examined, 21 of which contained 55 adult and two nymphal grasshoppers, four field crickets and one sand cricket.

Western Meadowlark (Sturnella neglecta)--Forty-four of the 83 stomachs contained Orthoptera,39 containing 73 adult and 6 nymphal grasshoppers; five field crickets and one sand cricket also were present in the additional five stomachs.

Yellow-headed Blackbird (Xanthocephalus xanthocephalus).--Two of the twelve stomachs collected contained three grasshoppers.

Thick-billed Redwing (Agelaius phoeniceus fortis).--Fifty-seven stomachs contained six grasshoppers in five stomachs and two field crickets in another.

Brewer's Blackbird (Euphagus cyanocephalus cyanocephalus).--One-hundred-five stomachs were examined; 40 contained Orthoptera, including 51 adult and 9 nymphal grasshoppers in 30 stomachs; the other ten stomachs held 16 field crickets.

Bullock's Oriole (Icterus bullocki bullocki).--One of the three stomachs examined held an adult grasshopper, another a nymph.

House Finch (Carpodacus mexicanus frontalis).--Of the 32 stomachs examined only one contained an Orthopteron - a grasshopper.

Western Vesper Sparrow (Pooecetes gramineus confinis).--Twenty of the 68 stomachs contained 32 adult and three nymphal grasshoppers. Several birds were collected while they still held a grasshopper in their beaks.

Western Lark Sparrow (Chondestes grammacus strigatus).--Fourteen of 17 stomachs examined held 28 adult and 7 nymphal grasshoppers.

Sage Sparrow (Amphispiza nevadensis nevadensis).--Of sixteen birds collected, one contained four grasshoppers.

Western Chipping Sparrow (Spizella passerina arizonae).--Of 207 stomachs examined, 15 contained Orthoptera, consisting of 15 adult and 5 nymphal grasshoppers and one field cricket.

White-crowned Sparrow (Zonotrichia leucophrys leucophrys).--One grasshopper nymph was the only Orthopteron in the 68 stomachs examined.

Gambel's Sparrow (Zonotrichia leucophrys gambeli).--Twenty-eight of the 92 stomachs examined contained a total of 37 Orthoptera, all adult grasshoppers.

Virginia

James McDonald Grayson: Virginia Polytechnic Institute, Blacksburg, Va.

Studies of some factors influencing coloration of the grasshopper, Melanoplus bivittatus Say. Based on portion of doctoral thesis 646 submitted July 16, 1941 to Iowa State College.

Experiments were conducted to determine the effects upon the coloration of the nymphs, and the color types of the adults of the two-lined grasshopper, of such factors as temperature, humidity, rearing many per cage as opposed to one per cage, the absence of light, and different colored lights. When reared at low temperatures the nymphs possessed more black pigment than when reared at high temperatures; however, at the higher temperatures there was found to be a tendency toward the production of dark phase adults. The nymphs reared under crowded conditions contained more black pigment than those reared one per cage; however, when reared under solitary conditions there was found to be a tendency toward the production of dark phase adults. No conspicuous differences were detected in the coloration of either the nymphs or the adults as a result of rearing them through the nymphal period in different humidities, in the absence of light, or under different colored lights.

Observations were made on the offspring arising from the mating of typical males and females of each color type. The results in the F_1 generation from these preliminary experiments indicated that the color type of the parent may be a factor in the determination of the adult coloration of the offspring.

Wisconsin

E. L. Chambers: State Entomologist, Madison, Wisconsin.

No very active control program of grasshoppers was carried on in Wisconsin during the past two years due to the reduced grasshopper populations and the abundance of green food in the limited areas infested. Because of the abundance of green food in the infested areas, the hoppers were not forced to migrate into cultivated crops.

Considerable numbers of grasshoppers appeared in a number of counties and in these some limited control measures were carried on, but these compaigns were handled with the usual procedure. The formula of the principal bait used consists of the following:

Sawdust	2 bushels
Whey	2 gallons
Sodium arsenite	1 quart
Water	1 gallon

During the past summer sodium fluosilicate was substituted for the sodium arsenite in one or two counties and the results seemed to be equally satisfactory.

