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The attention of learned societies and other institutions which exchange scientific publications with the University of Kansas is called to the list of publications of this University on the third and fourth pages of the cover of this issue.

Those marked "Supply exhausted" cannot be furnished at all; those marked "Supply small" cannot be furnished separately; those marked "Supply large" will gladly be furnished to any of our exchanges who may need them to complete their files.

Back numbers of the *Kansas University Quarterly* and *Geological Survey,* as far as possible, will be sent to those of our newer correspondents who are able and willing to reciprocate.

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LIBRARY NEW YORK BOTANICAL GARDEN

The Cicadellidæ of Kansas.*

BY P. B. LAWSON.

INTRODUCTION.

The first attempt to make a list of the *Cicadellidæ* of Kansas seems to have been made by Professor E. A. Popenoe, who in 1885, in the Transactions of the Kansas Academy of Science, vol. IX, p. 63, listed a few of the members of this family that he had personally collected in the two preceding years. Nothing more seems to have been done along this line till the year 1905, when there appeared a list of the Kansas species in the Transactions of the Kansas Academy of Science, vol. XIX, p. 235, by Mr. F. F. Crevecœur, in which some eighty species and varieties were reported, nearly if not all of them taken by himself, within a few miles of his home at Onaga, Kan. He was followed by Mr. E. S. Tucker, who in 1906, in vol. XX, part 2, p. 192, of the same publication, added twenty-three species to Mr. Crevecœur's list, all of these species being taken in Douglas county. A fourth list was published in 1907 by the same writer in the Kansas University *Science Bulletin*, vol. IV, p. 65, where were listed the species taken by him in Douglas and Sedgwick counties. And finally, in 1911, there appeared a complete list of all the *Cicadellidæ* taken in the state to date, by Mr. S. E. Crumb, who published his list, along with available host plant records, in the Transactions of the Kansas Academy of Science, vol. XXIV, p. 232.

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* Submitted to the Department of Entomology and to the graduate faculty of the University of Kansas in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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It would seem that with five lists already published of the Cicadellid fauna of the state, that some other group might well have been chosen for further work. State lists, such as the ones referred to, are of great value to systematic entomologists in determining the geographical distribution and limits of the species enumerated, but to the beginner, who starts out to get acquainted with the fauna of a given region, they cannot be of much help, other than to inform him that he might or ought to run across the species so listed. Accordingly we have thought that a systematic treatise of the known Kansas forms might not be out of place.

It has been our aim to make this paper something more than a state list. The attempt has been made to provide, rather, a sort of manual for the study of our native forms. Accordingly keys have been provided for the separation of all the groups down to species, descriptions have been written for all the species known to occur in the state, and, as far as possible, host plant and locality records have been added to assist in the finding of any desired species.

We have, moreover, attempted to bring together our latest knowledge concerning the economic importance of this family. Many articles have been written on this subject, but each treats only of some particular phase of it. It has been thought that a summing up of our knowledge on this subject might help to a correct appreciation of the economic position of this group.

The systematic position of this and of related families is of interest to the systematist. We have not tried to advance any essentially new ideas on the subject, but have thought it advisable to give what seem to be the prevailing ideas on this line.

No attempt has been made to give a detailed description of the morphology of the *Cicadellidæ.* We have included only a brief chapter on this phase, just enough to enable one to properly use the keys and understand the descriptions. But we have gone rather fully into a study of what we have called the "internal male genitalia." This is what may properly be considered the original part of this paper, and therefore we have devoted a whole chapter to its discussion.

It should be said here that the list of species is by no means complete. We know of some species, previously listed as occurring in the state, which are here omitted. This has been done because of what seem to have been doubtful determinations. We have endeavored to exclude every species of the occurrence of which in the state we had any doubt. Accordingly we have practically confined ourselves to the species represented in the Snow collection at the University of Kansas. There are other collections in the state which will yield additional records. It is our purpose to examine these as soon as possible and add to this list. Among others, the collection of the Kansas State Agricultural College and Crevecœur's collection will yield further records, as will the private collections of Prof. Herbert Osborn and others who have collected in the state. These all should have been included in this paper, but a combination of circumstances seems to have made it impossible.

We have, however, included in the keys, and given descriptions of a goodly number of species, which, judging from their known occurrence, are likely to be found in the state. We believe this will add to the usefulness of the paper.

The question of bibliographies has proved to be a troublesome one. It was finally decided to give a rather full bibliography for each species, but to omit, except in cases where the bibliography was brief, the mere lists and those papers which do not distinctly add to our knowledge of the group. Accordingly we have chosen our bibliographies with a view to showing the course of the synonomy of the species, and to those papers which give information as to life history, food plants, economic importance and control, and those which give figures illustrating the species. In addition we have tried to include a list of the papers which have appeared since the publication of Van Duzee's catalogue.

ACKNOWLEDGMENTS.

This paper was started and completed under the direction of Prof. S. J. Hunter, head of the department of entomology in Kansas State University. To him the writer is greatly indebted for making this work possible and for his ever readiness to help with suggestion or with needed equipment or material. Dr. H. B. Hungerford, of the same department, has also been keenly sympathetic and helpful during the carrying on of the work.

Prof. Herbert Osborn kindly determined much material for me, as did Dr. E. D. Ball. I am especially indebted to the latter for much help received from him during a period of six weeks spent at Ames. During that time he gave me many helpful suggestions out of his large acquaintance with this group, and turned over his whole collection and library, as well as the collections of the Iowa State Agricultural College, for my use and study. I was thus enabled to examine many of the Osborn and Ball types, Doctor Ball's individual types, and as many of Van Duzee's types as are in the college collection. It would be hard to conceive of any one being more free and ready to help with the results of their years of labor and study.

Needless to say, many papers on the *Cicadellidæ* have been freely used. The bibliography given would have been impossible without Van Duzee's wonderful catalogue, with the exception here and there of a few papers on the economic phase, and of the papers which have appeared since the catalogue was issued. Besides the catalogue, we have used freely the papers written jointly by Osborn and Ball, as well as the individual papers of each. Van Duzee's writings on the family have been very helpful, as have De Long's paper on the Tennessee species and on the genus *Chlorotettix*.

The writer was fortunate to start his study of this group with a very large collection already gathered together from all over the state. Credit should be given to several of those whose locality records are here being used. Prof. F. H. Snow's name appears on many of the specimens collected in Kansas. The records of Pottawatomie county are practically all those of Mr. F. F. Crevecœur. Mr. E. S. Tucker took many species from

Sedgwick and Douglas counties. Mr. S. E. Crumb made large collections from Douglas and Cherokee counties. Mr. F. X. Williams should have credit for the specimens taken in most of the extreme western and northwestern counties. Mr. R. H. Beamer collected many species, especially in the southeastern counties. Dr. C. P. Alexander also collected several species, chiefly in Reno and Hodgeman counties. The records from Riley county, as well as several others, were sent me by Dr. M. C. Tanquary, of the Kansas State Agricultural College. Unfortunately this list was not received in time to be fully incorporated in this paper.

Thanks are also due to Miss Gertrude Standing for her great help in typewriting this paper. To these, and to all who in any way assisted with the work, the writer is greatly indebted.

Economic Importance of the Cicadellidæ.

The relation of the *Cicadellidæ* to problems of economic importance has received a very varying degree of attention from entomologists. The Homopterists, and especially those who have studied this particular family, have always been more or less forward in calling attention to their destructiveness. On the other hand, many entomologists have had their attention so taken up with insects whose damage has been so much more evident that they have regarded the *Cicadellidæ* as having very little bearing or relation to real economic entomology. But it is not our purpose to say that the one group has been too enthusiastic, and the other too reticent, in recognizing the true economic position of these forms. It is our purpose merely to discuss the problem in the light of our present-day knowledge, and let the reader decide which group is right, or whether each is but partly right.

The damage done by the *Cicadellidæ* is that of puncturing the tissue of the leaf or stem of a plant, and then with its efficient little mouth parts sucking up the plant juices. Because of this means of feeding, the damage is seldom seen, certainly not by the casual or superficial observer. The work of insects with biting mouth parts, on the contrary, is readily seen, for the host plant soon is distorted or destroyed by the biting out of portions of the leaves or stems. Thus the work of grasshoppers, beetles, etc., is soon manifest, even though they be present in relatively small numbers. The results of the feeding of a large number of *Cicadellidæ* on a plant may not be noticed, however, till the plant is beyond rescue, for it will retain its form until pumped dry and the leaves begin to curl up and fall.

There are other reasons, too, why these insects escape notice so often, even though doing damage. In the first place, they are very small, not small as all insects go, but small as compared with the insects which the ordinary person usually observes, and in comparison with many of our main economic pests. They vary considerably in size, many being under 3 mm. in lengt[1] while others, especially South American species, may reach 18 or 20 mm. in length. Our largest forms are about 14 mm. in length, or slightly over half an inch, while our smallest forms are close to one-twelfth of an inch long. The majority or our species run from three to seven millimeters in length, or from about one-eighth to one-fourth of an inch.

Their small size, coupled with the fact that they usually remain on the under side of the leaf or blade of grass, accounts very readily for their so easily escaping detection. Then, too, as a rule, they are protectively colored, that is, they usually greatly resemble their surroundings in color. Thus a green species on a green blade of grass may not be seen even though in full view, and when one is looking straight at it. In some species also the art of camouflaging seems to have reached perfection. Though the general colors may not correspond very well with those of the host plant, yet there is a stripe here or a spot there which seem to be present solely for the purpose of making the insect invisible, at least such is their effect. Some species also, such as *Dorycephalus*, show clearly an adaptation of form, as well as color, to their environment. Sitting on a head of *Elymus*, they so greatly resemble their surroundings as to be practically invisible, and according to Professor Osborn a head of the host may be carefully examined and reveal no insect until it is shaken loose.

Frequently, too, the damage done by this group of insects is attributed to other insects or to the attacks of fungi. Usually the result of the continued sucking of the life juices of the plant results in more or less discoloration of the plant cells around the puncture. These spots often resemble the spots produced by other insects and may often be mistaken for the presence of some fungous disease. Professor Osborn points out the fact that the work of species infesting grasses and grains may be readily confused with the work of aphids or thrips, but that usually the aphids do not discolor nor produce spots on the infested plant, at least during the early stages, while the injury of the thrips is indicated by small dots or lines which usually run parallel with the leaf veins and remain white. The spot produced by the leaf hopper, on the other hand, while at first pale, later changes to a brown or black color. Furthermore, if the leaf hoppers are the guilty parties, the fact will usually be recognized by the presence of their molted skins, some of which, at least, will usually be found clinging to the leaf or grass blade.

The injury to plants by the *Cicadellidæ* may be divided into two groups. First, the sucking of the plant juices till the plant is killed or its vitality so reduced as to result in a reduced yield of food or fruit. Second, the transmission of plant diseases. Much work has been done on the former group by Professor Osborn, and on the latter by Doctor Ball. In the following discussion I have drawn very largely from the work done by them.

The matter of the reduction of the yield due to the sucking of the plant juices, is rather a peculiar one. Or perhaps it reveals a rather peculiar turn of mind in mankind. I believe it shows that there is still a great field of development for economic entomology and a field which should receive much attention.

In the main, agriculturists and many entomologists have turned their attention to fighting those insect pests which do very visible and usually a very serious amount of damage. The average farmer will at once notice a pest that will destroy, in a mass, several rows of his corn. Or he would notice at once, and fight with all his energy, anything that picked out about every tenth hill and utterly destroyed it, though not touching the other nine hills. But the same man seemingly pays no attention to any pest that reduces in the aggregate the yield of the whole field to the amount that would have been produced by the destroyed rows or by the every tenth hill, as long as he sees no very apparent and severe damage and the field as a whole seems to be doing fairly well. The same would apply to wheat and oats, rye and barley, alfalfa and clover, prairie hay and pasture. The question ought to be, not how much did the field raise, but what could such a field yield if no damage whatever be done by injurious insects?

No matter what the crop, or what any one's views may be as to the damage done by leaf hoppers, all must agree that every little bug takes some of the life juices that belong to the plant, and that this multiplied by hundreds or thousands cannot but help reduce the yield of the crop infested. So it is with this thought in mind, namely, that we ought to strive after the best possible yields, yields not hampered nor reduced by insect pests, that we turn to discuss the damage done by leaf hoppers to the various crops.

The damage done by reducing yields may be divided into four heads:

1. Damage to forage crops and pastures.
2. Damage to grains.
3. Damage to orchards, vineyards and gardens.
4. Damage to shade trees and ornamental plants.

The total value of our forage crops would be hard to estimate and also to overestimate, for under this head would come the leguminous crops such as the clovers and alfalfa, the hay crops both wild and cultivated, and the immense amount of food furnished by pastures. The following table, copied from Hitchcock's textbook on grasses, will give some idea of the tremendous importance of such crops in a single year, 1909:

	Acres.	Production (Tons).	Value (Dollars).
Timothy alone	14,686,393	17,985,420	188,082,895
Timothy and clover mixed	19,542,382	24,748,555	257,280,330
Clover alone	2,443,263	3,158,324	29,334,356
Alfalfa	4,707,146	11,859,881	93,103,998
Millet or Hungarian grass	1,117,769	1,546,533	11,145,226
Other tame or cultivated grasses,	4,218,957	4,166,772	44,408,775
Wild, salt or prairie grasses	17,186,522	18,383,574	91,026,169
Grains cut green	4,324,878	5,367,292	61,686,131
Coarse forage	4,034,432	9,982,305	46,753,262

Thus we find nearly 75 million acres of land devoted to producing forage crops, yielding annually nearly one hundred million tons valued at over 800 millions of dollars. For today all these figures, especially that of the value, must be decidedly low. Then too they do not include the immense value of the forage produced by the millions of acres of pastures.

The amount of loss to such crops due to insects is hard to estimate and it is still more difficult to correctly determine the amount of injury due to one group of insects when there are many different kinds infesting the crop. But we are perhaps safe in saying that by far the most numerous and widespread of the insects affecting such crops are the leaf hoppers, and that a goodly share of the shrinkage in such crops, due to insect pests, is due normally to these forms. It will require much more accurate and persistent experimenting than has yet been done to enable us to be at all dogmatic about the exact relation of the *Cicadellidæ* to the forage crops, but yet, thanks largely to Professor Osborn's work, we can safely accept some facts, while holding others in abeyance till further work is done.

The seriousness of the damage to the forage crops depends of course on the number of leaf hoppers present. Not much has been done to get accurate data concerning their numbers, but Professor Osborn has found that frequently the numbers run up far above a million per acre, and he is of the opinion that in such grasses as timothy and blue grass, a million per acre would not be putting the figure too high. In work on the potato-leaf hopper Doctor Ball has found that in the period of their greatest abundance several million leaf hoppers may be found to an acre of potatoes.

Then, as to the amount of food taken by this number of leaf hoppers from the plants of that acre, and the resultant depreciation in weight of the amount of hay cut, we again have no definite figures because of the lack of experimentation. But after years of observation, Professor Osborn gives as his opinion that in some cases at least, from 25 to 50 per cent of the growth of such grasses may go to feed the leaf hoppers.

In Bulletin 248 of the Maine Agricultural Experiment Station, Professor Osborn gives some idea as to the leaf-hopper damage to the hay crop of that state. In 1913 there were 1,194,000 acres of hay in the state, which yielded about a ton of hay per acre, the value of the crop being over sixteen and a half million dollars. That acreage should have produced two to three times as much as it did, and if leaf hoppers are responsible for even ten per cent of such shrinkage, their damage becomes very serious and their control should call for serious attention. Applying these figures to the hay crop of the entire country, we see that at the very conservative estimate of a ten per cent loss, the leaf hoppers reduce the hay yield by at least ten million tons, valued in 1909 at about 80 millions of dollars and to-day at perhaps fully twice that sum. Thus these insignificant little creatures become a cause for real consideration, for at the very least, if the above estimates be anywhere near the truth, we can safely accuse them of causing an annual loss of 100 million dollars to the hay crop.

But there is still more to this problem than the mere decrease in yield. Professor Osborn, in the above-mentioned bulletin, also considers the effect upon the quality of hay produced, and shows that hay that has escaped the attacks of such insects is of much more value than a similar amount of hay that has been infested by them, for the former seems to show a distinctly higher percentage of protein and fat than the latter. If further investigations along this line confirm this, it makes the case against the leaf hoppers even more serious.

Attention should be called at this point to the fact that all the above figures apply only to the cultivated forage crops. Pastures are injured fully as much, if not more, than all the cultivated crops. But even if we apply the same figures as the above, and accuse the leaf hoppers of reducing the value of the pastures by ten per cent, we add to their debt a tremendous figure, for the value of such pastures is very great.

The species concerned in damaging forage crops are many, but several stand out as distinctly more serious than the rest. Seriously injurious to the leguminous crops is *Aceratagallia sanguinolenta,* commonly called the clover-leaf hopper. Gibson states that as many as 600 of these have been counted on a single plant, and that aside from the drain upon the plant the egg punctures cause gall-like formations in the surrounding tissue. *Empoasca mali* is also accused of being sometimes injurious to this crop. *Dræculacephala mollipes* is to be considered a serious pest of grasses as well as of grains. Others of great importance are *Deltocephalus inimicus, affinis, sayi, balli, Euscelis exitiosus, Phlepsius irroratus,* and *Cicadula 6-notata.* All the above are very common in Kansas. In some parts of the country *Dræculacephala reticulata* and *noveboracensis, Deltocephalus configuratus, Acocephalus striatus* and *albifrons,* and *Helochara communis,* the last in low lands, are also considered as more or less injurious to grasses. In central and western Kansas the native pastures, composed largely of *Bouteloua* and *Buchloe,* are very heavily infested with various species of the genus *Aconura.*

Coming now to the relation of leaf hoppers to the grain crops, we find many instances where wheat, oats, corn, rye, and barley have been injured. In Bulletin 108 of the United States Department of Agriculture, Professor Osborn gives a list of recorded serious damage by these insects. The sharp-headed grain leaf hopper, *Dræculacephala mollipes,* is undoubtedly the most serious of such forms, but such species as *Dræculacephala reticulata, Deltocephalus inimicus, Euscelis exitiosus,* and *Cicadula 6-notata* have also been recorded as doing some damage.

The damage to orchards, vineyards and gardens is perhaps not as serious as the damage to the forage crops and grains, yet here too we find serious damage at times. Few of our fruit trees are at all seriously infested with leaf hoppers. About the only species that seem at all troublesome are *Empoasca mali* and *Typhlocyba rosæ.* The former Mr. F. H. Lathrop reports as injuring apple, which it infests along with *Empoasca unicolor* and *Typhlocyba rosæ,* producing "a severe and characteristic curling of the foliage and resultant injury to the tree." The damage done by *Typhlocyba rosæ* is described by Mr. Leroy Childs as follows: "The insects during their twenty-nine to forty days of nymphal development are constant feeders, and when present in numbers are capable of removing much food that would otherwise be utilized by the plant. One insect feeding continually on an apple leaf during this period removes or destroys from one-third to one-half of the green chlorophyll. Four or five insects have been observed to remove, with the possible exception of a narrow green margin on the edge, the entire green coloration of the leaves. An injury of this extent, in the case of a general infestation over the tree, noticeably inhibits normal functioning of the leaves. Trees so infested appear yellowish-brown during late summer and are much below normal in vigor.

"The insects confine their feeding to the under surfaces of the leaves entirely. The first indication of their presence is the appearance of yellow spots on the upper surfaces of the leaves. As feeding continues these spots become larger and more numerous until the leaf shows a decided greenish-yellow coloration. Leaves so injured are deprived from further functioning and their presence on the tree only further devitalizes it by acting as surfaces for evaporation. In cases of a severe infestation many of the injured leaves drop prematurely during the latter part of August."

Other fruit trees, such as plum trees, are frequently infected with leaf hoppers, but no appreciable damage seems to result.

The damage to vineyards by several species of leaf hoppers is very severe and either involves the outlay of considerable expense for spraying or else greatly reduces the amount and quality of the crop as well as lowering the vitality of the vines. The chief species concerned here is *Erythroneura comes* and its several varieties, although *Erythroneura tricincta, illinoiensis, obliqua, crevecœuri* and others are frequent feeders on the grape. The bulletins by Slingerland, Quayle, Hartzell and Johnson fully deal with the damage and control of these forms.

Leaf hoppers as a group do not seem to injure garden crops seriously. But there are a few species that at times do serious damage. Notably injurious here is *Empoasca mali,* which is a serious pest of such crops as beans and potatoes. Here also comes the injury to sugar beets by *Eutettix tenellus.* The injury by these species in this case, however, has to do with the relation of leaf hoppers to plant diseases, and will therefore be discussed under that head.

In the cotton-growing region several members of the subfamily *Cicadellinæ* have been considered injurious to the cotton, though Sanderson seems to doubt their having any effect on the plant. The supposedly injurious forms here are *Homalodisca triquetra, Aulacizes irrorata* and two species of *Oncometopia.* Essig gives *Cicadella atropunctata* as injurious to such plants as blackberry, grape, lemon, orange and raspberry.

It can perhaps hardly be said that leaf hoppers are injurious to shade trees. While a large number of species normally live on trees, and others at times may infest them, yet no really serious injury seems to have been reported. Thus the members of the genus *Idiocerus* are largely confined to willows, cottonwood and *Cratægus. Cicadella hieroglyphica* and its varieties, many species of *Macropsis* and some species of *Empoasca* occur on willow. *Bythoscopus apicalis* is confined to honey locust. *Oncopsis distinctus* lives on walnut, a *Scaphoideus* on elm, *Typhlocyba lethierryi* on hard maple. The nearest to real injury to shade trees ever seen by the writer was observed on noticing the decolored condition of the leaves of a young sycamore tree. On examination the leaves were found to be heavily infested by an *Erythroneura,* the damage being very similar to that of the grape-leaf hopper to the grape.

The damage to ornamental plants also is not very serious. Few cases are recorded of any such damage. It is sufficient perhaps here to note the work of the rose-leaf hopper which, in parts of the country, seriously injures rose bushes, the damage being similar to that on the apple by the same species. The writer has noticed a few leaf hoppers in greenhouses but seemingly they are never present in large enough numbers to demand attention.

When we turn, however, from the damage done by the *Cicadellidæ* by the mere sucking up of the sap of the plant, to the possible and proved relations of the insects to the transmission of plant diseases, we enter at once an open and a very important field. We will discuss this phase of the economic importance of the group under the following heads:

1. Leaf hoppers and bacterial diseases.
    a. Leaf hoppers and curly-leaf.
    b. Leaf hoppers and fire blight.
2. Leaf hoppers and hopperburn.
3. Leaf hoppers as possible disseminators of fungous diseases.

The relation of leaf hoppers to the transmission of bacterial plant diseases opens at once a very large and important field. Who knows but what these and related insects are responsible for many of the diseases that have hitherto baffled the plant pathologist and been the despair of the farmer and horticulturist?

Doctor Ball's excellent work has opened up the way for the future on this line. He seems to have proved definitely that such insects may be the normal disseminators of plant diseases, just as, in the case of the mosquito, they are responsible for spreading animal diseases. After years of work on the beet-leaf hopper and its relation to curly-leaf in the sugar beet, among others, the following facts, quoted from his bulletins, were proved:

"The punctures of the beet-leaf hopper (*Eutettix tenellus*) cause a specific disease in sugar beets called 'curly-leaf.'

"Leaf hoppers taken from wild plants did not transmit the disease until they fed on diseased beets. Three hours on a beet rendered them pathogenic, but they could not transmit till after an incubation period of one or two days.

"Curly-leaf has never been produced except through the punctures of a beet-leaf hopper. If a single leaf hopper is applied to a beet for five minutes, the curly-leaf disease will appear after about two weeks, if conditions are favorable."

The above facts, added to the fact that the bacterial agent, *Bacillus morulans*, has been isolated by Boncquet, show conclusively that these insects may be responsible for similar plant diseases. And since the amount of damage done in such cases is very large, the field should prove both interesting and important.

Not very much has been done on the relation of insects to the transmission of *Bacillus amylovorous* which causes "fire blight." Doctor Merrill has worked on the relation of aphids to the spread of this disease, and Mr. F. H. Lathrop has done some work on the relation of *Empoasca mali* to the same disease. The latter reports that while in the tests *Empoasca unicolor* and *Typhlocyba rosæ* showed negative or doubtful results, *Empoasca mali* seemed to be a positive agent in the spread of the bacteria and in the infecting of new shoots. Should this work be confirmed we would have a practically untouched field opened to us, which, with careful work, might better enable us to be victors in the fight against this serious disease.

But we are not yet through with *Empoasca mali*. Again it is under indictment, this time for producing what should be called "hopperburn," especially on potatoes. Here again we are indebted to Doctor Ball, who seems to have shown that this insect produces much of what in the past has gone under the name of "tipburn." Furthermore, that hopperburn is perhaps a disease similar to curly-leaf, and that it differs from tipburn by readily-told characteristics, the latter being the result of purely physiological conditions. In the past two summers great damage has been done by this disease, if such it shall prove to be, but for which this leaf hopper alone seems responsible.

Again, leaf hoppers may prove to be disseminators of fungous diseases. Any insect of course may play this rôle, but because of their feeding and egg-laying habits, combined with their jumping disposition, they seem to be especially suited to transmit such fungi from plant to plant and thus spread the disease. This is a field as yet untouched that might yield discoveries of importance to the agriculturist and horticulturist.

Perhaps this discussion of the economic importance of the group would not be complete without a brief résumé of the methods of control. This consists in using natural farming methods and spraying. The chief ways to control the species damaging forage and grain crops would be those of rotation and clean farming. These of course are the best for the soil and are also the way to check insects. Most of such forms hibernate in the egg stage under the sheath of the grass blades. If therefore the places where such grasses occur, such as the fence and hedge rows, the corners, and land adjoining fields, be burned over in the winter, there will follow a great diminution of the hoppers the following season. Pastures especially should be burned over once in two or three years if they are seriously infested with these insects. The time of planting certain crops, and the time of mowing grasses may be so regulated as to result in escaping serious injury from the leaf hoppers. Thus Gibson reports that cutting the alfalfa crop from a week to ten days earlier will often check the clover-leaf hopper. If a crop is mowed so as to catch most of the leaf hoppers in the egg or nymphal stage the majority of the eggs will be destroyed and most of the nymphs will starve before they can migrate to other food.

Hopperdozers are sometimes used as direct controls to catch and destroy large numbers of the leaf hoppers when they are present in unusual numbers.

In the case of grain fields best results are obtained by plowing as soon after harvest as possible and then keeping the ground free from grass and weeds till planted. This, combined with rotation and clean farming around the edges, would be insurance against leaf-hopper damage. The beet-leaf hopper is also controlled by cultural methods.

The leaf hoppers in vineyards are mainly controlled by spraying, though hopperdozers are sometimes used. The usual spray material is "Black Leaf 40," 1 part to 1,500 or 1,600 parts of water, applied at the time of the presence of the maximum number of nymphs. Doctor Ball gives the same contact insecticide for the control of *Empoasca mali* on potatoes, using it at the rate of one pint to 100 gallons of water with five pounds of soap added, two applications to be made a week or ten days apart. The rose-leaf hopper and forms doing similar damage can be controlled in the same way. Mr. Childs suggests also the use of the rose as a trap crop in the control of the latter as an apple pest.

At this point we may also call attention to another bad habit of *Empoasca mali.* In Psyche, XXV, p. 101, 1918, Mr. George Becker called attention to this species attacking man. The writer has had several people tell him about being bitten by little green leaf hoppers, but not till a short time ago did he have any personal proof of the fact. One night, while collecting under a light, he felt a little prick on his hand, and on looking down saw a little green leaf hopper at work. It was secured and proved to be the species mentioned.

The matter of such biting brings up an interesting question, for so few of the Homoptera have ever been known to be guilty of such conduct. In fact, outside of the occasional piercing of Cicadas, the writer does not know of any other members of this order that have been recorded as attacking man. Whether they merely prick the skin because it is their nature to be piercing something or whether they are really fond of an occasional meal of blood would be an interesting question for determination.

From the foregoing discussion of the economic importance of the group it will be seen that it is necessary to know which are injurious species and which are not. Hence the value of a systematic study of the group and an acquaintance with its forms, so as to be able to single out those of economic importance.

Life History.

The life histories of a majority, even of the economic species of *Cicadellidæ,* have not been fully worked out. Some have, however, been worked out in detail, so that it is fairly easy to give a general life history for the group.

These insects belong to an order in which the metamorphosis is incomplete, that is, there is no distinct pupal or quiescent stage in the life cycle. It would, however, be better to speak of them as having a gradual metamorphosis rather than an incomplete one, reserving the latter term, as pointed out by Professor Comstock, for such water forms as dragon flies, which do not resemble the adult at all in their imperfect stages and yet cannot be said to have a complete metamorphosis. Thus there are three stages in their life cycle, namely, egg, nymph and adult.

The female leaf hopper is provided with a strong enough ovipositor to enable her to push the eggs in under the covering of some plant tissue. There is of course a great deal of difference in the different groups, and even among the species of the same genus, in the kind of material chosen for egg deposition, it being the rule that the eggs are always deposited in the kind of plant which is to furnish food for the nymphs on emerging.

In general it may be said that grass-feeding species deposit their eggs either between the sheath of the blade and the stem, or else in the margin of the leaf, where a layer of epidermis covers the egg. In either case the eggs are protected by a part of the host plant. Other forms deposit their eggs in the veins of leaves or sometimes under the epidermis in the tissue between the veins. Such is the case with the grape-leaf hopper, the potato-leaf hopper and a host of others. Still others deposit eggs in the stems of their host plants. This is true of such forms as the rose-leaf hopper, the apple-leaf hopper (*Empoasca unicolor*) and others. Some, such as the clover-leaf hopper, deposit their eggs either in the leaves or the stems of their host plant. In a few cases also the same species may oviposit alternately in two different hosts. This has been shown to be the case with the rose-leaf hopper, the overwintering eggs being deposited in the rose, while the eggs for the second generation are deposited in apple. Here we seem to have a good case of alternation of hosts ~~generations~~, for only a very small percentage of these insects remain on the apple, their summer host, to deposit overwintering eggs. Of course where a species is a general feeder, it may oviposit in any of its host plants.

The eggs are usually whitish, elongate, and often slightly curved. Before they hatch the eyes of the nymphs are usually seen as distinct reddish spots.

Comparatively little is known concerning the number of eggs deposited by a single individual. In some cases the number seems to be quite low, while in others it is rather large. Some grass-feeding species deposit a few eggs together; others as many as fifty side by side. Osborn states that *Parabolocratus viridis* may lay as many as 120 eggs in a single hour. Of course eggs deposited under the sheaths of the grass blades are more readily found than those deposited in the leaf or stem. In the case of the latter, however, a blister-like swelling seems to develop around the eggs shortly after deposition, which helps in locating them, or the leaf may be held up to the sunlight and the eggs often discovered.

The period of incubation varies greatly in length. Eggs laid in the fall hatch the following spring or summer, the egg stage thus lasting several months. Eggs laid in the spring or summer hatch in varying lengths of time. Osborn gives an average of about a month for the duration of the egg stage of *Dorycephalus platyrhynchus,* and 10 to 17 days for *Deltocephalus inimicus.* Gibson gives 5 to 17 days as the length of the incubation period for eggs of *Aceratagallia sanguinolenta* during the summer in the latitude of southern Illinois, and from 3 to 35 days, with an average of 12 days, depending upon the temperature, for eggs of *Dræculacephala mollipes* in southern Arizona.

The nymphs are readily recognized as the young of Cicadellids, usually having more or less of the form of the adult except for the wings, though usually lacking most of the coloration of the adult till just before or after the last molt. During the nymphal stage the wings are represented by wing pads which gradually increase in size, but even just before the fifth or last molt they are much smaller than the wings of the adult.

Not only do the nymphs usually look like the adults, but they usually act like them too. They have the curious habit of running sidewise which is so characteristic of the family, and are also capable of jumping, as are the adults, though they are not as active as are the perfect forms.

The number of molts is usually, if not always, five. There are some records of but four molts in some forms, but if true, it is only so of a very few species. Molting occurs nearly always on the under side of the leaf, and here the molted skins may readily be found, for they are usually firmly attached to the leaf.

The length of the nymphal stage varies greatly in the different species. A few species overwinter as nymphs, in which case this stage lasts for several months. In summer, however, the nymphal stage usually lasts for several weeks. Thus Gibson gives 18 to 35 days, with an average of 25, for the length of the nymphal stage of the clover-leaf hopper, and 20 to 51 days, according to temperature, for *Dræculacephala mollipes* at Tempe, Ariz. Johnson gives from 19 to 37 days for the duration of the nymphal stage of the grape-leaf hopper in the Lake Erie valley. Childs gives above 35 days for the first brood nymphs of the rose-leaf hopper, and about 24 days for those of the second brood in Oregon. Osborn gives ten months as the length of the nymphal stage of *Dorycephalus platyrhynchus*, for this species overwinters as a nymph.

But very few attempts have been made to determine the length of the life of the adult. Childs, however, has given us some interesting data on this point. He found that the males of the first generation of the rose-leaf hopper die in from four to ten days after mating. Fertile females he found to live a month to a month and a half after mating, while unmated females live very much longer, some specimens being kept for 70 days, and a single one for 116 days, death in both cases being due to starvation. Individuals of the second brood were kept alive for 129 days. The unmated male, he states, lives a much shorter period. Of course it is well known that in the case of species which hibernate as adults, both males and females live several months.

The overwintering of the leaf hoppers is varied. Many pass through the winter as adults, a few as nymphs, and the majority perhaps as eggs. But no set rule can be given regarding the habits of any group, for even within the genus we do not find uniformity as to the condition in which hibernation occurs. Thus *Empoasca mali* overwinters as an adult, while *E. unicolor* hibernates in the egg stage. The nearest that we dare come to generalizing may be to state that the majority of species which oviposit in grass, pass through the winter in the egg stage, while a large number of those ovipositing in trees hibernate as adults. It seems, therefore, that the greater number of our forms overwinter in the egg stage.

The hibernating adults are often found under leaves and rubbish in the woods. This is especially true of many *Typhlocybini.* Of course where the winters are warm, we can hardly designate any stage as the hibernating stage, for under favorable circumstances they may breed throughout the year.

The number of generations per season is also an interesting question. Should we generalize we would say that the majority of species have two generations in a season. As to the rest, some undoubtedly have three or more generations, while some have only one. Thus Gibson claims three generations a year for the clover-leaf hopper in southern Missouri and four or more further south. Professor Osborn says there are two generations a year of *Dræculacephala mollipes* in Ohio, while Gibson claims six for southern Arizona. Others, like *Empoasca unicolor,* have but a single generation. Most members of the genus *Deltocephalus* have two broods, as do such forms as many members of the genus *Euscelis* and many of the *Typhlocybini.*

Natural Enemies.

In one of his bulletins Professor Osborn has given quite an extended account of the natural enemies of the leaf hoppers. We will do little more than to give the substance of this and of one or two other papers, for comparatively little work has been done on this line.

The natural enemies of the leaf hoppers may be divided into four groups, as follows:

1. Predaceous enemies.
2. Parasitic enemies.
3. Fungus diseases.
4. Climatic conditions.

The predaceous enemies of leaf hoppers do not seem to be an important means of control. Among such enemies are the birds, but even such active foes do not seem to be very efficient in controlling them. It has been found that while a goodly number of birds feed upon Cicadellids, yet in the aggregate such food forms but a small part of their dietary. Professor Osborn sums up the relation of birds to leaf hoppers as follows:

1. 119 species of birds are known to feed upon leaf hoppers.
2. Only 700 out of 47,000 bird stomachs examined contained leaf hoppers, or less than one out of every fifty.
3. The leaf-hopper content of a majority of these stomachs was only from 1 to 10 per cent, so that not more than one-thousandth part of the food of birds can be composed of leaf hoppers.

Domestic birds such as turkeys and chickens are said to feed on leaf hoppers, but their inroads on such insects could not be considered as serious.

Toads and frogs, being insectivorous, should use a small proportion of leaf hoppers in their dietary. Gibson states that the former has been observed feeding on them in alfalfa fields.

Among the *Arthropoda* themselves we find perhaps the most efficient predaceous foes of the leaf hoppers, though all combined do not seem to do anything appreciable in holding them in check. Various spiders and mites are said to be among such enemies. Slingerland and Johnson give the names of mites predaceous on the grape-leaf hopper in their bulletins on that species. Childs gives a list of spiders preying upon the rose-leaf hopper, while Professor Osborn gives a large list of spiders that have been known to feed upon leaf hoppers.

Insects themselves furnish several predaceous enemies. Thus Osborn mentions such enemies among the *Nabidæ* and *Lygaeidæ.* Quayle mentions ladybirds, aphis lions and ants as enemies of the grape-leaf hopper, while previously, Walsh, Glover and Slingerland had recorded one of the dance flies, a soldier bug, and the larvæ of *Chrysopa,* respectively, as also feeding on the same leaf hopper. Johnson accuses a Capsid of attacking this species also. Gibson mentions the agricultural ant as an enemy of *Draeculacephala mollipes.* Childs records a Scatophagid as an enemy of the rose-leaf hopper and also observes that dragon flies have been observed attacking that species. The writer one evening observed some damsel flies flying over the grasses near the edge of a pond. They so evidently seemed to be hunting that they were closely watched and were soon seen to be attempting to catch some very small Locustid nymphs and also to be after the leaf hoppers. Several times the leaf hoppers were seen to escape by their characteristic shift to the under side of the grass blades. Finally a damsel fly was observed to have caught one of the hoppers, and we were able to get close enough to identify the species as *Deltocephalus inimicus* and to catch the predator, not, however, before the last sign of his meal had disappeared.

There are records of at least two families of wasps that provision their nests with leaf hoppers. Comstock states that the *Nyssonidæ* provision their nests with the immature stages of these insects. F. X. Williams described a member of this family, *Harpactus gyponæ,* from Grant county, Kansas, which used the adults and nymphs of *Gypona cinerea* for this purpose. He found also that *Mimesa argentifrons,* a member of the family *Mimesidæ,* provisioned her nest with *Euscelis exitiosus.* Further studies with these and related families of wasps might reveal the importance of these insects as natural enemies of the leaf hoppers.

The chief natural enemies of the leaf hoppers are the parasitic insects. These are undoubtedly responsible for holding these insects in check, so that they do only the usual amount of damage annually. Such parasites are found in the dipterous genus *Pipunculus* and among the *Strepsiptera.* But far more important than these are the hymenopterous parasites belonging to the subfamily *Anteoninæ* and to the family *Bethylidæ.* Dr. F. A. Fenton's paper on this group shows how extensive is the parasitization of leaf hoppers by these forms which parasitize the nymphs and adults. Professor Osborn states that sometimes 20 per cent of the individuals of some of our native species are thus parasitized. The members of the genus *Gonotopus* parasitize the majority of the *Jassini,* while *Aphelopus* is the only parasite of the *Typhlocybini.* Various hymenopterous egg parasites are also at times very efficient.

The relation of fungous diseases to leaf-hopper control is yet an open question. Only rarely have they been recorded as attacking these insects. Professors Garman, Webster, and Thaxter are seemingly the only ones reporting such cases. The first two give records of *Draeculacephala mollipes* being attacked by *Empusa grylli.* Professor Thaxter, in 1890, observed *Empusa* killing the grape-leaf hopper in Connecticut. It seems very probable, however, that in favorable seasons this or other fungi may play some part in the natural control of the leaf hoppers as they do for instance in the checking of the grasshoppers.

Climatic conditions undoubtedly play an important part in the control of insects. Thus many a foreign insect, on introduction to this country, has not been able to gain a foothold because of the different and untoward weather conditions. It is well known also that even some forms which have become more or less acclimated, as well as native forms, are often kept in check by extremes of heat or cold. Thus in Kansas very severe winters or very hot summers are known to prevent outbreaks of *Toxoptera.* Undoubtedly the same is true of large numbers of insects, and among them, of the leaf hoppers. Johnson quotes Trimble as observing in 1865 that when the thermometer reached 100 degrees Fahrenheit, thousands of the grape-leaf hoppers were killed. It is easily shown that grape-leaf hopper nymphs are killed by an exposure of a few minutes to the hot sun, so that it is very probable that when it becomes very hot, and host plants wither, that many may not be able to find sufficient protection and therefore succumb to the extreme heat. No one doubts also that untold numbers of individuals are destroyed by the extreme cold, freezes, and snows of winter, regardless of whether hibernation occurs in the egg, nymphal or adult stage. Actual experimentation with extremes of heat and cold, controlling also the moisture conditions, should give us interesting and perhaps very instructive data as to just what part climatic conditions do play in the control of such insects.

Geographical Distribution.

Leaf hoppers are so well distributed over the earth that they are truly cosmopolitan. They are well represented in all the faunal realms, and in some countries are among the commonest of the insects. In his catalogue of the Hemiptera of America north of Mexico, published in 1917, Mr. Van Duzee lists about 700 species, and the number now known must be well beyond that. I have been unable to get any estimate of the total number of species known to science.

Professor Osborn has pointed out two facts of great interest when one views this group as a whole or when the fauna of two continents are compared. First, the fact is soon observed, that the leaf hopper fauna of even two widely-separated portions of the earth, are essentially and fundamentally alike in group characters. This is taken as showing a common origin of the groups. And second, that though in the main characters and larger groupings there are so many similarities, yet there seem to be relatively very few cases of specific identity between the species of such separated countries or continents. Examples of this fact are numerous when our own forms are compared with the European. The subfamily *Paropinæ*, for example, occurs on both continents, yet not one of our eight species seems to occur in Europe. Of our seventy-five or more members of the genus *Deltocephalus* only four are known to occur in Europe. And this is about the case in almost any group one may choose.

This fact would argue for an early separation of our forms from the European and for a consequently long development here. It would seem to indicate also that introduction of leaf hoppers into new continents, separated by oceans, is to-day rather rare if occurring at all. And when one considers the few adaptations of these forms for transmission, especially as to life history, one is all the more convinced that such introduction does not often take place. If such be the case it is evident that the distribution of the leaf hoppers over the earth must have occurred in the early times when the different portions of the earth were more connected than they are now.

That leaf hoppers, however, are able to push out the limits of their environment once they are in a country and unhindered by high mountains or climatic conditions essentially different from that to which they are adapted, is very evident. The range of many of our North American species is steadily being increased. Thus Professor Osborn shows that *Dræculacephala reticulata* seems to be steadily pushing northward from its southern home, seemingly having the power to adapt itself to such minor changes as it may meet. *Euscelis exitiosus* he also believes to have recently spread over the United States.

In the United States we find a rather general distribution of the members of this family with the exception of the *Paropinæ.* The members of this subfamily are seemingly confined to California or at least to the west of the Rockies. The *Bythoscopinæ* on the other hand, are found well across the states The *Agallia* group while found from north to south and east to west, is yet undoubtedly subtropical. The genus *Idiocerus* is in the main more northerly in its distribution. The members of the genus *Macropsis* are more abundant in the Northeastern states, few reaching the Pacific coast. *Oncopsis* is practically northern in its distribution, while the members of the genus *Bythoscopus* are well represented in the Western states though also occurring in the south and east. Thus in one subfamily we find groups which favor each of the several portions of the country in their distribution.

The *Cicadellinæ* are tropical or subtropical as a group. Naturally we therefore find the subfamily best represented in our Southern states though many species seem to have been able to adapt themselves to northern conditions and some are found commonly even in Canada. They occur across the continent from east to west. Only two or three of the nearly fifty species of the United States are known to occur in Europe. Many of them, however, are found in Mexico and the West Indies, some such region seemingly being their original home.

Comparatively few members of the subfamily *Gyponinæ* seem to be found on our western coast. As a group they seem to be tropical or subtropical and hence are best represented in our Southern states, though some species extend through our Northern states into Canada. They are found in the Eastern as well as the Western states.

Of the great subfamily *Jassinæ,* we find representatives in all parts of the United States. Here too, however, we see many restrictions to certain regions. Thus the genus *Acucephalus* is confined largely to the Northeastern states. *Cicadula, Thamnotettix* and others are largely northern, *Uhleriella, Aligia, Neocœlidia* and others largely western, *Spangbergiella* and *Acinopterus* essentially southern, while still others, such as *Deltocephalus,* seem to find their optimum conditions in the Middle West. Others are undoubtedly largely Rocky Mountain forms. Some genera, on the other hand, and even some species, seem to be able to find favorable conditions clear across the continent and from the north to the south, so that they may be spoken of as occurring throughout the United States.

Systematic Position.

The *Cicadellidæ* were formerly placed in the great order *Hemiptera.* Of late years the suborders of this order have been given ordinal rank, so that to-day we speak of these insects as belonging to the order *Homoptera.* This order undoubtedly stands as the highest among those insects which have an incomplete metamorphosis.

In the division of this order there seems to be a general disposition to follow Amyot and Serville in forming the two groups *Auchenorhynchi* and *Sternorhynchi,* the former to include those families in which the beak arises clearly from the posterior or lower part of the head, the latter including the families where the beak seems to arise from between the prothoracic legs. These groups may be further separated by the character of the antennæ and the number of tarsal joints. In the former the antennæ are usually awl-shaped or setaceous; in the latter they vary in form but are never bristle-like. The members of the former group also always have three-jointed tarsi, while the tarsi of the latter are composed of but one or two segments and rarely are lacking.

Some authorities in dividing the *Hemiptera* into suborders make the *Auchenorhynchi* equal to their suborder *Homoptera* and the *Sternorhynchi* to the suborder *Gularostria.*

Along with the *Cicadidæ, Membracidæ, Cercopidæ,* and *Fulgoridæ,* the *Cicadellidæ* belong to the *Auchenorhynchi,* and it is with this group that we are particularly concerned in discussing the systematic position of the leaf hoppers.

It now seems to be generally believed that the *Cicadidæ* are the lowest of these five families. Comstock and Needham pointed out in 1899, in a paper on the wings of insects, that this family had the nearest to the primitive condition of wing venation of any *Hemiptera.* Funkhouser does not believe that the wings of the *Cicadidæ* are as generalized as those of the *Membracidæ,* though agreeing in placing them below the latter in phylogenetic rank. This is Osborn's opinion also. The fact that they are the only *Auchenorhynchi* with three ocelli, the others having two or none, would indicate their more primitive condition.

It is quite commonly believed also by Homopterists that the *Fulgoridæ* represent the most specialized forms of this group. This opinion was held by Kirkaldy and Hansen and is held today by Funkhouser and others. One cannot look carefully at the wonderful antennæ of a large number of these forms without agreeing with this disposition of the family provided the development of the antennæ and its sensory organs be considered an important criterion. Certain it is that they must be placed by themselves, for it would be hard to try to connect them closely with any of the four other families of the group.

The three families, *Membracidæ, Cicadellidæ,* and *Cercopidæ* are now left for consideration. One cannot have even a casual acquaintance with these forms without realizing their similarity and close affinity. That they are all three derived from a common stem seems to be plainly evident. The question is as to their relative position.

Having made the *Cicadidæ* the lowest and the *Fulgoridæ* the highest families of the *Auchenorhynchi,* we must necessarily place the remaining families in between, so that we now have the *Cicadidæ* arising from a lower stem, the *Membracidæ, Cicadellidæ,* and *Cercopidæ* from a middle one, and the *Fulgoridæ* from a third and highest one.

When we study the families arising from this middle stem it seems that Funkhouser has made his point in claiming that the *Membracidæ* are the lowest of the three. This would put them next to the *Cicadidæ,* but as we have indicated, their relationship would not be so much with them as with the other families of the middle stem. In support of his position he shows that the *Membracidæ* have a very poorly developed sensory system, causing them to respond very slowly to stimuli, that the wings are very generalized, and that the genital organs are simple. In the first, if not in all of these respects, the *Cicadellidæ* and *Cercopidæ* are certainly more specialized.

The question now arises as to which of these two families is closer to the *Membracidæ.* Here we are helped by a curious insect which seems to be half Membracid and half Cicadellid. I refer to *Æthalion,* an insect found in this country and in Central and South America. It looks very much like a Cicadellid, but instead of having a double row of prominent spines on the hind tibiæ, has those parts of the leg covered with weak spines or hairs quite promiscuously arranged. Here is an approach to the Cicadellid leg. On the other hand, it has certain very distinct Membracid characters though lacking the chief characteristic of the family, namely, the Membracid pronotum. So similar is this insect to both these families that entomologists have had much trouble in deciding to which it belongs. Stal placed it with the *Membracidæ,* but Ashmead included it with the *Bythoscopidæ.* Van Duzee places it under a subfamily of its own, as a Membracid, but as the form of that family closest to the *Cicadellidæ.*

Thus we seem to be safe in putting the *Cicadellidæ* next to and above the *Membracidæ* because of their better sensory system, and because of this connecting form. It is not at all improbable, however, that the *Æthalioninæ* will later be placed in a family by themselves, but in any case they would still constitute the link between these two families.

The *Cercopidæ* do not seem to show such close relationships to the *Membracidæ,* nor do they seem to be as closely connected with the *Cicadellidæ* as is this family to the tree hoppers. There seem to be no forms connecting them with the leaf hoppers, and yet their relationship with them and the tree hoppers is very evident. For this reason it seems probable that they are an older offshoot from this middle stem than either of the other two, and this would seem to be evidenced also by their peculiar life history.

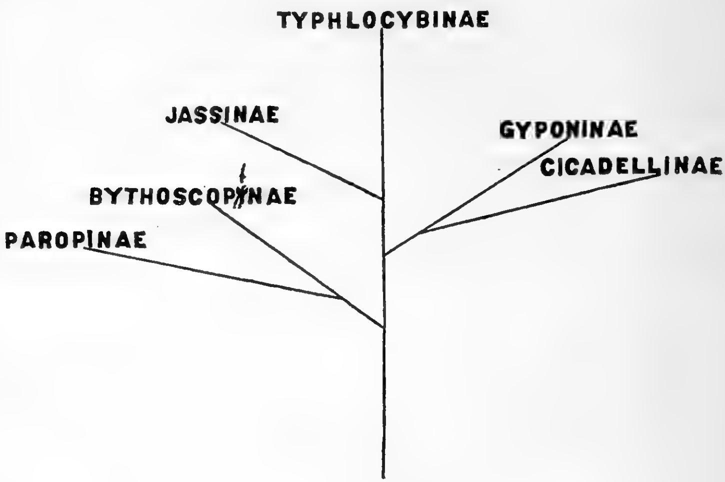
It seems probable that the nymphal habit of enveloping themselves in a mass of spittle could not be a habit easily or quickly developed. That it is a protective habit is certain, for as Dr. F. A. Fenton has shown, while large numbers of Cicadellids and Fulgorids, also a Membracid, are parasitized by the *Anteoninæ,* we have yet to find a single instance of the parasitization of a Cercopid. Thus this habit has been long enough in development to have seemingly made it an absolute success in the protection of these insects from their parasitic foes. So that considering their specialized life history, along with their morphology and the absence of intermediate forms between them and the Cicadellids, we would place the *Cercopidæ* above the latter and have them leaving the middle stem before the Membracids and Cicadellids.