The following publication was prepared and issued Jan. 26, 1938 by the Division of Entomology, Wisconsin Department of Agriculture and markets, State Capital, Madison, Wisconsin: "Fight the Grasshopper While There is Still a Fighting Chance."

Wyoming

B. Thomas Snipes: State Entomologist, Powell, Wyoming.

Grasshopper control on a field basis was continued during the past year by power sprays. Initial experiments were begun along these lines several years ago by Mr. Corkins. Unfortunately, from a research standpoint, this work does not permit of clean-cut reports or warrant the drawing of conclusions based on comparative data. A fairly large number of farmers and ranchers in the Big Horn Basin area annually follow the practice of spraying for grasshopper control in alfalfa fields.

A straight zinc arsenite solution composed of three pounds per hundred gallons of water is used. No sticker is added. The spray solution is used at the rate of 100 to 150 gallons per acre. Applications are made to the borders of fields or to the entire fields as necessity requires.

Texas

F. B. Isely, Trinity University, San Antonia, Texas

Work is being continued on the projects begun some time ago. These projects are concerned with a study of the distribution of Orthoptera in relation to environment, and food specificity and habits of grasshoppers as revealed in cage studies.

Oklahoma

Charles H. Brett: Oklahoma Agr. Exp. Sta., Stillwater, Oklahoma.

A Study of the Migratory Grasshopper, Melanoplus mexicanus (Riley)

During the past four years a study of the interrelated effects of temperature, relative humidity, and certain foods on the mortality of nymphs, the time required to reach maturity, and the biometry of the adults of the migratory grasshopper Melanoplus mexicanus (Riley) has been conducted. This project, originally begun at the Kansas Experiment Station, is now being conducted as a cooperative project between the above and the Oklahoma Experiment Station.

Four rearing compartments equipped with electrically controlled temperature and humidity regulators are used. During a single rearing phase, all of these compartments are held at the same constant temperature with the humidity varied in each of them progressively at 20%, 35%, 50%, and 65%. At the present time significant records have been obtained with these humidities at temperatures of 75°F, 80°F, 85°F, and 95°F. Such records are complete for rearings on head lettuce and alfalfa and partially complete for rearings on Reid yellow dent corn and Atlas sorgo. It is planned to continue similar rearings at 100°F.

Many interesting results have been obtained. A few of these may be mentioned here in brief. There is a definite tendency for nymphal mortality to decrease at low temperatures with low humidity and at high temperatures with high humidity, the minimum mortality being at 75°F-20% humidity and 95°F-50% humidity. At 80°F, 85°F, and 35% humidity there is no great variation. The time required for nymphal development decreases as temperature increases, a fact which has often been shown experimentally; however, an exaggeration of this occurs as humidity rises. At the higher humidities, a greater period of time is required at low temperatures and a shortened period of time at high temperatures.

A slight increase in wing length occurs at the higher temperatures, but it appears to be only in proportion with the increase in body weight. A very striking variation in wing length has been observed in the case of those individuals reared on common alfalfa cuttings at low temperatures and high humidities. Here in many instances the wings are very poorly developed, reaching a length of about 6 millimeters as compared with a normal wing length of from 17 to 20 millimeters. This condition has been observed in grasshoppers found in alfalfa fields by myself and others, I venture the opinion that alfalfa being an attractive crop and at the same time one which is not suited to the maximum development of the migratory grasshopper, may play some part in the prevention of outbreak populations. Individuals reared on alfalfa are almost invariably small, lack fecundity and suffer a high mortality rate.

In addition to the above mentioned measurements, records are also kept on the length of the posterior femur, width of the head, length and height of the pronotum and its width at the constriction. It is hoped that a step forward will be made in our knowledge of the migratory grasshopper by this attempt to correlate body measurements with development and climatic factors.