Diagrammatically this phylogenetic relationship would be expressed as follows:

When we consider the relationships of the different subfamilies of the *Cicadellidæ* we again find opportunity for differences of opinion. Van Duzee in his catalogue arranges them in the following order, beginning with the lowest:

Paropinæ.
Bythoscopinæ.
Cicadellinæ.
Gyponinæ.
Jassinæ.

Dr. F. A. Fenton in his paper on the parasites of leaf hoppers gives the following phylogenetic tree for these subfamilies:



Here the tribe *Typhlocybini* has been removed from the *Jassinæ* and given subfamily rank, the phylogenetic arrangement, however, agreeing with that of Van Duzee, whose arrangement seems to be quite generally accepted.

A question that yet may have to be decided differently is that of the position of the tribe *Typhlocybini* or the subfamily *Typhlocybinæ.* In many ways they appear to be the highest members of the family. This is especially true of their wings which show very evidently a specialized condition as compared with the wings of the members of the other subfamilies. The loss of the ocelli in some of the genera may also be taken to indicate specialization.

Gillette, however, in his monograph of the American members of the subfamily, calls them the lowest of the leaf hoppers, and there are others who at least partially share this view. In this connection the work on the parasites of these forms is rather interesting.

Fenton finds that the members of the tribe *Typhlocybini* are parasitized only by members of the genus *Aphelopus* and curiously enough Kornhauser finds that our only known Membracid parasite is a member of the same genus.

While we would not argue that this was any proof that the *Typhlocybini* are the closest leaf hoppers to the Membracids, and therefore the lowest of the *Cicadellidæ,* yet, if Kellogg can trace the relationships of seemingly unrelated birds through the agency of their parasites, may it not be possible to do something of the same kind here. If closely related *Mallophaga* are found only on closely related birds, may we not expect to find closely related parasites parasitizing closely related *Homoptera?* In fact do we not find this in the case of all insects? For certainly it would be easier for a parasite to adapt itself to parasitizing a closely related form than one distantly related. So that it may be that in a few years we may find the *Typhlocybini* to be not the highest, but among the lower, if not the very lowest of all the groups of this family.

PLATE I.

1. Dorsal view of *Phlepsius irroratus.* (*v*, vertex; *e*, compound eye; *p*, pronotum; *s*, scutellum; *c*, clavus; *es*, elytral suture; *cs*, claval suture; *co*, corium.)

2. Face of *Phlepsius irroratus.* (*f*, front; *e*, compound eye; *a*, antenna; *l*, lora; *g*, gena; *c*, clypeus; *lr*, labrum; *la*, labium.)

3. Metathoracic leg of *Phlepsius irroratus.* (*c*, coxa; *t*, trochanter; *f*, femur; *ti*, tibia; *ta*, tarsus.)

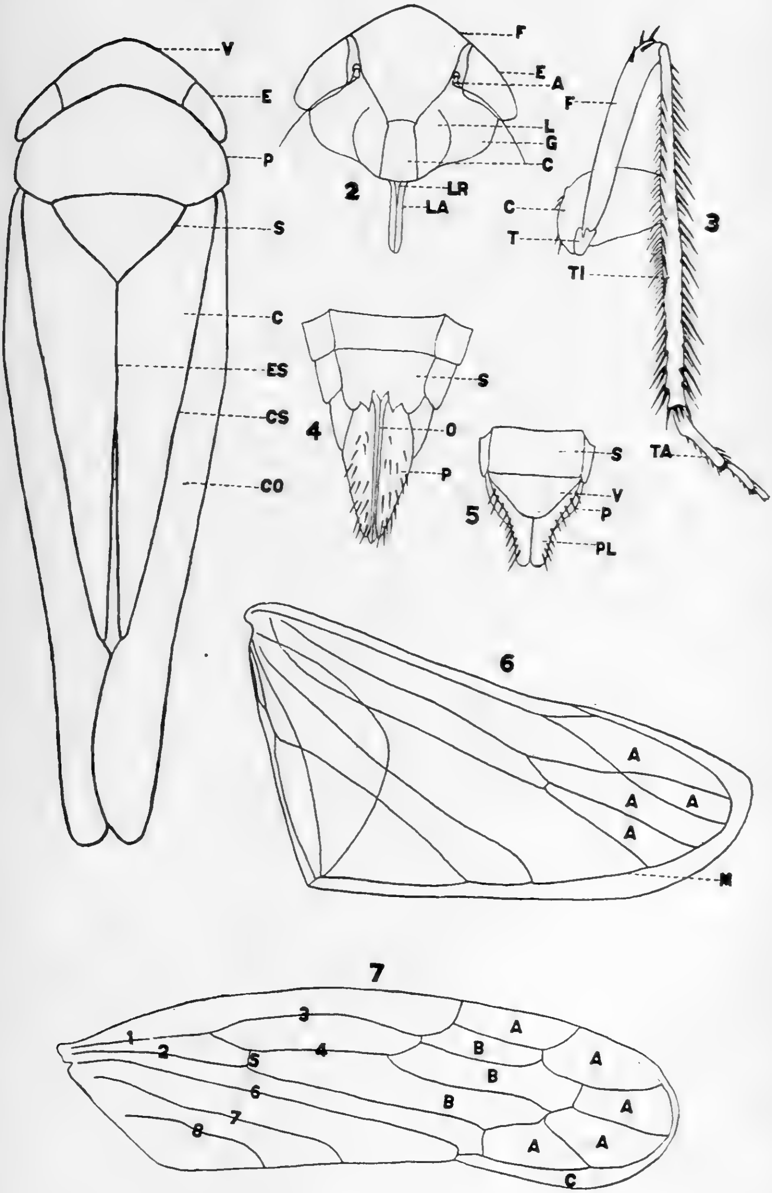
4. Tip of abdomen of female *Phlepsius irroratus.* (*s*, last ventral segment; *o*, ovipositor; *p*, pygofer.)

5. Tip of abdomen of male *Phlepsius irroratus* (*s*, last ventral segment; *v*, valve; *p*, pygofer; *pl*, plates.)

6. Hind wing of *Phlepsius irroratus.* (*a*, apical cells; *m*, marginal vein.)

7. Elytron of *Phlepsius irroratus.* (1, first sector; 2, second sector; 3, outer branch of first sector; 4, inner branch of first sector; 5, first cross nervure between sectors; 6, claval suture; 7, outer claval vein; 8, inner claval vein; *a*, apical cells; *b*, anteapical cells; *c*, appendix.)

PLATE I.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The Chief Morphological Features.

While there have been some attempts to work out the morphology of the *Cicadellidæ*, yet it does not seem that the subject has yet received much thorough investigation. Therefore in this paper we propose to give only as much information on the morphology as will enable one to recognize members of the family, and enable them to use the keys for their specific determination. It is hoped at some future time to carefully study the morphology, both external and internal, of the family.

As in all insects, the body of the leaf hopper is divided into three distinct regions, namely, *head, thorax,* and *abdomen.* The chief features of each are briefly described below and illustrated in the accompanying plate (plate I).

The upper or dorsal portion of the head is called the *vertex.* There is no distinct division between this portion and the rest of the head, but often there is more or less of a distinct margin between it and the face. The greater portion of the latter is called the *front.* It is not separated from the vertex by a distinct dividing line or suture, but is distinctly bounded laterally by sutures which frequently run past the antennæ clear to the anterior margin of the head. On the lower side or ventrally the front is bounded by a transverse suture. The *clypeus* is the rectangular sclerite attached to the anterior or lower edge of the front. The *loræ* are the rather semicircular sclerites on either side of the front and clypeus, while the *genæ* are the large sclerites extending from below the eyes and surrounding the *loræ.* It might be stated that Cogan claims that the clypeus proper is not clearly differentiated in the *Homoptera,* and that what is usually called the clypeus is really the *labrum* or upper lip.

The eyes are of two kinds, *compound* and *simple.* The former are always large and prominent and occupy a large part of the head. The simple eyes or *ocelli* are always small, and are lacking in many members of the *Typhlocybini.* In the *Paropinæ* and *Bythoscopinæ* they are situated on the front, below the margin of the vertex, in the *Cicadellinæ* and *Gyponinæ* they are situated on the vertex, while in the *Jassinæ* they are on or near the margin of the vertex.

The *antennæ* or feelers are always setaceous or bristle-like. They are on the face between the compound eyes and the front. The basal segments are large but soon they become very small. The number of segments is comparatively large. In the genus *Idiocerus* the antennæ are used in the differentiation of the species due to the possession in the males of variously-shaped, flattened discs at the apex.

The mouth parts consist of a large 3-jointed beak or *proboscis* which, in a groove on its anterior or dorsal surface, bears a minute triangular sclerite and two pairs of brown stylets which run its whole length. The former is claimed by Cogan to be the small *epipharynx*. By some it is thought to be the *labrum* or upper lip, and the membrane below it the epipharnyx. The inner pair of stylets constitute the *maxillæ*, while the outer ones are the piercing *mandibles*. The proboscis or rostrum is the *labium* or lower lip.

The thorax, as in all insects, is composed of three segments called respectively the *pro-*, *meso-*, and *metathorax*. Dorsally however, only two of these segments are seen. The large portion behind the head is the tergum or dorsal sclerite of the prothorax and is called the *pronotum*. The triangular sclerite back of the pronotum is a part of the dorsal sclerite of the mesothorax and is called the *scutellum*. The side pieces of the thoracic segments are called *pro-*, *meso-*, and *metapleuræ*, respectively.

The appendages of the thorax are the legs and the wings. Each of the three segments bears a pair of legs and the meso- and metathorax a pair of wings in addition. The legs have the usual segments, but the *tibiæ* are very long and very characteristically armed with a double row of stout spines. The *tarsi* are invariably 3-jointed.

The mesothoracic wings are thicker than the membranous metathoracic wings. The former are often called the *elytra* and a few speak of them as *tegmina*. In the accompanying plate the different parts of the wing are labelled according to the terms used in the following systematic treatise of the Kansas species. The metathoracic or hind wings are sometimes simply called the *wings*. They are much wider than the elytra and when at rest have the inner portion distinctly folded.

In the *Typhlocybini* their venation is of importance in the separation of the genera, otherwise they are not much used systematically.

The *abdomen* consists of a number of distinct segments, but the segmentation of the terminal portion is indistinct. Each segment consists of two pieces, a dorsal *tergum* and a ventral *sternum*. These are connected by *pleural membranes.* There are eight distinct tergites, the last one being called the *pygofer.* This sclerite is usually more or less divided caudo-dorsally and through this excision rises the *anal tube* which bears the *anus* at its apex. The question as to the number of segments composing the anal tube is an interesting one and one that requires careful study. In the female the pygofers nearly enclose the *ovipositor* which is composed of three pairs of *valves.* The pygofers are usually exceeded in length by the ovipositor.

The terminal sternites are of importance in classification. In the female, in many genera, the last sternite is characteristic of the species and is much used in differentiating them. In a comparatively few species this *last ventral segment* is described as being composed of an outer and inner membrane. This is the case in the *Deltocephalus compactus-weedi* group. It may be that a careful study with caustic potash specimens will reveal the existence of such a condition in many more, if not in all of the *Cicadellidæ.*

In the male the sternite just before the valve is called the *last ventral sternite.* The *valve* is usually a small and triangular sclerite situated just before the *plates.* In many genera the valve is described as lacking, but it seems more probable that it is never absent, but only apparently so because it is often overlapped by the last ventral segment. It is of great value in classification. In some genera, however, it cannot be much used.

Just caudad of the valve is a pair of usually triangular sclerites, called *plates.* These also are often much used in classification. They are fastened to the posterior margin of the valve. Their homology brings up a question yet to be worked out, for the question at once arises as to whether they represent the divided sternite of the ninth abdominal segment, or whether they are paired reproductive appendages, derived as are the other reproductive appendages from primitive locomotory organs. The *plates* vary much in size and shape in the different genera and even in species of the same genus. When viewed ventrally they frequently completely cover the pygofers, though often they are very small and much exceeded by the pygofers.

In systematic work on the *Cicadellidæ,* the last sternite, commonly called the last ventral segment, with the pygofers and ovipositor of the female, and the last ventral segment, valve, plates, and pygofers of the male, have been spoken of as the *genitalia.* In this paper they are spoken of as the *external genitalia* to distinguish them from the other, hitherto little used, more or less hidden genitalia, which, to distinguish them from the above, are here called the *internal genitalia.*

The Male Internal Genitalia.

The genitalia of the various groups of insects are being studied more and more both by the morphologist and systematist, for it is now well known that in many groups they are a very great help if not the chief means of separation and classification. Along with the venation of the wing, they have often furnished the chief characters for working out the systematic problems of many groups. Already much use has been made of them as witnessed by work on the *Melanopli* and other *Orthoptera*, many groups of the *Lepidoptera, Coleoptera, Diptera, Hymenoptera,* and other orders. Knight's paper on the genus *Lygus* is illustrative of their value in systematic work.

In the *Homoptera* some use has been made of the terminal portion of the abdomen in classification. The importance of the pygidium in the *Diaspinæ* is now well known to all, and the use of the terminal sclerites in the *Cicadellidæ* has done much to help in the differentiation of the species. As before mentioned, the pygofers, last ventral segment, and ovipositor of the female, and the pygofers, last ventral segment, valve, and plates of the male, have been the parts spoken of as the genitalia of this family. These are the parts that are external and are thus readily observed. There are other parts of the genitalia, however, which have been but little used and yet which it seems are of much importance and could be readily used, especially in cases where all other helps seem to fail. These portions are what we have called the "internal male genitalia," using the word "internal" merely to distinguish them from the ordinarily used organs which we have styled the "external genitalia." In reality these organs are not internal, being situated in an open genital chamber which is the "terminal chamber" of Sharp's *Pentatomidæ.*

These organs have been but little used in systematic work on the *Cicadellidæ.* Johnson in his bulletin on the grape-leaf hopper gives a drawing of them as he saw them in that species, but evidently no attempt was made to get at their connection with the abdomen and with each other. In his Hemiptera-Homoptera of the British Isles, Edwards occasionally makes a little use of these organs and figures portions of them, but again no effort was made to dissect them out and get at the relative differences in the various genera or species.

Hitherto Prof. Franz Then seems to have come the nearest to actually using these organs in systematic work on the leaf hoppers. In his papers on several members of the genera *Deltocephalus* and *Thamnotettix* he figures in a comparative way the internal genitalia of several species and shows that they vary characteristically for each species. His figures, however, do not show the details of form and structure nor the connection of the various parts.

The organs that we have placed under the heading of internal genitalia are three in number. These we have called the paired *styles,* the *style-œdagus* connective, and the *œdagus.*

The styles are always paired and fastened to the dorsal surface of the plates. At the point of their attachment to the plates the latter bear distinct ridges or chitinous thickenings usually near the antero-lateral margin. These styles are chitinous organs varying very much in shape. They are sometimes simply columnar in form, but most often triangular in outline. They are often fastened to the plates at about their middle, though usually nearer the anterior end. They vary much in their shape at either end in the different species, but most particularly in the form of the posterior end. There are also usually characteristic irregularities or processes along the margins. The greater portion of the styles usually projects out into the genital chamber and is therefore really external, but the anterior part of it always passes through the membrane forming the anterior wall of the genital chamber, and reaches into the body cavity, often reaching into the cavity of the seventh abdominal segment. Professor Then applied the term "Griffel" to a style. They are undoubtedly a pair of claspers.

The style-œdagus connective, or briefly, the connective, is a chitinous sclerite which connects the two styles and is also usually connected with the œdagus at its caudal extremity. I have been unable to find in the literature a homologous sclerite and hence do not know whether it has already been named. Professor Then called it the "Stutze." The term I have suggested for it is in keeping with his name for it also explains its function. It is undoubtedly used to coördinate the action of the styles in copulation and usually also with them, that of the œdagus. There are always more or less prominent processes on the mesal margins of the styles to which the connective is fastened. It varies much in the different genera being sometimes simply a transverse chitinous bar, at other times it is U- or V-shaped, and often is quite elongate and columnar in form. In rare cases it seems to have no connection with the œdagus and is then much reduced in size. The question of its homology seems to afford an interesting problem for future work.

The œdagus is commonly spoken of as the penis sheath. ~~In this case I believe it is the penis itself and the terms have been used synonymously.~~ Professor Then called it the "Membrum virile." It is also a chitinous sclerite, connected anteriorly with the connective. It assumes a great variety of forms and is often very characteristic even in closely-related species. Its base is usually quite enlarged or bears a more or less strongly developed dorsally directed process. This is for the purpose of fastening it to the wall of the genital chamber which is composed of the membranes that form the anal tube and the ental surfaces of the pygofers. The terminal portion of the œdagus is variously developed, sometimes simply, often with additional chitinous lateral or ventral processes.

In addition to the above it has been found that the pygofers themselves often bear chitinous bars or spines that are distinctive of the species. Thus the posterior margin of the pygofers often bears a characteristic tooth or lobe, and in the sides of these organs there are often characteristically shaped chitinous structures. In some genera moreover the dorsal margin bears chitinous bars which are specifically distinct and which in some genera are united anteriorly, forming a U- or V-shaped chitinous structure around the base of the anal tube. These structures are, of course, too small for superficial study, but because of being in the pygofers, are described, when present, with the external genitalia. They seem to be of equal importance in some cases with the internal genitalia in the separation of species and varieties that show no differences in the external genitalia.

It has been the purpose of this paper to study and describe these internal genitalia in representatives of the more important and common of our genera. Although this has been done for a goodly number of species, yet the real value of such work will not appear till a whole genus is worked, and then its worth will be readily seen. Accordingly what is here done is only to prepare the way for such work, to show that there are possibilities with the leaf hoppers on this line, to get acquainted with the structures, and gain experience in the necessary technique.

The technique employed is as follows: The specimens to be examined are first soaked in a ten per cent solution of caustic potash. The time they are left in the solution depends altogether on the size and color of the specimen. Light and delicate species are left for only two or three hours. Large and dark forms may require several days before they are clear. Care should be taken however not to leave small species in too long as they become too light. If plenty of material is at hand the whole specimen may be dropped into the fluid, otherwise only the abdomen or the tip of the abdomen need be used, thus retaining much of the value of the desirable specimen. For this soaking the specimens may be kept in small vials, each bearing a number, so that accurate records may be kept and the mixing of the species avoided. In this way the same vial of caustic potash can be used over and over again till the fluid becomes too dirty.

When thoroughly cleared up by the caustic potash, the specimens are removed into a watch crystal of distilled water. A watch crystal with the middle of its convex surface flattened is the best. This enables one to rest it without fear of tipping on the glass stage of a binocular. The particular binocular used was a Bausch & Lomb machine with a 32 mm. objective and 8x oculars. The watch crystal and stage both being glass excellent illumination can be obtained by using a spotlight on the mirror of the binocular. Minuten Nadeln are the most satisfactory dissecting needles for such work, ordinary dissecting needles being altogether too big for work with the smaller forms, particularly the *Typhlocybini*.

It was found best to first draw all the organs in situ from a lateral view. As accurate a drawing as possible was made in this way and any parts not clearly seen were later cleared up when the pygofers were torn open and the organs fully exposed to view. Then the styles may be torn loose from the plates and the œdagus from the membrane of the genital chamber, and thus the styles, the connective, and the œdagus be freed intact. These were then usually drawn in their normal position, that is a dorsal view of them was obtained. Thus with the previous lateral in situ view, and a dorsal view, a fairly accurate idea of these organs can be gained. Both these drawings were later verified and if necessary corrected when the mounted genitalia were studied with the higher magnification of the compound microscope.

The drawing of these organs was greatly facilitated by using, in one of the oculars, an eye-piece scale ruled into squares. The drawing paper was then ruled into inch squares corresponding to these squares. In this way drawings can be made quickly and accurately and with all the various species drawn to the same scale. Our drawings are about 40 times the size of the genitalia.

After they are dissected out and drawn, the genitalia are transferred to 95 per cent alcohol for a few minutes, then to xylol for a similar period, and finally mounted on slides in Canada balsam. A pin with a small loop in the end and with the other end fastened into a wooden handle is an excellent tool for the transfer of these tiny organs from one liquid to another.

As in other groups of insects it will be found that these genitalia show distinct and specific differences in some genera, while in others they are, for purposes of classification, of little or no value. In some cases however I believe they are practically the only criterion that will enable us to correctly decide between species and varieties, and also to decide the generic position of some forms, which though specifically distinct, yet give much trouble as to their true generic disposition.

The value of these internal genitalia may readily be shown in the little that has been done on the *Agallia* group. In their review of the members of this genus Osborn & Ball pointed out the existence of three groups within the genus. The differences between these groups, while based partly on adult characters, were more particularly indicated in the nymphs, which vary considerably both as to structure and life history. In 1907 Kirkaldy, recognizing the distinctions between these groups, gave to them subgeneric rank, and accordingly divided the genus into the subgenera *Agalliopsis, Agallia,* and *Aceratagallia.*

In the work on the internal genitalia of these forms, representatives of each were examined, and it was found that in these organs there are distinct differences between the members of the three subgenera, and that in each subgenus these organs, though differing specifically, are yet of the same general type. Thus in *Agallia novella,* a member of the subgenus *Agalliopsis,* the styles are each composed of two distinct sclerites, a condition not found in any member of the other subgenera. The œdagus is also characteristic of the subgenus, being much larger and with accessory lateral processes which do not occur in the other subgenera. Moreover, it was found that this species has, partially imbedded in the pygofers and partially free, a very peculiar and characteristic chitinous process corresponding to which there is nothing in the other subgenera.

Agallia constricta and *4-punctata* were then studied as types of the subgenus *Agallia.* Here the styles were found to consist of a single piece, and though distinctly and specifically different in the two species, were yet of the same type, each being somewhat club-shaped and terminating in two blunt apical processes. The œdagus also in each case was found to be of the same type and vastly different from that of *novella,* having an enlarged base and a long and curved terminal process. In *constricta,* however, it is much stouter and heavier basally than in *4-punctata.*

Agallia uhleri, sanguinolenta, and *cinerea* were next studied as representatives of the subgenus *Aceratagallia.* The three were found to agree in type of styles and œdagus which in the case of both organs was entirely different from that found in the other two subgenera. In this group the style consists of a more or less club-shaped basal portion and a broad flat terminal portion which has the mesal margin distinctly serrate. But the styles of the three species, while of the same type, are yet specifically distinct. Thus in *sanguinolenta* the terminal portion is drawn out into a long lateral tooth, while the style of *uhleri,* though much like it, lacks this lateral tooth. The style of *cinerea,* on the other hand, has the mesal margin strongly rounded apically, a condition not found in the other two, denoting the closer relationship of *uhleri* to *sanguinolenta* than to *cinerea*. These three forms agree also in having a small œdagus built on the same pattern but differing in minor details.

Thus it was found that representatives of these three subgenera, though each with its own characteristic genitalia, yet by these organs alone could readily be divided into three distinct groups. In view therefore of this, combined with the differences in the nymphs and the adults, it has been thought best to raise Kirkaldy's subgenera to generic rank. And this leads us to believe that with similar studies in other groups, similar changes, one way or the other, will be forthcoming.

The above shows the value of such studies in determining generic differences. It has been found throughout the work that they are also of great value in specific determinations within the genus. So far we have not run across a single case where we could not find specific differences in the genitalia of the species of any genus. It is true, however, that in some genera, such as *Idiocerus*, these differences may be very slight, and further and careful study must be given to them before they could be used very much in separating the species. Even here, however, it has been found that they have some value, for such species as *Idiocerus verticis* and *nervatus* can readily be distinguished by the structure of the œdagus.

Furthermore, we believe these genitalia will help to settle questions as to the specific or varietal rank of certain forms. Illustrations of this were readily found among the *Typhlocybini* as well as among other groups. Thus it was found that *Erythroneura obliqua* had a constant form of internal genitalia. When its variety *fumida*, however, was examined, it was found that in no way could it possibly be considered as belonging to the same species, for the differences both of styles and œdagus could not possibly be as great in mere varieties of the same species. In the styles it was found that the terminal tooth of the latter was invariably much longer and more slender, while the œdagus of the latter was distinctly bifid apically as compared with the bluntly apexed œdagus of the former. Then when the variety *dorsalis* was examined, the style was found to be very different apically from that of the preceding two forms, while the œdagus had a pair of very large and conspicuous lateral processes of which in the two preceding forms there was not even a suggestion. It seemed clear enough then that the three forms examined must be distinct species.

With the thought in mind that such would also prove to be the case with the variety *nœvus,* we started in to study the latter form, but to our surprise, we found that in no appreciable way did it differ from typical *obliqua,* and as far as the genitalia showed was a true variety. And when one considers the color markings, it can readily be seen that this form is certainly far nearer typical *obliqua* than are either *fumida* or *dorsalis.* Accordingly we have decided to give the latter two specific rank, while retaining *nœvus* as a variety.

In the same way it was found that the variety *nigra* of *Erythroneura vulnerata* could no longer be considered as such because of the absolute difference in these organs, and so it too is raised to specific rank.

Erythroneura comes and its varieties also furnished interesting results. All the varieties were not at hand for study, but all available ones were studied with the result that varieties *scutelleris, basalaris,* and *maculata* are here given specific rank, while the other varieties studied, namely, *ziczac, vitis, infuscata,* and *coloradensis,* are retained as varieties. The former three have a type of genitalia, especially the œdagus, entirely different from that found in the rest of the *comes* group. The differences are very strong and obvious. They differ, however, very characteristically among themselves in the shape of the chitinous process in the dorsal margin of the pygofers. In *basalaris* this process is a simple rod tapering to an acute tip. In *maculata* this process terminates in two short and stout and widely separated teeth. In *scutelleris* it is of the same type as in *maculata,* but terminates in two long slender and approximate teeth. Thus they are readily separated from each other.

Moreover, when one studies the color markings of these forms, it will be seen that these three are more distant from *comes* than are the four which are retained as varieties. The variety *coloradensis* differs from typical *comes* only in the black spots of the scutellum. In *ziczac* the spots of *comes* have darkened and fused into the characteristic elytral lines and these are carried on to the pronotum and head in *infuscata.* And, as Gillette states, *ziczac* can readily be taken as an intermediate form between the typical *comes* and the variety *vitis.*

It should be mentioned here, however, that even in the case of these four varieties minor differences were observed and further study to ascertain the limits of variation in the genitalia of this group might make changes in the position in which we at this time leave these varieties. For the present though it seems best to leave them as varieties. The three which here are given specific rank are, however, very distinctly good species.

It should also be mentioned here that in the larger groupings there is more or less uniformity in the form of the genitalia. This is not true of all the groups. But in some cases, as for example in the *Typhlocybini,* we find the styles characteristic of the group.

Thus in the larger groups, the genera, the species, and in the varieties, we find in a study of these organs much that either confirms our present disposition of the members of this family, or else that shows us how to improve in our classification. All that this paper shows is simply the possibility along this line. As previously stated, the real value of such studies can only be shown when genera are treated in their entirety. This it is hoped will be done for many, if not all the groups, in the years to come.

Recognition of the Cicadellidæ.

It is not probable that the *Cicadellidæ* would be confused with any of the *Homoptera Sternorhynchi*, for in the latter, among the differences, the beak seemingly arises from between the prothoracic legs instead of the posterior portion of the head, the antennæ are of any form except setaceous as they are in the leaf hoppers, and the tarsi are composed of one or two segments, while in the leaf hoppers there are always three.

Of the *Homoptera Auchenorhynchi* the *Cicadidæ*, because of their much larger size, need never be confused with the leaf hoppers. The *Fulgoridæ* are also distinguished from them by having the variously formed antennæ situated directly below the eyes, instead of having the invariably setaceous antennæ between and below the eyes. The *Membracidæ* usually have the pronotum extending back over the abdomen, whereas that of the leaf hoppers does not. In the few tree hoppers where the pronotum does not extend back over the abdomen, we do not find the hind tibiæ provided with the double row of stout spines as in the leaf hoppers. The *Cercopidæ* are separated from the leaf hoppers by also lacking these spines, having instead one or two stout spines along the tibiæ and a circlet of small ones at the apex.

The following is a key for the separation of these families:

A. Large insects with three ocelli. *Cicadidæ.*

AA. Smaller insects with two or no ocelli.

- B. Pronotum usually prolonged backward over abdomen; hind tibiæ without double row of spines. *Membracidæ.*
- BB. Pronotum never prolonged backward over abdomen.
  - C. Antennæ setaceous, between and below eyes.
    - D. Hind tibiæ with distinct double rows of spines. *Cicadellidæ.*
    - DD. Hind tibiæ with one or two stout spines and terminating in a circlet of small spines. *Cercopidæ.*
  - CC. Antennæ of various forms but directly below the eyes. *Fulgoridæ.*

It will be seen from the above that the characteristically spined hind tibiæ alone are enough to distinguish the leaf hoppers from any of the other families. Indeed this is the outstanding feature of the family.

Systematic Treatment of Kansas Species.

Van Duzee in his catalogue of the *Hemiptera* of America north of Mexico, divides the *Cicadellidæ* into five subfamilies, which may be separated by the following key:

A. Ocelli below margin of vertex.
  B. With a distinct margin between the vertex and the front. *Paropinæ.*
  BB. Without a distinct margin between the vertex and the front. *Bythoscopinæ.*
AA. Ocelli, if present, on or above margin of vertex.
  B. Ocelli on disc of vertex.
    C. Body elongate, cylindrical. *Cicadellinæ.*
    CC. Body more robust, flattened. *Gyponinæ.*
  BB. Ocelli, if present, on or near the margin of vertex. *Jassinæ.*

The *Paropinæ* do not occur in the state, being found only west of the Rockies.

Subfamily BYTHOSCOPINÆ (Dohrn).

The members of this subfamily are in the main short and broad species, having the ocelli below the margin of the vertex on the front, and with no distinct margin between the vertex and the front.

KEY TO GENERA.

A. Anterior margin of pronotum not distinctly produced beyond anterior margin of the eyes; vertex rounded anteriorly.
  B. Head as wide as, or wider than, pronotum.
    C. Elytra without a distinct appendix.
      D. Pronotum finely granulated.
        E. Posterior margin of vertex elevated, forming irregular curve. *Agalliopsis.*
        EE. Posterior margin of vertex normal, forming regular curve. *Agallia.*
      DD. Pronotum transversely and coarsely granulated. *Aceratagallia.*
    CC. Elytra with distinct appendix. *Idiocerus.*
  BB. Head narrower than pronotum. *Bythoscopus.*
AA. Anterior margin of pronotum distinctly produced beyond anterior margin of the eyes; vertex obtusely angulate.
  B. Striations of pronotum oblique. *Macropsis.*
  BB. Striations of pronotum transverse. *Oncopsis.*

Genus AGALLIOPSIS Kirk.

This genus is distinguished from related genera by the characteristic elevated and irregularly curved posterior margin of the vertex. This condition results from a similarly formed vertex in the nymphs, in which, according to Osborn and Ball, "the entire posterior margin of the vertex is elevated and carried obliquely upward and forward before the eyes on the same plane as the face, the upper carinate margin being shallowly roundingly bilobed."

Only two species of this genus are found in the United States, one of which occurs in Kansas.

Agalliopsis novella (Say).

(Pl. 2, figs. 1-4.)

Jassus novellus Say, Jl. Acad. Nat. Sci. Phila., VI, p. 309, 1831.
Macropsis nobilis Forbes, 14th Rept. Ill. St. Ent., p. 22, 1884.
Agallia novellus Van D., Can. Ent., XXI, p. 8, 1889.
Idiocerus novellus Prov., Pet. Faune Ent. Can., III, p. 293, 1890.
Agallia novella Van D., Bul. Buf. Soc. Nat. Sci., V, p. 196, 1894.
Agallia novella O. & B., Proc. Dav. Acad. Nat. Sci., VII, p. 54, 1898.
Agallia novella DeL., Tenn. St. Bd. Ent., Bul. 17, p. 13, 1916.
Agallia novella Van D., Cat. Hemip. N. A., p. 571, 1917.
Agallia novella Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 20, 1919.

Form: The body outline forms almost a perfect wedge. It is comparatively more slender than the members of the genus *Agallia*. Length, about 3.75 mm. Vertex short, gradually lengthening toward eyes, with distinct lobe caudad of mesal margin of eyes. Pronotum twice as wide as long, anterior margin quite convex between lobes of vertex, posterior margin slightly concave within same limits, lateral margins obsolete, humeral margins long, longer than in *Agallia constricta*. Elytra very long, extending far beyond tip of abdomen.

Color: There is a considerable range of variation in the color. Some specimens, especially females, are often almost unicolorously light brown, barely showing the four black spots near the margin of the vertex. Others, usually males, have a much more variegated appearance, being dark brown, with lighter markings along the margin of the vertex, sides of the scutellum, the basal half and tip of the clavus. In such forms the four black spots of the vertex are very prominent, as is the median line of the pronotum with its dark black spot on either side.

External genitalia: Female, last ventral segment very long laterally but only about half as long medially, due to a deep circular excision; pygofers exceeded by the ovipositor. Male, valve about two-thirds as long as wide, truncate behind; plates long and scarcely tapering except near tip and forming the lid to a box formed by the very peculiar and very characteristic pygofers. The last-mentioned organs alone are enough to distinguish the males of this species.

Male internal genitalia: Styles composed of two unequal pieces, the larger ventrad of the smaller; connective inverted Y-shaped, with slender rounding arms and stem broadened to connect with œdagus; œdagus with wedge-shaped base, to end of which is fastened U-shaped structure consisting of a straight anterior arm and a curved posterior one. A pair of slender pointed stylets arise near base of the U and run caudad along either side of the curved arm of the U. In the side of each pygofer is imbedded a curved chitinous bar, the ends of which on emerging turn dorsad and end in a toothed, triangular, pointed style. At the base of the anal tube lies a well developed horseshoe, the tips of which end in upturned points in the pygofers.

Distribution: Cherokee, Riley, Douglas and Pottawatomie counties are the only ones in which this species has yet been taken. Presumably it occurs throughout the eastern portion of the State.

Hosts: The records show that grasses and weeds in woods or shaded places have yielded all our specimens.

Genus AGALLIA Curt.

This is group I of the genus *Agallia* of Osborn and Ball. It differs from the preceding genus in not having the elevated and irregularly curved posterior margin of the vertex, and from the following genus in that the pronotum is finely granulated instead of being coarsely punctured and transversely striated.

Just two species of this genus occur in Kansas. These may be distinguished by the following key.

KEY TO SPECIES.

A. Broader, stouter, male plates tapering regularly to acute tip, last ventral segment of female with posterior margin usually elevated. *4-punctata.*

AA. Narrower, more slender, male plates distinctly constricted near the middle, last ventral segment of female with posterior half distinctly depressed. *constricta.*

Agallia 4-punctata (Prov.).

(Pl. 2, figs. 5-6.)

Bythoscopus 4-punctata Prov., Nat. Can., IV, p. 376, 1872.
(*Agallia flacida* Uhl. MS) Van. D., Can. Ent., XXI, p. 9, 1889.
Agallia quadripunctata Van D., Ent. Am., V, p. 167, 1889.
Ulopa canadensis Van D., Trans. Am. Ent. Soc., XIX, p. 301, 1892.
Agallia 4-punctata G. & B., Hemip. Colo., p. 80, 1895.
Agallia 4-punctata O. & B., Proc. Dav. Acad. Sci., VII, p. 48, 1898.
Agallia 4-punctata DeL., Tenn. St. Bd. Ent., Bul. 17, p. 12, 1916.
Agallia 4-punctata Van D., Cat. Hemip. N. A., p. 572, 1917.
Agallia 4-punctata Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 21, 1919.

Form: This species is not only larger than the other species of the *Agallia* group found in the state, but it is also proportionately more robust, and hence is readily distinguished. Length, about 4 mm. Vertex short, of about same length throughout. Pronotum more than twice as broad as long, anterior margin broadly convex, posterior margin slightly concave, humeral margins rounding to eye. There is a very distinct bulge to the sides of the elytra that seems quite characteristic.

Color: Varies from yellowish brown to almost dark brown. Usually quite uniformly colored, except for the two dark spots on vertex and pronotum. Males and females colored alike. More uniform in color than the following species.

External genitalia: Female, last ventral segment three-fourths as long as wide, tapering through posterior third, hind margin usually elevated; pygofers broad, exceeded by ovipositor. Male, valve about twice as broad as long, slightly produced medially; plates broad at base, tapering evenly to acute tips. The straightness and evenness of the plates is characteristic. Pygofers shorter than plates and almost hidden by the latter.

Male internal genitalia: Styles club-shaped, terminating in two short lobes, the inner of which is sharply pointed; connective broad and well-developed, consisting of a short caudally directed portion and a long part directed cephalad to unite with the œdagus; œdagus consists of a broad T-shaped portion from the base of which arises a very long slender process extending caudad beyond the margin of the pygofers.

Distribution: Douglas, Riley, Labette and Pottawatomie counties have furnished the Kansas specimens hitherto collected. There are specimens from Kansas City, Mo., in the Snow collection. The range of this species would seem to be that of the preceding.

Hosts: Osborn and Ball give the following host plants: Horse-radish, beet, *Helianthus, Eupatorium.*

Agallia constricta Van D.

(Pl. 2, figs. 7-10.)

Agallia constricta Van D., Can. Ent., XXVI, p. 90, 1894.
Agallia constricta O. & B., Proc. Dav. Acad. Sci., VII, p. 52, 1898.
Agallia constricta DeL., Tenn. St. Bd. Ent., Bul. 17, p. 13, 1916.
Agallia constricta Van D., Cat. Hemip. N. A., p. 572, 1917.
Agallia constricta Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 19, 1919.

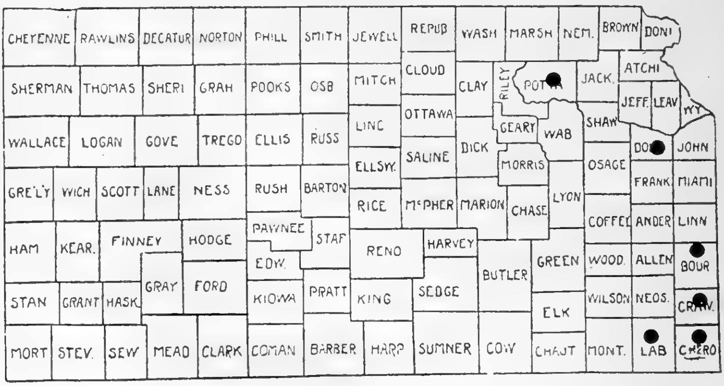
Form: A good deal like preceding species but somewhat smaller, not so robust, elytra longer and narrower. Length, 3.5 to 4 mm. Vertex slightly longer next the eyes than elsewhere, posterior margin slightly elevated; pronotum twice as wide as long, anterior margin strongly convex, posterior margin slightly concave, humeral margins distinctly developed at the expense of the practically obsolete lateral margins.

Color: Much the color of *4-punctata.* The type shows a pair of large black spots on vertex, and a pair on posterior half of pronotum. Vertex with a median brown line extending the length of the pronotum and almost entire length of scutellum. Posterior half of scutellum lighter colored than the rest of the quite uniformly colored body.

External genitalia: Female, last ventral segment about as long as wide, posterior half depressed on either side of a median carinate line, posterior margin obtusely rounded; pygofers wide and slightly exceeded by ovipositor. Male, valve twice as broad as long, margins parallel; plates long and narrow, constricted near middle, making these organs very characteristic; pygofers large, equalling or exceeding the plates.

Male internal genitalia: Styles of same type as in *4-punctata* only the processes here are much longer; connective T-shaped, not as wide as in *4-punctata*, and without the bend of the former; œdagus large, horn-shaped, with small dorsal process at base and bifid at tip.

Distribution: This species, like the preceding, seems to be found only in Eastern Kansas as shown by the following map:



Hosts: Our specimens were taken when sweeping grasses and weeds, on alfalfa, and at electric lights. It seems to be quite a general feeder occurring on a variety of food plants.

Genus ACERATAGALLIA Kirk.

This is the third group of Osborn and Ball. These forms are readily separated from the other members of the *Agallia* group by the coarsely punctured and transversely striated pronotum. There are no round black spots on the pronotum, which is either unicolorous or marked with dark bands.

The three members of this genus that occur in the State may be separated by the following key:

KEY TO SPECIES.

A. Spots on vertex large, usually dark, forms. *sanguinolenta.*
AA. Spots on vertex small, lighter forms.
  B. Elytra greatly exceeding tip of abdomen. *uhleri.*
  BB. Elytra scarcely exceeding tip of abdomen. *cinerea.*

Aceratagallia sanguinolenta (Prov.).

(Pl. 3, figs. 5-8.)

Bythoscopus sanguinolentus Prov., Nat. Can., IV, p. 376, 1872.
Bythoscopus siccifolius Uhl., Bul. U. S. Geol. Geog. Surv., I, p. 359, 1876.
Agallia siccifolius Van D., Can. Ent., XXI, p. 9, 1889.
Agallia sanguinolenta Van D., Ent. Am., V, p. 166, 1889.
Agallia sanguinolenta G. & B., Hemip. Colo., p. 81, 1895.
Agallia sanguinolenta O. & B., Proc. Dav. Acad. Sci., VII, p. 58, 1898.
Agallia sanguinolenta Gibs., U. S. Dept. Agr., Bur. Ent., Bul. 737, 1916.
Agallia sanguinolenta DeL., Tenn. St. Bd. Ent., Bul. 17, p. 14, 1916.
Agallia sanguinolenta Van D., Cat. Hemip. N. A., p. 573, 1917.
Agallia sanguinolenta Fent., Ohio Jl. Sci., XVIII, No. 6, p. 182, 1918.
Agallia sanguinolenta Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 22, 1919.

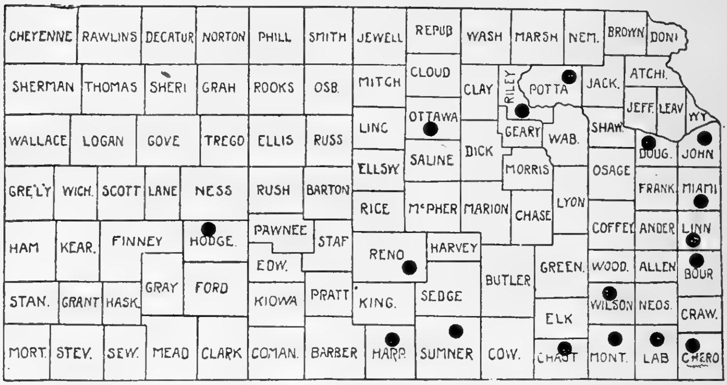
Form: A short, broad and quite flattened species. Length about 3 mm. Vertex longer than in preceding members of *Agallia* group and distinctly longer at middle than next to eyes. Pronotum twice wider than long, transversely striated, especially on posterior two-thirds, with anterior margin broadly rounded, posterior margin truncate or very slightly concave, lateral margins very short, humeral margins straight. Elytra broad, little longer than abdomen in female, considerably longer in some males.

Color: Light grey, with markings varying from very light to very dark. Vertex with two large black spots, broad median brown band and brown lines next the eyes. Face with suture, six or seven pairs of frontal arcs, and a median line on clypeus, brown. Pronotum with an interrupted arc of six brown dashes parallel with anterior margin, and with three longitudinal brown lines running caudad from the arc, the median band with a light band in its middle. Elytra with a mottled appearance, nervures brownish.

External genitalia: Female, last ventral segment over twice as wide as long, posterior margin sinuate, appearing to have two small lobes separated by a median notch; pygofers broad and exceeded by the ovipositor. Male, valve short, about six times as wide as long, truncate, lateral margins strongly narrowed posteriorly; plates broad, tapering to truncated tips, bases appearing constricted because enclosed by pygofers whose tips, thickly set with coarse hairs, slightly exceed tips of plates.

Male internal genitalia: Styles composed of cephalic club-shaped portion with the clubs bent mesad and a caudal flat part with the inner margin strongly serrate for its entire length and the latero-caudal corner drawn out into a long stout point, the points for attachment of connective very prominent; connective with broad, rounded base, slightly concave on anterior margin, and with well developed stem; œdagus short and stout, U-shaped, with arms short. Collar at base of anal tube V-shaped with sides strongly divergent and appearing to be composed of five segments.

Distribution: This species seems to be more widely distributed in the state than any other of the *Agallia* group. The records show it reaching further west than the others, as shown by the following map:



Hosts: This is one of the species of economic importance feeding especially on members of the *Leguminosæ.* It is very common on alfalfa and clover but may be often found in large numbers on wheat, barley and rye, and also on wild grasses.

Aceratagallia uhleri (Van D.).

(Pl. 3, figs. 1-4.)

Agallia uhleri Van D., Can. Ent., XXVI, p. 91, 1894.
Agallia uhleri G. & B., Hemip. Colo., p. 81, 1895.
Agallia uhleri O. & B., Proc. Dav. Acad. Sci., VII, p. 59, 1898.
Agallia uhleri Van D., Cat. Hemip. N. A., p. 574, 1917.

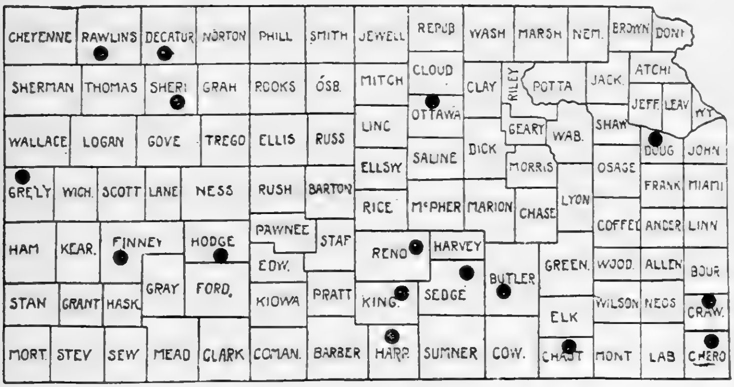
Form: Not as broad and flat as *sanguinolenta,* elytra much longer. Length, 3 to 3.25 mm. Vertex shorter than in *sanguinolenta,* very slightly longer medially than next to the eyes. Pronotum with anterior margin broadly rounded, posterior margin slightly concave, lateral margins long, reaching the eyes.

Color: The type shows the vertex bearing two black spots, smaller than in *sanguinolenta;* pronotum shows two small, brown spots closer together than spots of vertex, and about a fourth of the way back from the anterior margin; scutellum with two large, black, triangular, basal spots, the greater portion of which show up black through the pronotum; elytra light gray with darker nervures, thin, showing nervures of hind wings.

External genitalia: Female, last ventral segment broader than long, slightly narrowed posteriorly, posterior margin appearing bilobed because of large median incision which reaches nearly half the distance to the base; pygofers broad, slightly exceeded by ovipositor. Male, valve about five times as wide as long, lateral margins fusing with posterior margins to form a regular curve; plates short and stout, slightly tapering and cupping to very broad truncate tips, base enclosed by pygofers, which, slightly exceeding tip of plates, form a median keel.

Male internal genitalia: Styles of same type as in *sanguinolenta* but without latero-caudal corner drawn out; connective much as in *sanguinolenta* and yet differing in several details; œdagus with rather long arm for attachment to connective and two arms forming a very shallow V, the whole forming an irregular V with the base formed by the part attached to the connective.

Distribution: This species seems to have a state-wide distribution, as shown by the following map:



Hosts: Definite host plants seem to be unknown. It is generally taken sweeping the prairie grasses.

Aceratagallia cinerea (O. & B.).

(Pl. 2, figs. 11-13.)

Agallia cincerea O. & B., Proc. Dav. Acad. Sci., VII, p. 62, 1898.
Agallia sanguinolenta var. inconspicua Bak., Psyche, VIII, p. 198, 1898.
Agallia cinerea Ball, Psyche, IX, p. 128, 1900.
Agallia cinerea Van D., Trans. San Diego Soc. Nat. Hist., II, p. 52, 1914.
Agallia cinerea DeL., Tenn. St. Bd. Ent., Bul. 17, p. 14, 1916.
Agallia cinerea Van D., Cat. Hemip. N. A., p. 574, 1917.
Agallia cinerea Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 22, 1919.

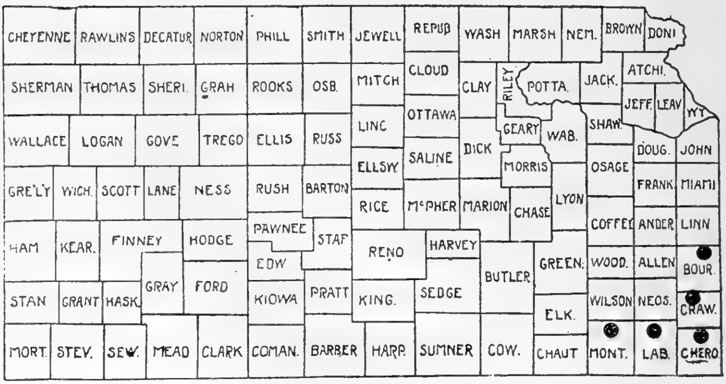
Form: Smaller than the other species of the *Agallia* group, broad and flattened. Vertex broad and as long as in any member of this group, distinctly longer at middle than next the eyes. Pronotum more than twice as wide as long, coarsely punctured, anterior margin broadly convex, posterior margin slightly concave, humeral margin long, reaching the eyes. Elytra a little longer than the abdomen.

Color: Generally uniformly light cinereous except for two small black spots on vertex. Much lighter than *uhleri*, being the lightest colored member of the *Agallia* group.

External genitalia: Female, last ventral segment a little less than three times as long as broad, posterior margin slightly sinuate and with a faint median notch; pygofers broad, barely exceeded by tip of ovipositor. Male, valve about five times as wide as long, the posterior, and lateral margins forming a regular curve; plates not as broad proportionately as in *uhleri,* tapering to somewhat truncate tips; pygofers enclosing base of plates and slightly exceeding them, meeting in a median ridge.

Male internal genitalia: Styles with broad basal club-shaped portion much as in two preceding species, but terminal half sinuate and terminal fourth broadly rounded and serrate medially, with caudo-lateral corner drawn out into strong point much as in *sanguinolenta.*

Distribution: So far this species has been taken only in the southeastern corner of the state, as shown by the following map:



Hosts: The definite host is unknown, our specimens being taken when sweeping in pastures.

Genus Idiocerus Lewis.

This genus contains rather large wedge-shaped insects which taper gradually from the wide head backward. The vertex is short, the margins parallel. The male antennæ frequently end in flattened discs. The elytra are long and narrow, usually exceeding the abdomen, and have a very large appendix. All of our forms live in trees, chiefly willow, cottonwood, and *Cratægus.*

Eight species of this genus have been taken in the state, but four other species likely occur in our fauna and are therefore included in the key.

KEY TO SPECIES.*

A. Vertex with two round black spots.
 B. Spots on vertex large, scarcely more than their own diameter from the eyes.
  C. Without black spots on pronotum and scutellum.
   D. Clavus unicolorous. *fitchi.*
   DD. Basal half of clavus bright yellow. *provancheri.*
  CC. With black spots on pronotum and scutellum. *cratægi.*
 BB. Spots on vertex small, two or more times their own diameter from the eyes.
  C. Nervures of elytra not distinctly alternating in color; outer anteapical cell, if present, triangular.
   D. Green forms, dark line along sutural margin of elytra. *snowi.*
   DD. Brown forms, without dark lines on sutural margin of elytra. *ramentosus.*
  CC. Nervures of elytra usually alternately light and dark, outer anteapical cell long and narrow.
   D. Cross nervure between first and second sectors broadly white. *moniliferæ.*
   DD. Cross nervure between first and second sectors not broadly white.
    E. Species larger, 5 mm. or over, darker; male antennæ with moderate discs on longer filaments. *alternatus.*
    EE. Species smaller, 4.5 mm. or less, lighter; male antennæ with very large discs on very short filaments. *verticis.*

AA. Vertex without round black spots.
 B. With dark band on sutural margin of elytra. *suturalis.*
 BB. Without dark band on sutural margin of elytra.
  C. Size large, over 5 mm. long.
   D. Outer anteapical cell present, male antennal discs large. *pallidus.*
   DD. Outer anteapical cell absent, male antennal discs very small. *duzeei.*
  CC. Size smaller, less than 5 mm. long, elytra hyaline, showing dark nervures of the wings. *nervatus.*

Idiocerus fitchi Van D.

Idiocerus fitchi Van D., Can. Ent., xli, p. 383, 1909 (n. n. for maculipennis Fh.).
Idiocerus maculipennis Fh., Homop. N. Y. St. Cab., p. 59, 1851.
Bythoscopus maculipennis Walk., List Homop., IV., p. 1161, 1852.
Idiocerus maculipennis Van D., Psyche, V, p. 388, 1890.
Idiocerus maculipennis O. & B., Proc. Dav. Acad. Sci., VII, pp. 73, 127, 1898.
Idiocerus maculipennis Osb., 20th Rept. N. Y. St. Ent., p. 507, 1905.
Idiocerus fitchi Britt. & Saund., Can. Ent., xlix, p. 149, pl. IX, 1917.
Idiocerus maculipennis Van D., Cat. Hemip. N. A., p. 580, 1917.
Idiocerus maculipennis Nic., Ent. News, XXX, p. 277, 1919.

* Adapted from Osborn and Ball, Proc. Dav. Acad. Sci., VII, p. 125, 1898.

This species has not yet been reported from the state, but likely occurs here. It is a chestnut brown species with two large, black spots on the vertex, the costal margin of the distal half of the wings has two large, dark-brown spots which are separated by a large hyaline band. Length, 5.25 to 5.75 mm. Ball records it as abundant on hawthorn and crabapple.

Idiocerus provancheri Van D.

Idiocerus provancheri Van D., Can. Ent., xxiii, p. 111, 1890. (n. n. for clitellarius Prov.)
Bythoscopus clitellarius Prov., Pet. Faune Ent. Can., iii, p. 288, 1890.
Idiocerus provancheri Osb., Proc. Ia. Acad. Sci., I, pt. 2, p. 126, 1892.
Idiocerus provancheri O. & B., Proc. Dav. Acad. Sci., VII, p. 127, 1898.
Idiocerus provancheri Osb., Me. Agr. Exp. Sta., Bul. 238, p. 77, 1916.
Idiocerus provancheri Van D., Cat. Hemip. N. A., p. 580, 1917.

This is another of the forms which, though not yet reported from Kansas, likely occur here. The females are fulvous brown, the males darker, but both are readily recognized by having broad, yellow stripes on the base of the clavus. Length, 5 to 5.3 mm. Occurs on *Cratægus.*

Idiocerus cratægi Van D.

Idiocerus cratægi Van D., Can. Ent., XXII, p. 110, 1890.
Idiocerus cratægi O. & B., Proc. Dav. Acad. Sci., VII, p. 128, 1898.
Idiocerus cratægi Osb., 20th Rept. N. Y. St. Ent., p. 507, 1905.
Idiocerus cratægi Van D., Cat. Hemip. N. A., p. 580, 1917.

This species will likely be found in the state sooner or later, though it has not yet been taken here. It is slightly smaller than the preceding species, olive drab in color, and at once recognized by the two rows of black spots on the vertex, prothorax and scutellum. Length, 4.75 to 5.25 mm. Feeds on *Cratægus*

Idiocerus snowi G. & B.

(Pl. 3, figs. 9-11.)

Idiocerus snowi G. & B., Hemip. Colo., p. 79, 1895.
Idiocerus snowi O. & B., Proc. Dav. Acad. Sci., VII, p. 129, 1898.
Idiocerus snowi Van D., Cat. Hemip. N. A., p. 579, 1917.

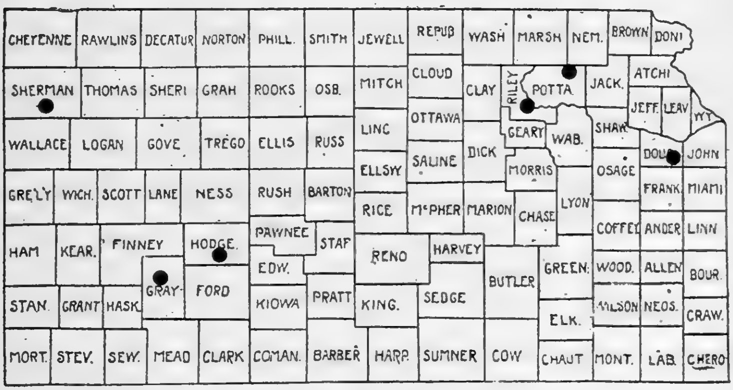
Form: Larger and usually more slender than preceding species. Length, 5.25 to 5.75 mm.

Color: Pale green except for two small, black spots on vertex, a dark band on sutural margin of elytra from tip of scutellum to tip of clavus. Elytra hyaline and with tips often somewhat dusky or brownish.

External genitalia: Female, last ventral segment less than three times as wide as long, lateral margins short, broadly curving with posterior margin to point of greatest length of the segment on either side of the broad but shallow median notch. Pygofers large, but exceeded by the ovipositor for more than a third of their length. Male, last ventral segment short except on median line, posterior margin sinuate with a large, obtusely pointed, median tooth; plates rather slender, somewhat exceeding the pygofers.

Male internal genitalia: Styles large, basal portion slender and straighter, distal portion stout and broadly curved; connective broad, corners attached to styles prominent, bearing a large ventral process, slightly concave at the end where it attaches to the œdagus; œdagus composed of a dorsal shorter heavy process for attachment, and a longer ventral process terminating in a sharp point, and bearing, at about its distal third, a pair of diverging anteriorly directed processes, giving this process an arrow-head appearance. Around the base of the anal tube is a heavy-set U-shaped collar with the arms of the U slightly diverging.

Distribution: This species likely occurs throughout the state, for specimens have been taken in the extreme western and eastern portions, as shown by the following map:



Idiocerus ramentosus (Uhl.).

Bythoscopus ramentosus Uhl., Bul. U. S. Geol. Geog. Surv., III, p. 465. 1877.
(*Idiocerus inscriptus* Uhl. MS.) in collections.
Idiocerus ramentosus Van D., Psyche, V, p. 389, 1890.
Idiocerus verticis Prov., Pet. Faune Ent. Can., III, p. 292, 1890.
Idiocerus mimicus G. & B., Hemip. Colo., p. 76, 1895.
Idiocerus ramentosus G. & B., Hemip. Colo., p. 79, 1895.
Idiocerus brunneus O. & B., Proc. Dav. Acad. Sci., VII, pp. 72, 129, 1898.
Idiocerus ramentosus O. & B., Proc. Dav. Acad. Sci., VII, p. 137, 1898.
Idiocerus ramentosus Gibs., Can. Ent., XLIX, p. 75, 1917.
Idiocerus ramentosus Van D., Cat. Hemip. N. A., p. 579, 1917.

This is another species which though not yet reported, will likely be found in Kansas.

It is a rather broad form, of a cinnamon-brown color, and having two small, black spots on the vertex. Length, 5.5 mm. It is a willow-feeding species.

Idiocerus moniliferæ O. &. B.

Idiocerus moniliferæ O. & B., Proc. Dav. Acad. Sci., VII, pp. 71, 131, 1898.
Idiocerus moniliferæ Tuck., Kan. Univ. Sci. Bul., IV, p. 65, 1907.
Idiocerus moniliferæ Van D., Cat. Hemip. N. A., p. 578, 1917.

Form: Rather broad and somewhat flattened. Length, 5.5 mm.

Color: Brownish species. Vertex and pronotum rather irregularly marked with dark-brown, scutellum with large, dark, triangular basal marks, and light-brown median band between the two, and two similar light-brown bands on posterior portion. Face with dark band above ocelli, and other irregular markings. Elytra hyaline, with nervures alternately light and dark, and differing from *alternatus* and *verticis* by having the cross nervure between the sectors broadly white.

External genitalia: Female, last ventral segment medially produced posteriorly and slightly notched; pygofers broad and long, only slightly exceeded by tip of ovipositor. Male, last ventral segment with very short lateral margins, posterior margin greatly produced posteriorly, forming a very large obtusely-pointed median projection; plates short and stout, exceeded by tips of pygofers; antennæ without discs.

Distribution: Douglas, Riley, and Wallace counties are the only ones in which specimens have been taken.

Host: Cottonwood.

Idiocerus alternatus Fh.

Idiocerus alternatus Fh., Homop. N. Y. St. Cab., p. 59, 1851
Bythoscopus alternatus Walk., List Homop., III, p. 876, 1851.
Idiocerus interruptus G. & B., Hemip. Colo., p. 74, 1895.
Idiocerus alternatus O. & B., Proc. Dav. Acad. Sci., VII, pp. 70, 131, 1898.
Idiocerus alternatus Osb., 20th Rept. N. Y. St. Ent., p. 506, 1905.
Idiocerus alternatus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 93, 1915.
Idiocerus alternatus DeL. Tenn. St. Bd. Ent., Bul. 17, p. 10, 1916.
Idiocerus alternatus Van D., Cat. Hemip. N. A., p. 577, 1917.
Idiocerus alternatus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 18, 1919.

Form: Smaller and not as robust as preceding species. Length, 5 to 5.25 mm.

Color: Brownish species, much as in preceding species. Vertex with two small, black spots. Broad median white band on pronotum and extending on to vertex. Elytra with nervures alternately light and dark, a distinct broad light band across the tips of the outer claval nervures and a smaller one at the tip of the clavus; cross nervure between the sectors dark.

External genitalia: Female, last ventral segment short, posterior margins truncate or slightly sinuate, with faint median notch, lateral margins strongly narrowed posteriorly; pygofers broad and long, but exceeded by the ovipositor for a third their length. Male, ventral segment very short except for two large lateral lobes which are separated by a wide and deep median incision in which is a very small median lobe; plates, slightly exceeded by the long pygofers; antennal discs nearly circular.

Distribution: So far, we have records of the collection of this species from four northern counties, namely: Douglas, Riley, Decatur and Rawlins.

Hosts: Willows.

Idiocerus verticis (Say).

(Pl. 4, figs. 4-6.)

Jassus verticis Say, Jl. Acad. Nat. Sci. Phila., VI, p. 308, 1831; Compl. Writ., ii, p. 383.
Bythoscopus verticis Uhl., Bul. U S. Geol. Geog. Surv., iii, p. 465, 1877.
Idiocerus verticis Van D., Psyche, v, p. 389, 1890
Idiocerus verticis G. & B., Hemip. Colo., p. 80, 1895.
Idiocerus verticis O. & B., Proc. Dav. Acad. Sci., vii, p. 132, 1898.
Idiocerus verticis Osb., 20th Rept. N. Y. St. Ent., p. 507, 1905.
Idiocerus verticis DeL., Tenn. St. Bd. Ent., Bul. 17, p. 11, 1916.
Idiocerus verticis Van D., Cat. Hemip. N. A., p. 577, 1917.

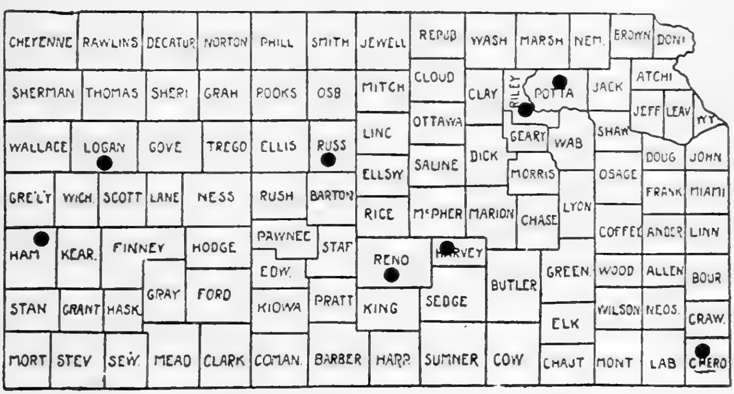
Form: The smallest member of the genus in Kansas. Length, 4.25 to 4.5 mm.

Color: Pale brownish to nearly white. Pair of small, black spots on vertex. Pronotum with light-brown markings on disc. Scutellum with basal angles black or brown. Brown nervures of elytra usually interrupted with white, dark specimens showing light spot across middle of clavus.

External genitalia: Female, last ventral segment much as in *alternatus,* short, posterior margin usually slightly sinuate on either side of the slightly produced and faintly notched median portion, lateral margins strongly narrowed posteriorly; pygofers exceeded by the ovipositor by about one-third their length. Male, last ventral segment as in *alternatus,* with long lateral lobes, large median incision with small median lobe, median incision sometimes not as deep as in *alternatus;* plates, long and slender, equalling the long pygofers; antennæ very short and with very large discs.

Male internal genitalia: Styles smaller than in *snowi,* basal part more slender; connective with three basal processes, as in *snowi,* but upper portion narrow, only half as wide; œdagus Y-shaped, with distinct base and slender upper arm, lower arm simple, without the arrowhead appearance as in *snowi;* collar around base of anal tube slender and open slightly at tip, forming almost a complete circle.

Distribution: A species seemingly occurring over the state, as shown by the following map:



Hosts: Willows.

Idiocerus suturalis Fh.

Idiocerus suturalis Fh., Homop. N. Y. St. Cab., p. 59, 1851.
Bythoscopus suturalis Walk., List. Homop., iv, p. 1162, 1852.
Idiocerus suturalis Van D., Can Ent, xxi, p. 8, 1899.
Idiocerus suturalis Van D., Psyche, v, p. 388, 1890.
Idiocerus suturalis G. & B., Hemip. Colo., p. 80, 1895.
Idiocerus suturalis O. & B., Proc. Dav. Acad. Sci., vii, p. 134, 1898.
Idiocerus suturalis Ball, Can. Ent., xxxiv, p. 311, 1902.
Idiocerus suturalis Osb., 20th Rept. N. Y. St. Ent., p. 506, 1905.
Idiocerus suturalis Osb., Me. Agr. Exp. Sta., Bul. 238, p. 95, 1915.
Idiocerus suturalis Van D., Cat. Hemip. N. A., p. 576, 1917.

Form: Larger than preceding species. Length, 5 to 5.75 mm.

Color: Light yellow, with pronotum and scutellum frequently marked in places with light brown, the basal angles of the latter sometimes with black triangles; elytra with sutural margins broadly marked with brown band which narrows to tip of clavus and then expands on membrane into a smoky area.

External genitalia: Female, last ventral segment with lateral margins about half as long as median length, due to a broad median lobe; pygofers broad and long, exceeded by ovipositor by about one-fifth their length. Male, last ventral segment very narrow, median incision broad and with a broad, short, triangular process; plates long and narrow, exceeding the short pygofers.

Distribution: Hitherto taken only in Douglas and Logan counties.

Hosts: Willows seem to be the ordinary host. Van Duzee reports taking specimens from poplar and birch, also.

Idiocerus pallidus Fh.

(Pl. 4, figs. 1-3.)

Idiocerus pallidus Fh., Homop. N. Y. St. Cab., p. 59, 1851.
Bythoscopus obsoletus Walk., List. Homop., iii, p. 873, 1851.
Bythoscopus pallidus Walk., List Homop., iv, p. 1162. 1852.
Idiocerus pallidus Van D., Can. Ent., xxi, p. 8, 1889.
Idiocerus unicolor Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 126, 1892.
Idiocerus pallidus G. & B., Hemip. Colo., p. 76, 1895.
Idiocerus pallidus O. & B., Proc. Dav. Acad. Sci., vii, p. 135, 1898.
Idiocerus pallidus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 93, 1915.
Idiocerus pallidus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 11, 1916.
Idiocerus pallidus Gibs., Can. Ent., xlix, p. 75, 1917.
Idiocerus pallidus Van D., Cat. Hemip. N. A., p. 575, 1917.
Idiocerus pallidus Fent., Ohio Jl. Sci., xviii, No. 6, p. 182, 1918.

Form: This and the following species are the largest members of this genus known to occur in the state. Broad. Length, 6 to 6.5 mm. Distinguished from *duzeei* by usually having long, triangular, outer anteapical cell.

Color: Our specimens are almost uniformly pale green with the eyes reddish-brown. Elytra are frequently iridescent but not fuscous-tipped as in *duzeei.*

External genitalia: Female, last ventral segment about one-fourth as long as wide laterally, but nearly one-half as long as wide medially, due to large rounded median lobe on posterior margin; pygofers exceeded by ovipositor for about one-third their length. Male, last ventral segment narrow, the tip of triangle, in the wide median incision, reaching posteriorly to point in line with lateral lobes; plates very long and narrow, frequently greatly exceeding the short pygofers.

Internal male genitalia: Styles large with basal portion much larger proportionally than in *verticis;* connective of same type as in *verticis* but with dorsal portion wider, though not as wide as in *snowi,* and with end fastened to œdagus much more deeply emarginated than in the latter; œdagus without basal portion as in *verticis,* dorsal arm very heavy and with heavy ventral portion provided with retrorse lateral processes which, however, are nearer the apex than in *snowi,* giving the arrowhead appearance; antennæ with moderately large oblong discs.

Distribution: Taken in Harvey, Harper, Riley, Pottawatomie, and Wyandotte counties.

Hosts: Willows. Doctor Osborn gives poplar as a host, too. Crevecœur records sweeping specimens from weeds in a pasture.

Idiocerus duzeei Prov.

Idiocerus duzeei Prov., Pet. Faune Ent. Can., iii, p. 292, 1890.
Idiocerus perplexus G. & B., Hemip. Colo., p. 78, 1895.
Idiocerus perplexus Bak., Ent. News, viii, p. 54, 1897.
Idiocerus duzeei O. & B., Proc. Dav. Acad. Sci., vii, p. 136, 1898.
Idiocerus duzeei Bak., Can. Ent., xxxii, p. 207, 1900.
Idiocerus perplexus Tuck, Univ. Kan. Sci. Bul., iv, p. 65, 1907.
Idiocerus perplexus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 95, 1915.
Idiocerus perplexus Van D., Cat. Hemip. N. A., p. 577, 1917.

Form: Slightly larger than *pallidus.* Elytra longer, broad, rarely having outer anteapical cell. Length, 6 to 7 mm.

Color: Yellowish-green, pronotum greenish, scutellum and elytra golden-yellow, latter becoming smoky at tip in female and darker still in male.

External genitalia: Female, last ventral segment longer laterally than in *pallidus,* and therefore having a less prominent lobe medially on the posterior margin; pygofers broad and long, slightly exceeded by ovipositor. Male, last ventral segment much as in *pallidus* but with median triangular lobe not quite as long; valves long and narrow, greatly exceeding the short pygofers; antennal disc more slender than in *pallidus.*

Distribution: Taken only in Pottawatomie and Riley counties.

Hosts: Osborn and Ball give cottonwood as the host of this species.

Idiocerus nervatus Van D.

(Pl. 4, figs. 7-9.)

Idiocerus nervatus Van D., Bul. Buf. Soc. Nat. Sci., v, pp. 194, 205, 1894.
Idiocerus nervatus G. & B., Hemip. Colo., p. 76, 1895.
Idiocerus nervatus O. & B., Proc. Dav. Acad. Nat. Sci., vii, p. 137, 1898.
Idiocerus nervatus Osb., 20th Rept. N. Y. St. Ent., p. 506, 1905.
Idiocerus nervatus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 11, 1916.
Idiocerus nervatus Van D., Cat. Hemip. N. A., p. 575, 1917.
Idiocerus nervatus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 18, 1919.

Form: Next to *verticis* the smallest member of the genus found in the state. A small, stout species with long elytra. Length, 4.5 to 4.75 mm.

Color: Quite uniformly greenish to yellowish in color. Elytra quite hyaline, showing clearly the dark nervures of the under wings.

External genitalia: Female, last ventral segment little over twice as broad as long, lateral margins rounding, posterior margins truncate or slightly sinuate to two very small median lobes, separated by suggestion of a median notch; ovipositor exceeding pygofers by nearly one-third their length. Male, last ventral segment short, very wide median excision bearing distinct, acutely pointed lobe; valves long and narrow, but not exceeding the long pygofers; male antennal disc small and nearly circular.

Internal male genitalia: Styles with very small basal portion, even smaller than in *verticis;* connective of same type as in *verticis* except that dorsal portion is more slender; œdagus like that of *verticis* except for the small pair of retrorse processes near the tip.

Distribution: Taken in Crawford, Douglas, Riley and Ottawa counties.

Hosts: Willows.

Genus BYTHOSCOPUS Germ.

To this genus belong short, stout species, with the head narrower than the prothorax, the anterior margin of which is not produced beyond the anterior margin of the eyes. The vertex is short, often with the margins nearly parallel, but frequently much longer on the median line than next the eyes. The pronotum is large, with very distinct, parallel, transverse striations. The elytra are subcoriaceous, short, deeply punctured, and with the punctures bearing short hairs.

Only one species of this genus has been recorded from Kansas, but it is probable that the following two occur.

KEY TO SPECIES.

A. Size 5.75 mm. or over, more slender forms. *lætus.*
AA. Size 5 mm. or less, short, broad forms. *apicalis.*

Bythoscopus lætus (Uhl.).

Pachyopsis lætus Uhl, Bul. Geol. Geog. Surv., iii, p. 466, 1877.
Macropsis lætus Ball, Ohio Nat., iii, p. 397, 1903.
Bythoscopus lætus Van D., Cat. Hemip. N. A., p. 589, 1917.

This large green species has not yet been taken in Kansas. Its host plant, *Rhus aromatica,* occurs here as well as on the plains of Colorado, where it has been taken. Its pink variety, *pætus* Ball, reported by Ball to occur on the fruit clusters of the plant, should also be found here. Length, 5.75 to 7 mm.

Bythoscopus apicalis (O. & B.).

Pl. 5, figs. 1-4.)

Macropsis apicalis O. & B., Proc. Dav. Acad. Sci., vii, p. 64, 1898.
Macropsis alabamensis Bak., Psyche, ix, p. 58, 1900.
Macropsis apicalis Ball, Psyche, ix, p. 129, 1900.
Macropsis apicalis DeL., Tenn. St. Bd. Ent., Bul. 17, p. 9, 1916.
Bythoscopus apicalis Van D., Cat. Hemip. N. A., p. 589, 1917.

Form: Short and broad. Vertex very short and narrow. Pronotum distinctly striated transversely, much broader than head, lateral margins long and widening posteriorly, humeral margins about as long as lateral margins, posterior margin broadly and slightly concave. Elytra appearing broad and short but exceeding abdomen, appendix large and glabrous, but rest of elytra deeply punctate with each puncture bearing a prominent hair.

Color: Uniformly bright green, except for small black spots on apex of elytra.

External genitalia: Female, last ventral segment a little over twice as long as broad, posterior angles prominent, with posterior margin sinuate to slightly produced broad median lobes which have a shallow notch between them; pygofers long, barely exceeded by tip of ovipositor or equalling or even exceeding ovipositor. Male, valve very large, prominently elevated on median line, as long as broad, posterior margin broadly convex.

Male internal genitalia: The plates are completely covered by the valve and are therefore here described with the internal organs. They are over twice as long as wide, having the outer anterior angle produced to connect with the styles and also having the inner posterior angles greatly produced and pointed, outer posterior angle large and broadly rounded, making the plate the broadest at this point. They are peculiar also in their position, standing almost vertically instead of being in the ordinary horizontal position. Styles are long and slender and somewhat curved, arising from the top or really the anterior end of the plates. The connective here seems to be composed of a U-shaped piece attached to the top of the plates. This piece has a small anterior lobe to which are fastened a pair of long chitinous organs, widest near the middle, and tapering to ends, one anteriorly curved and the other posteriorly. These organs look much like styles but judging from their vertical position and their relation to the other parts, I would conclude they are parts of a very characteristic connective rather than a second pair of styles. To a point near the middle of these latter organs is fastened the œdagus, consisting of a large, triangular dorsal piece, when viewed laterally, from the base of which there extends caudad the lower portion of the œdagus, which consists of two slender processes very much shorter than the styles. In the sides of the pygofers are imbedded two long chitinous organs as illustrated.

Distribution: Douglas county is the only place within the state where this species has been taken. There are specimens in the Snow collection from Kansas City, Mo. It should occur wherever its host is found.

Hosts: Seemingly confined to honey locust.

Genus MACROPSIS Lewis.

In this genus the vertex forms only a narrow margin to the pronotum, the head being almost entirely deflexed. It is as wide as the short and broad pronotum, the anterior margin of which is distinctly produced beyond the anterior margin of the eyes. The lateral margins of the pronotum are short, the posterior margin broadly or angularly concave, and its surface is distinctly and obliquely striated. The scutellum is broadly triangular and with a transverse depression before the apex. Elytra are thin and rather long.

Seven species of this genus likely occur in Kansas, five of which have been taken here. These may be separated by the following key:

KEY TO SPECIES *

A. General color above fuscous or rusty brown.
- B. Face marked with fuscous. *tristis.*
- BB. Face unicolorous. *trimaculata.*

AA. General color, orange or green.
- B. Elytra brownish or with dark brown median stripe.
  - C. Pronotum green, elytra with broad median band. *suturalis.*
  - CC. Pronotum yellow, elytra brownish. *crocea.*
- BB. Elytra greenish or slightly fuscous in male.
  - C. Larger species, vertex pointed, propleuræ of both sexes marked with black spots. *erythrocephala.*
  - CC. Smaller species, vertex more obtusely angled, propleuræ of female unmarked.
    - D. Females 5 to 6 mm. long, males with spots on propleuræ. *viridis.*
    - DD. Females less than 5 mm. long, males with propleuræ unmarked. *gleditschiæ.*

* Adapted from Osborn & Ball, Proc. Dav. Acad. Sci., vii, p. 114, 1898.

Macropsis tristis (Van D.).

Pediopsis tristis Van D., Can. Ent., xxii, p. 249, 1890.
Pediopsis tristis Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 126, 1892.
Pediopsis tristis O. & B., Proc. Dav. Acad. Sci., vii, pp. 66, 115, 1898.
Pediopsis tristis Ball, Ohio Nat., iii, p. 398, 1903.
Macropsis tristis Van D., Cat. Hemip. N. A., p. 585, 1917.

This species very likely occurs in Kansas. It is a grayish-brown form with face marked with a black band above and large spot below the ocelli. Striations of pronotum very distinct. Scutellum with dark triangular spots on basal angles. Elytra with light nervures, heavily fuscous-margined, making them very distinct and characteristic. Length, 4.75 to 5.5 mm.

Hosts: Dr. Ball gives wild plum as the host of this form.

Macropsis trimaculata (Fh.).

Pediopsis trimaculatus Fh., Homop. N. Y. St. Cab., p. 60, 1851.
Bythoscopus trimaculatus Walk., List Homop., iv, p. 1162, 1852.
Pediopsis insignis Van D., Ent. Am., v, p. 171, 1889.
Pediopsis insignis Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 126, 1892.
Pediopsis trimaculata O. & B., Proc. Dav. Acad. Sci., vii, p. 116, 1898.
Pediopsis trimaculata Ball, Ohio Nat., iii, p. 398, 1903.
Pediopsis trimaculata Osb., 20th Rept. N. Y. St. Ent., p. 504, 1905.
Pediopsis trimaculata Van D., Can. Ent., xli, p. 383, 1909.
Pediopsis trimaculata Osb., Me. Agr. Exp. Sta., Bul. 238, p. 91, 1915.
Macropsis trimaculata Van D., Cat. Hemip. N. A., p. 584, 1917.

Form: Smaller than preceding species. Length, 4 to 4.5 mm. Vertex and pronotum obtusely angled, latter distinctly striated and with posterior margin broadly and rather deeply concave.

Color: Yellowish-brown to dark brown, face unicolorous. Scutellum with triangular dark spot in each basal angle. Elytra with three white spots in a row on each elytron, the anterior one frequently wanting. Propleura with dark spot in both sexes. Differs from *tristis* in having face unmarked.

External genitalia: Female, last ventral segment about twice as broad as long, lateral margins greatly narrowed posteriorly, reducing posterior margin to less than one-half width of anterior margin, posterior margin broadly incised between the distinct lateral angles; pygofers long and narrow, exceeded by the ovipositor. Male, last ventral segment about twice as broad as long, posterior margin slightly emarginate medially; plates long and narrow, somewhat flattened, much exceeding the pygofers; broad and short, widest near the tip and ending truncately.

Distribution: Pottawatomie county is the only place in the state where this species has yet been taken.

Hosts: Occurs with the preceding form on wild plum.

Macropsis suturalis (O. & B.).

Pediopsis suturalis O. & B., Proc. Dav. Acad. Sci., vii, pp. 67, 119, 1898.
Pediopsis suturalis Wirtn., Ann. Carn. Mus., iii, p. 217, 1904.
Pediopsis suturalis Osb., Me. Agr. Exp. Sta., Bul. 238, p. 92, 1915.
Macropsis suturalis Van D., Cat. Hemip. N. A., p. 583, 1917.

Form: A large species. Length, 6 mm. Vertex and pronotum obtusely angled, the latter with the striations not as distinct as in preceding species. Elytra long and slender.

Color: Green all over except for dark brown lines starting on pronotum behind the eyes, including all the clavus, extending beyond clavus at about their distal half and continuing, as a narrow stripe, to tip of elytra.

External genitalia: Female, last ventral segment as in *trimaculata* but proportionately larger; pygofers very long and narrow, slightly exceeded by tip of ovipositor. Male, last ventral segment broad, slightly emarginate posteriorly; plates long and narrow, much exceeding the short but broad pygofers.

Distribution: Taken in Ottawa and Pottawatomie counties.

Hosts: Occurs in both counties on *Salix amygdaloides.*

Macropsis crocea (O. & B.).

Pediopsis crocea O. & B., Proc. Dav. Acad. Sci., vii, pp. 68, 120, 1898.
Macropsis crocea Van D., Cat. Hemip. N. A., p. 583, 1917.

Form: Stout. Length, 4 to 5.5 mm. Vertex and pronotum obtusely angled. Pronotum coarsely striated, posterior margin deeply concave, almost parallel with anterior margin. Elytra long and usually somewhat spread apart at tip.

Color: Yellow, but with elytra, especially clavus, clouded with brown.

External genitalia: Female, last ventral segment characteristic of the genus; pygofers long and narrow, exceeded by ovipositor. Male, last ventral segment over twice as broad as long; valve appearing to be short and triangular; plates long, narrow and flattened, exceeding the short, broad and truncate pygofers.

Distribution: This form has not yet been reported from Kansas.

Hosts: The types were taken on honey locust.

Macropsis erythrocephala (G. & B.).

Pediopsis erythrocephala G. & B., Hemip. Colo., p. 72, 1895.
Pediopsis erythrocephala O. & B., Proc. Dav. Acad. Sci., vii, p. 120, 1898.
Pediopsis erythrocephala Ball, Ohio Nat., iii, p. 398, 1903.
Pediopsis erythrocephala Tuck., Kans. Univ. Sci. Bul., iv, p. 65, 1907.
Macropsis erythrocephalus Van D., Cat. Hemip. N. A., p. 583, 1917.

Form: A large, stout species, larger than other green species of this genus. Length, 5 to 5.75 mm. Vertex and pronotum more acutely pointed than in most members of the genus. Striations of pronotum distinct, but rather fine.

Color: Green, varying to reddish-orange on face, pronotum, and scutellum of female. Male, greenish brown, with dark-brown spots laterally near anterior margin of pronotum and on basal angles of the scutellum. Propleuræ with large black spots in both sexes.

Genitalia: Characteristic of the genus.

Distribution: Gray and Pottawatomie counties have so far yielded specimens of this species.

Hosts: *Salix fluviatilis* seems to be the willow on which it occurs.

Macropsis viridis (Fh.).

(Pl. 5, figs. 7-9.)

Pediopsis viridis Fh., Homop. N. Y. St. Cab., p. 59, 1851.
Bythoscopus viridis Walk., List Homop., iv, p. 1162, 1852.
Pediopsis viridis Uhl., Bul. U. S. Geol. Geog. Surv., iii, p. 467, 1877.
Pediopsis viridis Van. D., Can. Ent., xxi, p. 9, 1889.
Pediopsis viridis Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 126, 1892.
Pediopsis viridis G. & B., Hemip. Colo., p. 73, 1895.
Pediopsis viridis O. & B., Proc. Dav. Acad. Sci., vii, p. 121, 1898.
Pediopsis viridis Osb., 20th Rept. N. Y. St. Ent., p. 504, 1915.
Pediopsis viridis Osb., Me. Agr. Exp. Sta., Bul. 238, p. 89, 1915.
Pediopsis viridis DeL. Tenn. St. Bd. Ent., Bul. 17, p. 16, 1916.
Macropsis viridis Van D., Cat. Hemip. N. A., p. 582, 1917.
Macropsis viridis Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 24, 1919.

Form: Medium sized, smaller than *erythrocephala*, larger than *gleditschiæ*. Length, 4.5 to 5.5 mm. Species with vertex and pronotum obtusely angled, the latter distinctly striated.

Color: Female green, with tips of elytra slightly fuscous; males green, but tinged with fuscous, elytra brownish practically all over. Males with black spot on propleuræ, thus differing from *gleditschiæ*.

External genitalia: Characteristic of the genus, with a very strong chitinous band bounding the posterior margin of the pygofers and extending dorsad in a prominent spine.

Male internal genitalia: Styles very long, with a distinct bend posterior to point of attachment with connective, terminal portion broadly curved and with sides about parallel clear to the tip, except for slight bulge about midway; connective large and stout, Y-shaped when viewed dorsally, with base of Y very heavy and with a dorsal terminal process; œdagus with distinct basal portion from which there extends dorsad a strong process and a longer, posteriorly tapering but dorsally curved portion.

Distribution: Taken in Douglas, Pottawatomie and Ottawa counties.

Hosts: Willow.

Macropsis gleditschiæ (O. & B.).

Pediopsis gleditschiæ O. & B., Proc. Dav. Acad. Sci., vii, pp. 67, 122, 1898.
Pediopsis gleditschiæ Wirtn., Ann. Carn. Mus., iii, p. 218, 1904.
Pediopsis gleditschiæ DeL., Tenn. St. Bd. Ent., Bul. 17, p. 16, 1916.
Macropsis gleditschiæ Van D., Cat. Hemip. N. A., p. 581, 1917.

Form: Smaller than *viridis*. Pronotum obtusely angled and with very distinct striations.

Color: Deeper green than *viridis*. Males slightly fuscous and in both cases the subhyaline elytra slightly brownish. Differs from other green forms in lacking the black spot on the propleuræ in both sexes.

External genitalia: Characteristic of the genus.

Distribution: Found so far only in Hamilton county, but likely occurs in eastern portions of the state as well, for specimens have been taken at Kansas City, Mo.

Hosts: Honey locust.

Genus ONCOPSIS Burm.

Like *Macropsis*, the members of this genus have the pronotum angularly produced beyond the anterior margin of the eyes, but the pronotum differs in being rather more reticulate than striate and with the reticulations running more transversely than obliquely. The pronotum is short and deeply concave posteriorly, with the lateral margins very short.

A single species of this genus has been taken in Kansas.

Oncopsis distinctus (Van D.).

(Pl. 5, figs. 5-6.)

Bythoscopus distinctus Van D., Ent. Am., vi, 224, 1890.
Bythoscopus distinctus O. & B., Proc. Dav. Acad. Sci., vii, p. 65, 1898.
Bythoscopus distinctus Osb., 20th Rept. N. Y. St. Ent., p. 504, 1905.
Bythoscopus distinctus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 15, 1916.
Oncopsis distinctus Van D., Cat. Hemip. N. A., p. 588, 1917.
Oncopsis distinctus Weiss, Ent. News, xxix, p. 310, 1918.

Form: A short robust species. Length, 4 to 4.5 mm. Vertex very short, posterior margin raised up from pronotum which is not as sharply angled as in *Macropsis*. Pronotum very deeply reticulate and scutellum somewhat less so. Elytra greatly exceeding abdomen and characterized by having only two anteapical cells and four apical cells.

Color: Vertex, pronotum and scutellum usually greenish, sometimes brownish, and usually pitted with black, the scutellum with triangular dark spots on basal angles. In light forms these black pits and spots may be absent. In typical and dark forms the elytra are quite dark across the base, have a dark band across tip of clavus and the apex darkened. In light specimens the elytra are gray with the dark spot at tip of clavus, cephalad of which appears a light area.

External genitalia: Female, last ventral segment sinuately produced medially and with small median notch; pygofers short and broad, widest at beginning of distal half and then tapering suddenly, slightly exceeded by ovipositor. Male, last ventral segment long, posterior margin truncate; plates long and narrow, about equal to the long narrow pygofers.

Internal male genitalia: Styles with anterior portion distinctly club-like, fastened to connective at middle of club, terminal portion long, slender at base, and gradually thickened to broad and plump tip, this terminal portion slightly curved; connective with three basal processes, the median one long, upper part slender and widening at tip attached to œdagus; œdagus, viewed dorsally, club-like, with a broad, heavy base and tip somewhat bifid, fastened at about its middle to a very characteristic broadly U-shaped structure with the tips of the arms directed strongly caudad; imbedded in the side of the pygofers, at their caudal end, are two small, pointed chitinous bars, one much smaller than the other.

Distribution: Reported only from Douglas and Pottawatomie counties. Probably occurs wherever its host is found.

Hosts: Taken abundantly on walnut.

Subfamily CICADELLINÆ Van D.

This subfamily and the *Gyponinæ* are at once distinguished from all other members of the *Cicadellidæ* by having the ocelli situated above the margin, on the disc of the vertex. The members of the *Cicadellinæ,* however, are cylindrical and elongate in form, as distinguished from the robust and flattened *Gyponinæ.*

Seven genera of this subfamily occur in Kansas.

KEY TO GENERA.*

A. Antennal sockets usually overhung by a distinct ledge which projects beyond curve of head, anterior tibiæ sulcate above or dilated at the extremity. Elytra narrow, not covering lateral margins of abdominal terga.

- B. Thorax roundingly six-angular, posterior margin rounding, with a slight median excavation. Vertex longitudinally furrowed. Claval veins distant. *Aulacizes.*
- BB. Thorax four-angular, posterior margin broadly emarginate, anterior and posterior margins nearly parallel. Claval veins often united in the middle or approaching and tied by a cross nervure.
  - C. Vertex triangular, longer than basal width, side margins nearly straight; face as seen from side nearly straight. *Homalodisca.*
  - CC. Vertex obtusely rounding, shorter than, or as long as basal width; face as seen from side, roundingly angled. *Oncometopia.*

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* Adapted from key by Prof. E. D. Ball, Proc. Ia. Acad. Sci., viii, p. 38, 1901.

AA. Ledge above antennal sockets small, not projecting beyond curve of head. Anterior tibiæ slender, round or triangular. Elytra broad, covering abdominal terga.
- B. Elytra not reticulately veined at apex, head not greatly produced.
  - C. Margin of vertex roundingly obtuse, front inflated.
    - D. Antennæ of male not enlarged at the apex, pronotum not twice as long as scutellum, posterior margin slightly emarginate.
      - E. Lateral margins of vertex not distinctly in line with the outer margins of the eyes. *Cicadella.*
      - EE. Lateral margins of vertex in line with the outer margins of the eyes. *Kolla.*
    - DD. Antennæ of male enlarged at apex, pronotum more than twice as long as scutellum, posterior margin deeply emarginate. *Helochara.*
  - CC. Vertex flat, margin distinct, acutely angled with front. *Graphocephala.*
- BB. Elytra reticulately veined on apical third. Head often produced into a triangle, longer than pronotum. *Dræculacephala.*

Genus AULACIZES A. & S.

In this genus the antennal sockets are overhung by a distinct ledge which projects beyond the line of the head. The rather long vertex is bluntly rounded. The pronotum is six-sided, widest at the lateral angles, and with posterior margin slightly emarginate. The anterior tibiæ are sulcate above. The elytra are long and narrow, not covering the terga of the abdomen.

A single specimen of this genus occurs in Kansas.

Aulacizes irrorata (Fabr.).

(Pl. 6, figs. 1-3.)

Cicada irrorata Fabr., Ent. Syst., iv, p. 33, 1794.
Cicada nigripennis Fabr., Ent. Syst., iv, p. 32, 1794.
Tettigonia irrorata Burm., Handb. d. Ent., ii, p. 119, 1835.
Proconia nigripennis Walk., List. Homop., iii, p. 783, 1851.
Aulacizes rufiventris Walk., List. Homop., iii, p. 796, 1851.
Aulacizes irrorata Walk., List. Homop., Suppl., p. 236, 1858.
Aulacizes irrorata Stal, Hemip. Fabr., ii, p. 64, 1869.
Aulacizes irrorata Uhl., Bul. U. S. Geol. Geog. Surv., 1, p. 357, 1876.
Aulacizes irrorata Woodw., Bul. Ill. St. Lab. Nat. Hist., iii, p. 19, pl. 2, figs. 15-18, 1887.
Aulacizes irrorata Ball, Proc. Ia. Acad. Sci., viii, p. 40, 1901.
Aulacizes irrorata Osb., 20th Rept. N. Y. St. Ent., p. 509, 1905.
Aulacizes irrorata DeL., Tenn. St. Bd. Ent., Bul. 17, p. 17, 1916.
Aulacizes irrorata Van D., Cat. Hemip. N. A., p. 594, 1917.
Aulacizes irrorata Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 2, 1918.
Aulacizes irrorata Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 27, 1919.

Form: A large, long species. Length, 11.5 to 12.5 mm. Head a little wider than pronotum, slightly longer than broad. Vertex very obtusely angulate, its surface irregular and with a prominent median furrow which widens greatly anteriorly. Pronotum 6-sided, surface irregular, posterior margin slightly concave. Elytra long and narrow, not completely covering terga of abdomen.

Color: Varying from light to dark reddish-brown, irrorate with yellow. Scutellum with an extra large yellow spot before apex; vertex and pronotum with more yellow than elytra except for yellow costal band on the latter. Front irregularly black below, pale above, with four black spots in a square above.

External genitalia: Female, last ventral segment a little over twice as long as broad, lateral margins much narrowed posteriorly, posterior margins produced with rather straight sides to a distinct but shallow median notch; pygofers narrow basally and still more distally, but wide at middle, equal to or exceeded by tip of ovipositor. Male, valve very small, often barely seen from under tip of last ventral segment; plates together forming a triangle a little broader than long, clothed with fine hairs; pygofers broad and short, about equalling the plates.

Internal male genitalia: Styles broad and slightly chitinized at base, tapering rather suddenly a little past their middle to heavily chitinized neck-like processes which widen distally into the shape of a bird's head, the attachment to the plates being a large conspicuous lobe at the base of the neck; connective long and slender, U-shaped, with arms sinuate at base and then reaching to œdagus as a long strap, with median longitudinal third heavily chitinized, this heavy chitinous band broadening toward the tip; œdagus with heavy body portion and three pairs of processes, a pair of blunt dorsal ones and two pairs of caudal processes, one pair short and lightly chitinized apically and situated dorsad of a longer and heavily chitinized pair.

Distribution: Taken in Cherokee and Montgomery counties. Occurs further north too, for specimens have been taken near Kansas City, Mo.

Hosts: Collected from weeds and shrubs. De Long reports taking it on oak.

Genus HOMALODISCA Stal.

Antennal ledge as in *Aulacizes,* head with prominent eyes, wider than pronotum, and as long as width between eyes. Front and vertex forming an acute angle. Pronotum four-angular, short, anterior and posterior margins nearly parallel. Elytra long and narrow, hyaline, claval nervures united near the middle. Anterior tibiæ sulcate.

Homalodisca triquetra (Fabr.).

(Pl. 6, figs. 4-6.)

Cicada triquetra Fabr., Syst. Rhyng., p. 63, 1803.
Tettigonia vitripennis Germ., Mag. d. Ent., iv, p. 61, 1821.
Tettigonia coagulata Say, Insects of La., p. 13, 1832.
Tettigonia ichthyocephala Sign., Ann. Soc. Ent. Fr., Ser. 3, iii, p. 494, 1854.
Tettigonia triquetra Sign., Ann. Soc. Ent. Fr., Ser. 3, iii, p. 240, 1855.
Ciccus triquetra Walk., List Homop., Suppl., p. 243, 1858.
Proconia admittens Walk., List Homop., Suppl., p. 227, 1858.
Proconia aurigena Walk., List Homop., Suppl., p. 228, 1858.
Proconia excludens Walk., Ins. Saund., Homop., p. 98, 1858.
Homalodisca triquetra Stal, Hemip. Fabr., ii, p. 64, 1869.
Homalodisca triquetra Fowl., Biol. Centr. Am., Homop., ii, p. 221, pl. 14, fig. 1, 1899.
Homalodisca triquetra Ball, Proc. Ia. Acad. Sci., viii, p. 47, pl. 2, fig. 1, 1901.
Homalodisca triquetra DeL., Tenn. St. Bd. Ent., Bul. 17, p. 19, 1916.
Homalodisca triquetra Van D., Cat. Hemip. N. A., p. 594, 1917.
Homalodisca triquetra Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 2, 1918.
Homalodisca triquetra Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 30, 1919.

Form: A long narrow species. Length, 13 mm. Vertex as long as basal width, apex bluntly rounding, with longitudinal median depression. Pronotum very coarsely pitted, short, anterior and posterior margins about parallel. Elytra long and narrow, hyaline, venation prominent.

Color: Brownish, with vertex, pronotum and scutellum irrorate with yellow. Elytra smoky, especially apically, with an opaque red spot of varying size on costal margin of the apical cells.

External genitalia: Female, last ventral segment very large and long, slightly narrowing to acute lateral angles between which the posterior margin is broadly incised to fully one-third its depth by a triangular, obtusely pointed and sinuately margined incision; pygofers broadest at their middle, and slightly exceeded by tip of ovipositor. Male, plates together forming a triangle wider than long, tips very acute; pygofers short but very broad, narrowed at base, slightly widening posteriorly, and covered with long fine hairs, with a short blunt chitinous process imbedded in side of each.

Male internal genitalia: Styles very small for such a large form, broadest at base and tapering sinuately to blunt apex, apical half much roughened with fine teeth; connective very short, consisting of a transverse band widest at the middle, especially posteriorly; œdagus very large and peculiar, body with a long anteriorly and vertically directed process to meet the connective which extends ventrad from the styles, with a stout dorsal process and two pairs of terminal processes, an outer short and blunt process and an inner large, sharply pointed process.

Distribution: A southern species not yet reported from Kansas. It may occur in the southern portions of the state.

Hosts: Unknown.

Genus Oncometopia Stal.

The members of this genus have a distinct ledge over the antennal socket. The eyes are prominent, making the head wider than the pronotum. Vertex is rounded and obtusely joined to the front. Pronotum is short, four-angular, the anterior and posterior margins nearly parallel, lateral margins slightly narrowed behind. Elytra long and narrow, not covering abdominal terga. Anterior tibiæ are slightly sulcate above.

Two species and one variety of this genus have been found in the state.

KEY TO SPECIES.

A. Size large, 12 mm. or more, cross nervure cephalad of fork of first sector. *undata.*

AA. Size smaller, 9 mm. or less, cross nervure caudad of fork of first sector. *lateralis.*

Oncometopia undata (Fabr.).

(Pl. 7, figs. 1-3.)

Cicada undata Fabr., Ent. Syst., iv, p. 32, 1794.
Cicada orbona Fabr., Ent. Syst., Suppl., p. 530, 1798.
Tettigonia undata Germ., Mag. d. Ent., iv, p. 61, 1821.
Proconia undata Walk., List Homop., iii, p. 783, 1851.
Proconia nigricans Walk., List Homop., iii, p. 783, 1851.
Proconia clarior Walk., List Homop., iii, p. 784, 1851.
Proconia lucernea Walk., List Homop., iii, p. 785, 1851..
Proconia marginata Walk., List Homop., iii, p. 785, 1851.
Proconia badia Walk., List Homop., iii, p. 786, 1851.
Proconia scutellata Walk., List Homop., iii, p. 786, 1851.
Proconia tenebrosa Walk., List Homop., iii, p. 787, 1851.
Proconia plagiata Walk., List Homop., iii, p. 788, 1851.
Tettigonia undata Sign., Ann. Soc. Ent. Fr., ser. 3, ii, p. 486, pl. 17, fig. 5, 1854.
Oncometopia undata Stal, Hemip. Fabr., ii, p. 62, 1869.
Oncometopia undata Woodw., Bul. Ill. St. Lab. Nat. Hist., iii, p. 15, pl. 2, figs. 10-14, 1887.
Gypona? badia Van D., Ent. News, v, p. 157, 1894.
Oncometopia undata Fowl., Biol. Centr. Am., Homop., ii, p. 231, pl. 14. figs. 19, 20, 1899.
Oncometopia undata Ball, Proc., Ia. Acad. Sci., viii, p. 41, 1901.
Oncometopia undata Osb., 20th Rept. N. Y. St. Ent., p. 509, 1905.
Oncometopia undata DeL., Tenn. St. Bd. Ent., Bul. 17, p. 18, 1916.
Oncometopia undata Van D., Cat. Hemip. N. A., p. 591, 1917.
Oncometopia undata Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 2, 1918.
Oncometopia undata Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 28, 1919.

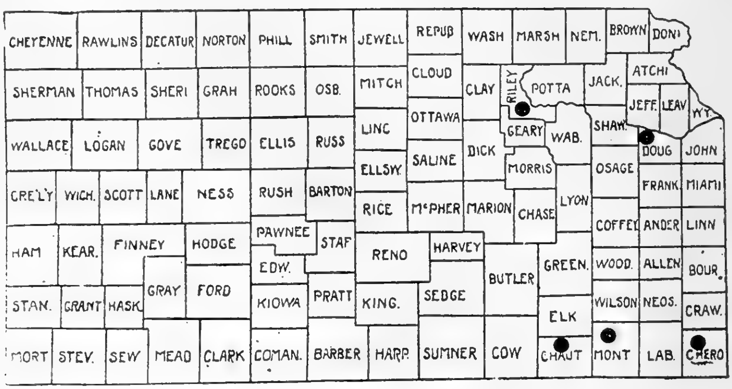
Form: A large, almost parallel-sided form. Length, 13 mm. Head broad, with prominent eyes. Vertex with sides very broadly rounded, very obtuse at apex, about two-thirds as long as basal width. Pronotum half wider than long, elevated. Elytra long and narrow, claval veins slightly approaching each other and usually with a cross nervure.

Color: Vertex, anterior margin of pronotum and scutellum rusty orange. Vertex with an incomplete black circle from which run out six or eight radiating lines. Scutellum also marked with dark lines. Pronotum, except anterior margin, and elytra varying much in color from slaty blue to brown and bright red. Elytra sometimes bear a large pruinose spot just back of the middle. Front orange with black median and lateral lines.

External genitalia: Female, last ventral segment longer than preceding, slightly narrowed posteriorly, posterior margin composed of three lobes, the lateral ones distinctly longer than the median; pygofers broad and short, sparsely covered with short, stout hairs and about equalled by the ovipositor. Male, plates small, forming a triangle about as long as wide, half the width of the last ventral segment; pygofers tapering posteriorly from the broad base, nearly twice the length of the plates; pygofers bearing an upturned chitinous process on caudal margin.

Internal male genitalia: Styles small for such a large species, pointed at anterior end, with a very large process for attachment to connective, slightly narrowed medially and then widened and narrowing to slightly out-turned and pointed tip, bearing several stout hairs on distal third of lateral margin; connective U-shaped with the loop very wide; œdagus large, prolonged anteriorly to meet connective, and with a very large anterior process extending dorsad, main portion dividing at apex into large rounded anterior process, a median smaller triangular one, and a posterior, acutely pointed still smaller one, a posterior process, also extending dorsad, long and narrow; long, crooked, slender chitinous bars extend down from base of anal tube to cephalo-dorsal portion of œdagus.

Distribution: Found in the eastern part of the state, as shown by the following map:



Hosts: Taken sweeping among weeds. De Long took specimens from ironweed.

Oncometopia lateralis (Fabr.).

(Pl. 8, figs. 1-2.)

Cercopis lateralis Fabr., Ent. Syst., Suppl., p. 524, 1798.
Cercopis marginella Fabr., Syst. Rhyng., p. 96, 1803.
Cercopis costalis Fabr., Syst. Rhyng., errata, 1803 (n. n. for *marginella* Fabr).
Tettigonia striata Walk., List Homop., iii, p. 775, 1851.
Tettigonia lugens Walk., List Homop., iii, p. 775, 1851.
Tettigonia pyrrhotelus Walk., List Homop., iii, p. 775, 1851.
Proconia costalis Walk., List Homop., Suppl., p. 224, 1858.
Proconia costalis Stal, Homop. Fabr., ii, p. 118, 1869.
Proconia costalis Van D., Can. Ent., xxi, p. 9, 1889.
Proconia costalis Osb., Proc., Ia. Acad. Sci., i, pt. 2, p. 125, 1892.
Oncometopia costalis Sloss., Ent. News, v, p. 5, 1894.
Oncometopia costalis G. & B., Hemip. Colo., p. 81, 1895.
Oncometopia lateralis Ball., Proc. Ia. Acad. Sci., viii, p. 44, 1901.
Oncometopia lateralis Osb., 20th Rept. N. Y. St. Ent., p. 509, 1905.
Oncometopia lateralis Osb., Me. Agr. Exp. Sta., Bul. 238, p. 99, 1915.
Oncometopia lateralis DeL., Tenn. St. Bd. Ent., Bul. 17, p. 18, 1916.
Oncometopia lateralis Van D., Cat. Hemip., N. A., p. 592, 1917.
Oncometopia lateralis Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 2, 1918.
Oncometopia lateralis Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 29, 1919.

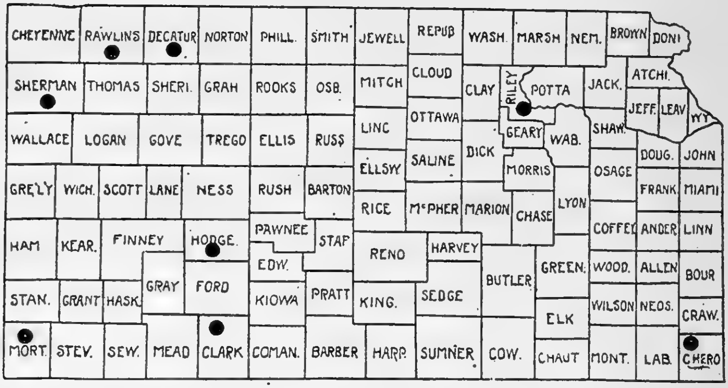
Form: Shorter than preceding species, but quite broad. Length, 7 to 8 mm. Head, about half as long as wide, vertex obtusely angled, eyes prominent. Pronotum short, anterior and posterior margins about parallel. Elytra broad and only slightly exceeding abdomen.

Color: Vertex, pronotum and scutellum black, irrorate with yellow. Elytra red to slaty blue, nervures black, frequently with light or yellow margins. Face black irrorate with yellow. Narrow yellow lateral stripe starts from eye, crosses thorax, and extends along margin of abdomen to pygofers.

External genitalia: Female, last ventral segment about twice as long as preceding, lateral margins narrowed posteriorly, posterior margin with broad incision on median third which reaches about one-fourth of way to base; pygofers large, widest at middle, exceeding ovipositor. Male, plates together forming a triangle longer than wide; pygofers long and narrow, exceeding plates, covered with fine hairs as are the plates.

Internal male genitalia: Styles much as in *undata*, proportionally broader, outer margin nearly straight, inner margin with broad lobe half way between apex and process for attachment to œdagus, apex with slight inwardly directed point, lateral margins of apical third serrate, a few slender hairs near lateral margin about one-third the distance from the tip; connective consisting of a broad strap-like piece between the styles with the ventral surface bearing a large square portion medially; œdagus large, produced anteriorly to meet connective, with a large dorsal process running first caudad and then cephalad, and two pairs of long slender terminal lobes running dorsad, the first pair broader and longer than the posterior pair.

Distribution: This species occurs throughout the state as shown by the following map.



Hosts: Osborn reports this species as occurring in bogs and low ground; De Long records it from grasses and weeds.

Oncometopia lateralis var. *limbata* (Say).

Tettigonia limbata Say, Jl. Acad. Nat. Sci. Phila., iv, p. 340, 1825.
Tettigonia costalis Sign., Ann. Soc. Ent. Fr., ser. 3, iii, p. 821, 1855.
Tettigonia septentrionalis Walk., List Homop., Suppl., p. 193, 1858.
Oncometopia limbata Van D., Psyche, v, p. 389, 1890.
Oncometopia lateralis var. limbata Ball, Proc. Ia. Acad. Sci., viii, p. 45, 1901.
Oncometopia lateralis var. limbata Van D., Cat. Hemip. N. A., p. 593, 1917.

Form: Somewhat smaller and narrower than preceding form, elytra longer.

Color: Black, vertex and face somewhat irrorate with yellow. Two small orange spots about one-third distance from anterior margin and in line with ocelli. Lateral yellow line broad and distinct.

Distribution: Rawlins county has furnished us our only specimen of this variety.

Hosts: Unknown.

Genus Cicadella Latr.

In this genus the ledges over the antennal sockets are not prominent. The vertex is bluntly conical, and slightly sloping, with the lateral margins not in a distinct line with the curve of the eye. Pronotum rather long, broadest at lateral angles. The elytra cover the terga of the abdomen and are not reticulately veined at the apex.

Two members of this genus and two varieties have been collected in Kansas, but two other species likely occur and are therefore included in the key.

KEY TO SPECIES.

A. Head as wide as pronotum, vertex wider than long, face in profile strongly curved.
  - B. Head marked with distinct lines forming a pattern.
    - C. Head pattern complex, no parallel lateral lines; length over 6 mm. *hieroglyphica.*
    - CC. Head pattern simple, with median and lateral parallel lines; length 6 mm. or less. *gothica.*
  - BB. Head marked with definite spots, not forming a distinct pattern. *atropunctata.*

AA. Head narrower than pronotum, vertex as long as wide, face in profile only slightly curved. *occatoria.*

Cicadella hieroglyphica (Say).

(Pl. 9, figs. 1-3.)

Tettigonia hieroglyphica Say, Jl. Acad. Nat. Sci. Phila., vi, p. 313, 1831.
Tettigonia hieroglyphica Sign., Ann. Soc. Ent. Fr., ser. 3, iii, p. 805, 1855.
Tettigonia hieroglyphica G. & B., Hemip. Colo., p. 81, 1895.
Tettigonia hieroglyphica Ball, Proc. Ia. Acad. Sci., viii, p. 51, 1901.
Tettigoniella hieroglyphica Van D., Trans. San Diego Soc. Nat. Hist., ii, p. 52, 1914.
Tettigoniella hieroglyphica DeL., Tenn. St. Bd. Ent., Bul. 17, p. 20, 1916.
Cicadella hieroglyphica Van D., Cat. Hemip. N. A., p. 597, 1917.
Cicadella hieroglyphica Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 3, 1918.

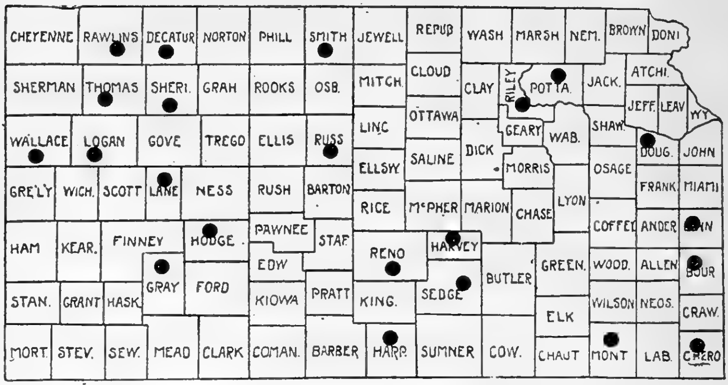
Form: Rather stout. Length, 6 to 7 mm. Vertex bluntly conical, wider than long. Pronotum nearly twice as wide as long, posterior angles broadly rounded, posterior margin medially emarginated. Elytra broad, but exceeding the abdomen.

Color: Varying from brick-red to greenish and slaty blue. Black markings on vertex very strong and distinct, enclosing a light colored T on basal half. Elytra with pale bands along costal, claval and sutural margins.

External genitalia: Female, last ventral segment about as wide as long, lateral margins narrowed posteriorly, posterior margin triangularly produced; pygofers long and narrow, equalling or slightly exceeding ovipositor, bearing a few stout hairs. Male, last ventral segment less than twice as wide as long; plates long, broad at base, but tapering to long acute apices, margins fringed with short hairs; pygofers long and narrow, equalling or exceeding plates and bearing stout hairs.

Male internal genitalia: Styles short, distinctly bent in at point of attachment to connective by a large, heavily chitinized lobe, then curving outward and tapering gradually to blunt apex, with an outwardly projecting process; connective slender, Y-shaped, stem of Y broadening to broad base; œdagus with pair of short processes extending dorsad from its point of attachment to connective, a long process leaving it dorsally from a point a little past its middle, and a similar longer one leaving it apically, the latter to the left of the former. These two processes are narrow and long, narrowest at the base, and widening to a point shortly before the apex where they are the widest, the right one wider than the left one, and then tapering to the acute tips. A pair of somewhat narrow triangular chitinous processes extend from the base of the anal tube to the main body of the œdagus.

Distribution; This species is well distributed over the state as shown by the following map:



Hosts: Taken abundantly on willows.

Cicadella hieroglyphica var. *dolobrata* (Ball).

Tettigonia hieroglyphica var. dolobrata Ball, Proc. Ia., Acad. Sci., viii, p. 52, pl. 3, fig. 2, 1901.

Tettigonia hieroglyphica var. dolobrata DeL., Tenn. St. Bd. Ent., Bul. 17, p. 20, 1916.

Cicadella hieroglyphica var. dolobrata Van D., Cat. Hemip. N. A., p. 597, 1917.

Cicadella hieroglyphica var. dolobrata Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 3, 1918.

This is a smaller form than the preceding, appearing more robust. In color it is typically black, retaining a few of the light markings of the typical *hieroglyphica* on the front, vertex, pronotum and scutellum, and generally having the claval sutures light.

Genitalia as in preceding form.

Distribution: Occurs along with the typical form.

Hosts: Willows.

Cicadella hieroglyphica var. *uhleri* (Ball).

Tettigonia hieroglyphica var. uhleri Ball, Proc. Ia. Acad. Sci., viii, p. 52, pl. 3, fig. 3, 1901.

Cicadella hieroglyphica var. uhleri Van D., Cat. Hemip. N. A., p. 597, 1917.

Cicadella hieroglyphica var. uhleri Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 3, 1918.

This variety is slightly larger than typical *hieroglyphica,* being more robust and with longer elytra. It varies very greatly in color, running from a brick-red through several shades of bluish or grayish green, and even to a fairly distinct bright green. The black markings of the vertex are much reduced in size, appearing only as narrow lines. Genitalia as in typical *hieroglyphica.*

Distribution: Much rarer with us than the two preceding forms. Reported from Douglas, Cherokee and Riley counties.

Hosts: Willows.

Cicadella gothica (Sign.).

Tettigonia gothica Sign., Ann. Soc. Ent. Fr., ser. 3, ii, p. 345, pl. 11, fig. 6, 1854.
Tettigonia hieroglyphica Harr., Hitchcock's Geol. Mass., edn. 2, p. 580, 1835.
Tettigonia similis Woodw., Bul. Ill. St. Lab. Nat. Hist., iii. p. 25, 1887.
Diedrocephala hieroglyphica Prov., Pet. Faune Ent. Can., iii, p. 267, 1889.
Tettigonia hieroglyphica Harr., Ottawa Nat., vi, p. 32, 1892.
Tettigonia similis Van D., Ent. News, v, p. 156, 1894.
Tettigonia similis Van D., Ent. News, v, p. 156, 1894.
Tettigonia similis O. & B., Proc. Ia. Acad. Sci., iv, p. 231, 1897.
Tettigonia gothica Ball, Proc. Ia. Acad. Sci., viii, p. 54, 1901.
Tettigonia gothica Osb., 20th Rept. N. Y. St. Ent., p. 510, 1905.
Tettigonia gothica Van D., Can. Ent., xli, p. 383, 1909.
Tettigonia gothica Osb., Me. Agr. Exp. Sta., Bul. 238, p. 100, 1915.
Tettigonia gothica DeL., Tenn. St. Bd. Ent., Bul. 17, p. 21, 1916.
Cicadella gothica Van D., Cat. Hemip. N. A., 597, 1917.
Cicadella gothica Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 3, 1918.

Form: Much like *hieroglyphica* but smaller. Length, 5.5 to 6 mm. Vertex more pointed than in preceding species, wider than long. Nervures of elytra distinct.

Color: Varies from light reddish to grayish-green. Vertex reddish or greenish-yellow, apex with black spot, margins of reflexed portions, a line from these to ocelli, and a pair of loops on the disc, black. Scutellum with distinct black marks. Elytra grayish-green or reddish, unicolorous, or irrorate with yellow.

External genitalia: Female, last ventral segment very long, raised medially, lateral margins narrowed posteriorly, posterior margin triangularly produced; pygofers long, bearing a few heavy hairs and equalled or slightly exceeded by the ovipositor. Male, last ventral segment about twice as broad as long, anterior and posterior margins parallel; plates very long and slender, margins with fine hairs and also with a row of stout hairs or bristles, slightly exceeding the spiny pygofers.

Distribution: Taken only in Douglas, Riley and Pottawatomie counties.

Hosts: Osborn reports taking this species from grass land and on birch and willow. De Long records taking it from oak.

Cicadella atropunctata (Sign.).

(Pl. 9, figs. 4-5.)

Tettigonia atropunctata Sign., Ann. Soc. Ent. Fr., p. 354, 1854.
Tettigonia circellata Bak., Psyche, viii, p. 285, 1898.
Tettigonia atropunctata Fowl., Biol. Centr. Am., Homop., ii, p. 266, pl. 17, fig. 27, 1900.
Tettigonia atropunctata Ball, Proc. Ia. Acad. Sci., viii, p. 55, pl. 4, fig. 2, 1901.
Tettigonia circellata Van D., Trans. San Diego Soc. Nat. Hist., ii, p. 53, 1914.
Tettigonia circellata Essig, Inj. Benef. Ins. Calif., edn. 2, p. 66, 1915.
Cicadella circellata Van D., Cat. Hemip. N. A., p. 598, 1917.
Cicadella circellata? Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 3, 1918.

Form: Longer and more slender than *gothica*. Length, 6 to 7 mm. Vertex bluntly rounded, about three-fourths as long as broad, two-thirds the length of the pronotum. Elytra long and narrowing posteriorly, giving the insect a wedge-shaped appearance.

Color: Vertex, front, face, anterior margin of pronotum and under side, yellowish; posterior part of pronotum and elytra bluish or bluish-green. Front with short median line, two broken lateral lines and margin, black. Clypeus black medially at apex; vertex with spot at apex, in the middle, outside of each ocellus, and a crescent on each side anteriorly, black. Pronotum with seven black dots near anterior margin and three on basal half. Nervures of elytra black.

External genitalia: Female, last ventral segment much longer than broad, about three times as long as penultimate segment, keeled, posterior margin greatly and acutely produced; pygofers very long and narrow, exceeding the ovipositor. Male, last ventral segment longer than preceding one, anterior and posterior margins parallel, as are the lateral margins; plates very long and slender, acutely pointed, and with row of stout hairs or spines along margin, slightly exceeded by the long and narrow pygofers.

Internal male genitalia: Styles small, basal portion heavier, posterior portion slender, curved, terminating acutely; connective slender, Y-shaped, the stem of the Y broadened basally; œdagus with broad, rather truncate base, a stout, blunt process running dorsad, and a pair of larger, broad-based, and acutely pointed, dorsally directed, terminal processes.

Distribution: Has not yet been reported from Kansas, but should occur in southern part of the state.

Hosts: Essig reports this species as a general feeder on such plants as grape, blackberry, raspberry, sunflower, etc.

This species so closely fits Signoret's description of *Tettigonia atropunctata*, that, with Dr. E. D. Ball, we do not follow Van Duzee's synonomy.

Cicadella occatoria (Say).

Tettigonia occatoria Say, Jl. Acad. Nat. Sci., Phila., vi, p. 311, 1831; Compl. Writ. ii, p. 385.

Tettigonia occatoria Say, Ann. Soc. Ent. Fr., ser. 3, ii, p. 353, pl. 18, fig. 11, 1854.

Tettigonia compta Fowl., Biol. Centr. Am., Homop., ii, p. 271, 1900.

Tettigonia occatoria Fowl., Biol. Centr. Am., Homop., ii, p. 279, pl. 18, fig. 29, 1900.

Tettigonia occatoria Ball, Proc. Ia. Acad. Sci., viii, p. 57, pl. 4, fig. 4, 1901.

Tettigoniella occatoria Van D., Bul. Buf. Soc. Nat. Sci., ix, p. 212, 1909.

Tettigoniella occatoria Osb., Ohio Nat., ix, p. 462, 1909.

Tettigoniella occatoria DeL., Tenn. St. Bd. Ent., Bul. 17, p. 21, 1916.

Cicadella occatoria Van D., Cat. Hemip. N. A., p. 598, 1917.

Cicadella occatoria Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 3, 1918.

Cicadella occatoria Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 31, 1919.

This species, though surely in Kansas, has seemingly not yet been taken. It is a long narrow form, about 6 mm. in length. The color is yellow, and it may be readily recognized by the longitudinal, brown stripes, four on the vertex, five on the pronotum, and with the elytra also striped. Female, last ventral segment less than twice as long as preceding one, posterior margin obtusely rounding or truncate; pygofers long and narrow, equalling ovipositor. Male, plates broad at base, very acute apically; pygofers long, narrow, scarcely tapering, much exceeding plates.

Hosts: According to De Long this species was taken on weeds and shrubs.

Genus Kolla Dist.

Distant describes this genus as follows: "Allied to *Tettigoniella,* but differing by the structure of vertex of the head, which is subconically narrowed anteriorly, with the lateral margins in a line with the outer margins of the eye; near the inner margin of the eyes the vertex is also more or less foveate; face with the lateral areas somewhat strongly, transversely striate, and centrally, longitudinally sinuate and flattened."

Three species of this genus have been collected in Kansas.

KEY TO SPECIES.

A. Conspicuously marked with bands and stripes.
  B. Elytra striped; over 5.5 mm. in length. *bifida.*
  BB. Elytra not striped; 5 mm or less in length. *geometrica.*
AA. Not marked with bands and stripes, rather uniformly brownish or black. *hartii.*

Kolla bifida (Say).

(Pl. 7, figs. 4-5.)

Tettigonia bifida Say, Jl. Acad. Nat. Sci. Phila., vi, p. 313, 1831; Compl. Writ., ii. p. 387.
Tettigonia bifida Fh., Homop. N. Y. St. Cab., p. 55, 1851.
Tettigonia tenella Walk., List Homop., iii, p. 770, 1851.
Tettigonia bifida Sign., Ann. Soc. Ent. Fr., ser. 3, ii, p. 11, pl, 1, fig. 11, 1854.
Helochara bifida Prov., Pet. Faune Ent. Can., iii, p. 338, 1890.
Tettigonia bifida Van D., Bul. Buf. Soc. Nat. Sci., v. p. 196, 1894.
Tettigonia bifida O. & B., Proc. Ia. Acad. Sci., iv, p. 175, 1897.
Tettigonia bifida Ball, Proc. Ia. Acad. Sci., viii, p. 58, pl. 5, fig. 1, 1901.
Tettigonia bifida Osb., 20th Rept. N. Y. St. Ent., p. 509, 1905.
Tettigonia bifida Osb., U. S. Dept. Agr. Bur. Ent., Bul. 108, p. 63, 1912.
Tettigonia bifida Osb., Me. Agr. Exp. Sta., Bul. 238, p. 99, 1915.
Kolla bifida DeL., Tenn. St. Bd. Ent., Bul. 17, p. 22, 1916.
Kolla bifida Van D., Cat. Hemip., N. A., p. 598, 1917.
Kolla bifida Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 5, 1918.
Cicadella bifida Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 31, 1919.

Form: A fairly large, robust species. Length, 5.5 to 6 mm. Vertex about twice as wide as long, bluntly conical. Pronotum slightly wider than head, and nearly twice as long, anterior margin broadly convex, posterior margin very slightly concave, lateral and humeral margins about equal. Elytra broad, venation very simple, there being no cross nervures before the apical cells.

Color: Vertex black with two white spots at apex and a median and basal band yellowish or white. Face very dark brown, lighter laterally. Pronotum greenish with anterior margin black, followed by a yellow band, posterior margin white or greenish-white, preceded by a black band.

Scutellum yellow with black transverse impression. Elytra green, nervures broadly black, apical cells smoky.

External genitalia: Female, last ventral segment long, convex, lateral margins tapering posteriorly and posterior margin with median half roundingly produced; pygofers long and narrow, forming a keel medially, exceeding ovipositor and clothed with very coarse large hairs. Male, plates short, wide at base, apices quite acutely produced, less than half the length of the long and narrow pygofers; lateral margins of plates and the pygofers with large, coarse hairs.

Internal male genitalia: Styles short, anterior end acutely pointed, distal half broad, apex truncate with laterally directed tooth; connective T-shaped with short cross piece and long stem, dorsally directed, to meet œdagus, the two parts seeming to be distinct pieces; œdagus consisting of two L-shaped pieces, the short branches directed dorsad and the long slender ones caudad and generally crossing each other; a pair of L-shaped processes with thickened terminal portions extend down from the anal tube to the œdagus.

Distribution: Taken in Douglas, Cherokee, Pottawatomie and Riley counties.

Hosts: Swept from grasses in low places.

Kolla geometrica (Sign.).

(Pl. 8, figs. 5-6.)

Tettigonia geometrica Sign., Ann. Soc. Ent. Fr., ser. 3, ii, p. 12, pl. 1, fig. 12, 1895.
Tettigonia psittacella Fowl., Biol. Centr. Am., Homop., ii, p. 290, pl. 19, fig. 26, 1900.
Tettigonia geometrica Ball, Proc. Ia. Acad. Sci., viii, p. 59, pl. 5, fig. 2, 1901.
Kolla geometrica Dist., Ann. Mag. Nat. Hist., ser. 8, i, p. 530, 1908.
Tettigonia geometrica Osb., Ohio Nat., ix, p. 461, 1909.
Kolla geometrica DeL., Tenn. St. Bd. Ent., Bul. 17, p. 23, 1916.
Kolla geometrica Van D., Cat. Hemip. N. A., p. 599, 1917.
Kolla geometrica Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 5, 1918.
Kolla geometrica Ols., Bul. Brooklyn Ent. Soc., xiii, p. 119, 1918.
Cicadella geometrica Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 32, 1919.

Form: Like *bifida* in structure but smaller. Length, 4.5 to 5 mm. Vertex about twice as long as wide, bluntly rounded. Pronotum as in *bifida*, wider than the head. Elytra long, not as broad as in *bifida*, venation simple, lacking cross veins before apical cells.

Color: Vertex black, with two yellow apical spots and median and basal yellow bands. Face black. Pronotum and scutellum as in *bifida* but with narrower bands and therefore a larger green discal portion. Elytra green, except for smoky apical cells, with three spots in front of these and costal margin light.

External genitalia: Female, last ventral segment about as in *bifida*, perhaps not produced quite as much on posterior margin. Male, plates as in *bifida* though perhaps more acutely pointed.

Internal male genitalia: Styles relatively shorter and broader than in *bifida;* œdagus with upright arms of the L relatively longer than in *bifida;* lower portion of chitinous processes extending down from anal tube also relatively heavier than in *bifida.*

Distribution: Taken in Cherokee county only.

Hosts: De Long reports sweeping this species from weeds and grasses in pastures, and especially from the ironweed, *Vernonia glauca.*

Kolla hartii (Ball).

(Pl. 7, figs. 6-7.)

Tettigonia hartii Ball, Proc. Ia. Acad. Sci., viii, p. 61, pl. 5, fig. 4, 1901.
Tettigonia hartii DeL., Tenn. St. Bd. Ent., Bul. 17, p. 20, 1916.
Kolla hartii Van D., Cat. Hemip. N. A., p. 599, 1917.
Kolla hartii Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 5, 1918.

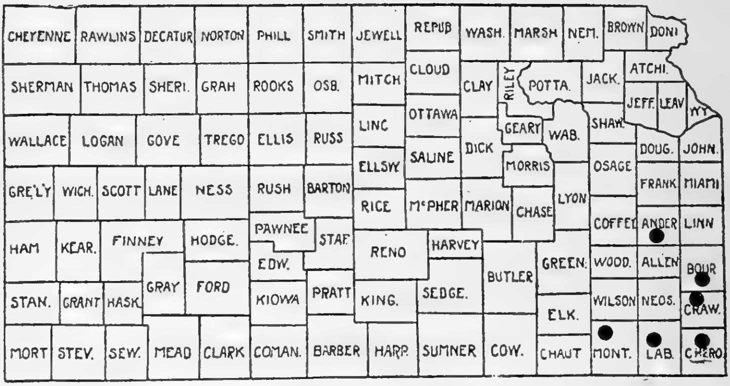
Form: Shorter and stouter than preceding species. Length, 3.75 to 5 mm. Vertex conical, obtusely rounding, twice as wide as long. Pronotum twice as long as vertex, about three-fifths as long as wide. Elytra broad, venation simple, as in *bifida.*

Color: Female, brownish. Vertex with pair of black spots on posterior margin and brown arcs that cover front on either side of a light median line extending up on to apex of vertex. Pronotum with irregular dark spots near anterior margin. Scutellum with dark triangular spots in basal angles. Elytra with nervures pale, claval margins lined with light blue. Male, shining black, with space around ocelli and apex of scutellum pale. Spot on apex of vertex white, front pale with dark arcs on either side of median pale line which has black borders that often enlarge to eliminate the pale line.

External genitalia: Female, last ventral segment about three-fifths as long as wide, posterior margin truncate, very slightly sinuate on either side of a very small median tooth; pygofers broad and long, forming median keel, exceeding ovipositor and bearing few large coarse hairs. Male, plates wide at base but tapering to long acute point posteriorly, with coarse hairs on lateral margins, much exceeded by the long, coarsely haired pygofers.

Internal male genitalia: Styles longer than in preceding members of the genus, apices curved inward; connective as in preceding species; œdagus U-shaped when viewed laterally, having two short processes extending more or less dorsad and a single process, twice as long, extending caudad, the base of the U being formed by this process; a very characteristic club-shaped process extends downward from the base of the anal tube.

Distribution: This species seemingly occurs only in the southeastern portion of the state as shown by the following map:



Hosts: De Long reports this species as common on grasses, especially *Aristida gracilis.*

Genus HELOCHARA Fh.

In this genus the head is slightly wider than the prothorax and considerably broader than long, slightly obtusely angled, and with the reflexed portion of the front distinctly elevated. The pronotum is long, being twice as long as the scutellum, and with such distinct lateral and humeral margins as to appear six-angular. Scutellum small, partially covered by pronotum. Elytra coriaceous, except for apical cells, veins distinct. Antennæ of males plate-like on apical third.

The single species of this genus occurring in the United States is found in Kansas.

Helochara communis Fh.

(Pl. 10, figs. 3-4.)

Helochara communis Fh., Homop. N. Y. St. Cab., p. 56, 1851.
Tettigonia herbida Walk., List Homop., iii, p. 769, 1851.
Tettigonia communis Walk., List Homop., iv, p. 1156, 1852.
Helochara communis Sign., Ann. Soc. Ent. Fr., ser. 3, ii, p. 730, pl. 21, fig. 17, 1854.
Helochara communis Osb., Proc. Ia. Acad Sci., i, pt. 2, p. 125, 1892.
Helochara communis G. & B., Hemip. Colo., p. 82, 1895.
Helochara communis Ball, Proc. Ia. Acad. Sci., viii, p. 62, pl. 6, fig. 1, 1901.
Helochara communis Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 60, 1912.
Helochara communis Osb., Me. Agr. Exp. Sta., Bul. 238, p. 103, 1915.
Helochara communis DeL., Tenn. St. Bd. Ent., Bul. 17, p. 24, 1916.
Helochara communis Van D., Cat. Hemip. N. A., p. 600, 1917.
Helochara communis Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 5, 1918.

Form: Rather small, robust species. Length, 4 to 7 mm. Vertex broader than long, slightly and obtusely pointed and with the elevated portions of front strongly elevated. Pronotum large and long, anterior margin broadly rounded, posterior margin distinctly emarginate. Scutellum short, overlapped by pronotum. Elytra coriaceous except at apex. Whole dorsal surface distinctly punctate.

Color: A green form. Head and anterior region of pronotum more yellowish. Front, including reflexed portion, with lateral brown arcs. In male, face black because of broadening and fusing of the arcs.

External genitalia: Female, last ventral segment over two-thirds as long as broad, lateral margins narrowed posteriorly, posterior margin incised on either side of the medially produced lobe; pygofers long and narrow, slightly exceeding ovipositor and bearing a few, coarse, short hairs on either side of the ovipositor. Male, valve short and broadly triangular; plates broad at base but tapering and prolonged acutely, exceeding the short pygofers.

Internal male genitalia: Styles with basal half gradually tapering, a large process on mesal margin for attachment to connective and posteriorly a large lateral bulge, the distal portion curved slightly outwardly, toothed on mesal margin and terminating rather truncately with a distinct outward point; connective T-shaped, the cross piece heavier than the standard; œdagus consisting of a pair of heavy dorsally directed processes and a pair of narrower, larger, sinuate and acutely pointed terminal processes.

Distribution: This species probably occurs throughout the eastern portion of the state, but hitherto has been reported only from Cherokee county.

Hosts: Found only on swamp grasses.

Genus GRAPHOCEPHALA Van D.

In this genus the head is narrower than the pronotum, the vertex is flat, obtusely rounding and with a distinct margin. The front is not inflated. The pronotum is narrowed anteriorly and with the posterior margin slightly emarginate. The elytra are long and coriaceous, venation obscured, and with rather long apical cells.

Two of the three United States' species have been taken in Kansas.

KEY TO SPECIES.

A. Large, 9 mm. or over, vertex unmarked. *coccinea.*

AA. Smaller, 6 mm. or under, vertex marked with black lines. *versuta.*

Graphocephala coccinea (Forst.).

(Pl. 8, figs. 3-4.)

Cicada coccinea Forst., Nov. Spec. Ins., p. 69, 1711.

Tettigonia quardivittata Say, Jl. Acad. Nat. Sci. Phila., vi, p. 312, 1831; Compl. Writ., ii, p. 386.

Tettigonia coccinea Harr., in Hitchcock, Geol. Mass., edn. 2, p. 580, 1835.

Proconia quadrivittata Fh., Homop. N. Y. St. Cab., p. 55, 1851.

Tettigonia picta Walk., List Homop., iii, p. 758, 1851.

Tettigonia quadrivittata Sign., Ann. Soc. Ent. Fr.. ser. 3, ii, p. 348, pl. 11, fig. 11, 1851.

Aulacizes quadrivittata Fh., Trans. N. Y. St. Agr. Soc., xvi, p. 450, 1856.

Diedrocephala coccinea Uhl., Bul. U. S. Geol. Geog. Surv., i, p. 357, 1876.

Diedrocephala quadrivittata Glov., U. S. Dept. Agr., Rept. for 1876, p. 33.

Diedrocephala coccinea Van D., Can. Ent., xxi, p. 9, 1889.

Diedrocephala coccinea Osb., U. S. Dept. Agr., Div. Ent., Bul. 22, p. 28, 1890.

Diedrocephala coccinea Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 125, 1892.

Diedrocephala coccinea Ball, Proc. Ia. Acad. Sci., iv, p. 177, 1897.

Tettigonia quadrivittata Fowl., Biol. Centr. Am., Homop., ii, p. 276, 1900.

Tettigonia idonea Fowl., Biol. Centr. Am., Homop., ii, p. 276, 1900.

Diedrocephala coccinea Osb., 20th Rept. N. Y. St. Ent., p. 510, 1905.

Diedrocephala coccinea Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 60, 1912.

Diedrocephala coccinea Osb., Me. Agr. Exp. Sta., Bul. 238, p. 101, 1915.

Diedrocephala coccinea DeL., Tenn. St. Bd. Ent., Bul. 17, p. 25, 1916.

Diedrocephala coccinea Gibs., Can. Ent., xlviii, p. 178, 1916.

Graphocephala coccinea Van D., Cat. Hemip. N. A., p. 601, 1917.

Graphocephala coccinea Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 5, 1918.

Graphocephala coccinea Ols., Bul. Brooklyn Ent. Soc., xiii, p. 120, 1918.

Graphocephala coccinea Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 32, 1919.

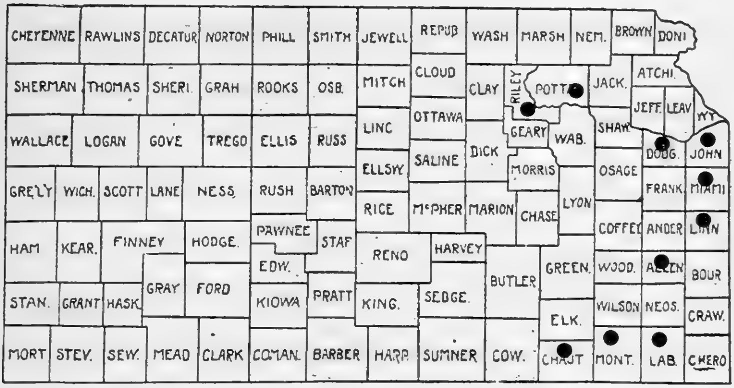
Form: A large, cylindric, elongated form. Length, 8 to 9 mm. Vertex, wider than long, two-thirds length of pronotum, roundingly acutely angled. Pronotum narrowed anteriorly with lateral and humeral angles about equal, posterior margin distinctly emarginate. Elytra long and narrow.

Color: Face yellow, separated from orange-yellow vertex by broad black line on margin. Vertex with two, small, black marginal lines before the ocelli, and frequently the posterior half reddish or green medially. Pronotum red with narrow light green band on anterior margin, and a posterior large dark green W, with outer arms turned mesad. Elytra red with costal, claval and sutural margins and median stripe on corium, green, the apex and appendix black.

External genitalia: Female, last ventral segment slightly longer than wide, lateral margins slightly narrowed posteriorly, posterior margins broadly rounded and medially produced; pygofers long and narrow, equalling ovipositor and bearing a few coarse hairs on either side of median line. Male, plates long, broad at base but apically greatly produced and concavely tapering to long acute tip, lateral margins bearing stiff hairs; pygofers long and narrow, greatly exceeding plates and covered with numerous coarse hairs.

Internal male genitalia: Styles tapering at anterior end, curved outward medially and ending in distinctly out-turned apices; connective slender, Y-shaped; œdagus with triangular body when viewed laterally, a long, slender process leaving it from near distal end, and a still longer, heavier one extending dorsad from the distal apex; a V-shaped chitinous bar at base of anal tube.

Distribution: Reports and specimens at hand seem to show this species as occurring only in eastern Kansas. It undoubtedly occurs further west in the state than is shown by the following map:



Hosts: Seemingly we have here a very general feeder. It has been taken from numerous weeds, shrubs and trees. The writer this season found the nymphs of the last instar in large numbers on *Ambrosia trifida* during the last week in July and the first week in August. By the last week in August the nymphs had all molted into adults.

Graphocephala versuta (Say).

Tettigonia versuta Say, Jl. Acad. Nat. Sci. Phila., vi, p. 311, 1831; Compl. Writ., ii, p. 386.

Tettigonia versuta Sign., Ann. Soc. Ent. Fr., ser. 3, p. 348, pl. 11, fig. 10, 1854.

Diedrocephala versuta Woodw., Bul. Ill. St. Lab. Nat. Hist., iii, p. 22, 1887.

Diedrocephala versuta Osb., U. S. Dept. Agr., Div. Ent., Bul. 22, p. 27, 1890.

Tettigonia redacta Fowl., Biol. Centr. Am., Homop., ii, p. 276, pl. 18, fig. 21, 1900.

Diedrocephala versuta Ball, Proc. Ia. Acad. Sci., viii, p. 64, pl. 6, fig. 3, 1901.

Diedrocephala versuta DeL., Tenn. St. Bd. Ent., Bul. 17, p. 25, 1916.

Diedrocephala versuta Gibs., Can. Ent., xlviii, p. 177, 1916.

Graphocephala versuta Van D., Cat. Hemip. N. A., p. 602, 1917.

Graphocephala versuta Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 5, 1918.

Graphocephala versuta Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 33, 1919.

Form: Like *coccinea* but smaller. Length, 5 to 6 mm. Vertex broader than long, a little shorter than pronotum, apex blunt, lateral margins distinctly rounding. Pronotum narrowed anteriorly, humeral margins slightly longer than lateral margins. Elytra not quite as long as in *coccinea*.

Color: Vertex with black marginal lines and with pair of median parallel lines connecting anteriorly with broken lines which run back parallel with the margin, between the margin and the ocelli. Space between parallel lines and around the margin whitish or yellowish, the rest reddish. Face yellow, pronotum yellowish anteriorly, greenish posteriorly, often with red bands continuous with red bands of clavus and of head, between which are blue bands. Scutellum red or yellowish with black markings. Elytra blue, claval suture with a blue stripe either side of which is a broader red one, apex and posterior third of costal margin pale with several small, dark, triangular spots.

External genitalia: Female, last ventral segment as long as broad, lateral margins strongly tapering posteriorly, the disc longitudinally elevated, posterior margin produced angularly; pygofers long and narrow, equalling or slightly exceeded by ovipositor, forming distinct keel on mesal margin, bearing a few short, coarse hairs. Male, plates long and narrow, often twice as long as the last ventral segment and bearing coarse hairs on the lateral margins; pygofers exceeded by the plates.

Distribution: Taken in Cherokee county.

Hosts: Gibson gives cowpeas and clover as hosts. De Long took specimens from shrubs and weeds. Probably a general feeder like the preceding.

Genus DRÆCULACEPHALA Ball.

The following is the original description of the genus: "Similar to *Diedrocephala,* the vertex usually longer and more acutely angled. Face, as seen from side, usually straight, or slightly concave to the middle of clypeus, where it is broken backwards. Disc of clypeus quite gibbous. Pronotum with the lateral margins parallel, narrower than or only equalling the eye. Elytra long, narrowing apically, greenish, the nervures raised, distinct, the apical and the ante-apical cells irregularly reticulate veined. Anterior tibiæ slender, round.

"Type of the genus *D. mollipes* Say."

Two members of this genus have been collected in Kansas. *D. noveboracensis* has not yet been reported in the state but likely occurs in the northeastern portion and is therefore included in the key. *D. reticulata* should be found in the southern part.

KEY TO SPECIES.*

A. Front, as seen from side, almost straight. Sides of front with dark arcs.
  - B. Vertex long, acute, margins as seen from above straight, spots on apex minute or none. Profile of front straight.
    - C. Size small, vertex of female distinctly longer than broad. Lines on vertex usually faint. Last ventral segment of male broad. *mollipes*

* Adapted from key by Dr. E. D. Ball, Proc. Ia. Acad. Sci., viii, p. 67, 1901.

A. Front, as seen from side, almost straight—*concluded.*

CC. Size larger, vertex of female distinctly shorter than broad. Lines on vertex usually distinct and broad. Last ventral segment of male long, cylindrical. *angulifera.*

BB. Vertex shorter, roundingly acute, margins as seen from above slightly rounding, spots on apex distinct. Profile of front slightly rounding. *noveboracensis.*

AA. Front, as seen from side distinctly rounding. Sides of front mottled with brown or unmarked. *reticulata.*

Dræculacephala mollipes (Say).

(Pl. 9, figs. 6-7.)

Tettigonia mollipes Say, Jl. Acad. Nat. Sci. Phila., vi, p. 312, 1831; Compl. Writ., ii, p. 383.

Tettigonia mollipes Harr., in Hitchcock Geol. Mass., edn. 2, p. 580, 1835.

Aulacizes mollipes Fh., Homop. N. Y. St. Cab., p. 56, 1851.

Tettigonia innotata Walk., List Homop., iii, p. 770, 1851.

Tettigonia antica Walk., List. Homop., iii, p. 771, 1851.

Diedrocephala mollipes Sign., Ann. Soc. Ent. Fr., ser. 3, ii, p. 726, pl. 21, figs. 12, 13, 1854.

Acopsis viridis Prov., Nat. Can., iv, p. 352, 1872.

Diedrocephala mollipes Osb., Rept. Ia. St. Agr. Soc., for 1892, p. 687.

Tettigonia mollipes Fowl., Biol. Centr. Am., Homop., ii, p. 273, pl. 18, fig. 15, 1900.

Dræculacephala mollipes Ball, Proc. Ia. Acad. Sci., viii, p. 67, pl. 7, fig. 1, 1901.

Dræculacephala mollipes Osb., 20th Rept. N. Y. St. Ent., p. 511, 1905.

Dræculacephala mollipes Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 56, 1912.

Dræculacephala mollipes Osb., Me. Agr. Exp. Sta., Bul. 238, p. 103, 1915.

Dræculacephala mollipes Gibs., U. S. Dept. Agr., Div. Ent., Bul. 254, 1915.

Dræculacephala mollipes Van D., Ent. News, xxvi, p. 178, 1915.

Dræculacephala mollipes DeL., Tenn. St. Bd. Ent., Bul. 17, p. 27, 1916.

Dræculacephala mollipes Gibs., Can. Ent., xlviii, p. 177, 1916.

Dræculacephala mollipes Van D., Cat. Hemip. N. A., p. 603, 1917.

Dræculacephala mollipes Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 6, 1918.

Dræculacephala mollipes Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 37, 1919.

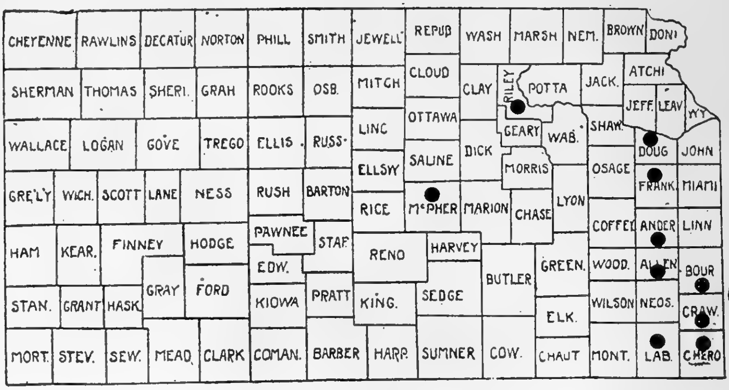
Form: Rather long and slender. Length, 6 to 9.5 mm. Vertex very long, acutely angled, sides straight, disc flat, longer in female than in male. Face straight in profile. Pronotum with lateral margins parallel, anterior margin rounding, posterior margin emarginate. Elytra long, nervures distinctly raised, apical portion reticulate.

Color: Vertex, anterior part of pronotum and scutellum yellow, latter two sometimes greenish. Vertex with two small apical spots, lines on reflexed portion of front, a median and a pair of lateral lines, brown. Face yellow to fuscous with nine pairs of brown arcs laterally. Disc of pronotum and elytra bright green, nervures light, costal and apical margins light.

External genitalia: Female, last ventral segment about two-thirds as long as broad, posterior margin sinuate on either side of obtusely rounded median lobe; pygofers long and narrow, equalling or exceeding ovipositor and bearing a few stout, coarse hairs along sutural margin. Male, valve short, angularly produced; plates large, as long as pygofers, and with short, stout hairs on margin.

Internal male genitalia: Styles with proximal portion large and scarcely tapering, large lobes for connection to connective, distal half first curving outward and then with a seeming terminal inwardly projecting segment which is toothed on the inner margin near the apex, and then curved outward at the extreme tip; connective T-shaped, with the cross bar heavy; œdagus consisting of a T-shaped heavy piece with a very short standard, from the sides of which extend out two long, tapering and twisting processes, the points of which extend laterad; a heavy characteristically shaped chitinous process extends downward from the base of the anal tube.

Distribution: Occurs throughout the eastern portion of the state as shown by the following map:



Hosts: This is a very general feeder, but because it occurs on so many cultivated crops, often in very large numbers, it is to be considered an insect of economic importance. The writer has taken it on corn, many native grasses and at lights. Gibson gives the following hosts: Wheat, barley, oats, alfalfa, Johnson grass, kafir corn, sorghum, cowpeas, Bermuda grasses and many native grasses. Osborn gives rye, bluegrass and brome grass as additional hosts. It is also known to feed on timothy.

Dræculacephala angulifera (Walk.).

Tettigonia angulifera Walk., List Homop., iii, p. 771, 1851.

Diedrocephala angulifera Sign., Ann. Soc. Ent. Fr., ser. 3, ii, p. 727, pl. 21, fig. 14, 1851.

Diedrocephala angulifera Van D., Ent. News, v, 156, 1894.

Dræculacephala angulifera Ball, Proc. Ia. Acad. Sci., viii, p. 69, pl. 7, fig. 4, 1901.

Dræculacephala angulifera Osb., 20th Rept. N. Y. St. Ent., p. 511, 1905.

Dræculacephala angulifera Van D., Ent. News, xxvi, p. 178, 1915.

Dræculacephala angulifera Osb., Me. Agr. Exp. Sta., Bul. 238, p. 102, 1915; Bul. 248, p. 78, 1916.

Dræculacephala angulifera Van D., Cat. Hemip. N. A., p. 603, 1917.

Dræculacephala angulifera Weiss, Ent. News, xxix, p. 310, 1918.

Dræculacephala angulifera Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 6, 1918.

Form: Larger and broader than preceding species. Length 8 to 11 mm. Vertex distinctly shorter than broad, disc concave anteriorly. Pronotum wide with long lateral margins. Elytra long, but broader than in *mollipes* though with similar venation.

Color: About as in *mollipes* except that the lines on the vertex are broad and distinct.

External genitalia: Female, last ventral segment about three-fourths as long as wide, lateral margins strongly tapering posteriorly, posterior margin strongly and angularly produced medially; pygofers very long and narrow, equalling or slightly exceeded by ovipositor, and bearing a very few coarse, stout hairs along either side of the ovipositor. Male, last ventral segment characteristic, distinctly longer than wide, cylindrical; valve semicircular, strongly and angularly produced medially; plates long and slender, slightly divergent, nearly equalling pygofers, tips curved upward and inward, and bearing a few hairs on lateral margins.

Distribution: Sedgwick county is the only place in the state from which specimens of this species have yet been taken.

Hosts: Doctor Osborn reports this species as occurring in the coarse grasses of lowlands and in timothy.

Dræculacephala noveboracensis (Fh.).

Aulacizes noveboracensis Fh., Homop. N. Y. St. Cab., p. 56, 1851.
Tettigonia prasina Walk., List Homop., iii, p. 768, 1851.
Tettingonia noveboracensis Walk., List Homop., iv, p. 1158, 1852.
Diedrocephala noveboracensis Sign., Ann. Soc. Ent. Fr., ser. 3, ii, p. 19, pl. 2, fig. 5, 1854.
Diedrocephala noveboracensis Osb., U. S. Dept. Agr., Div. Ent., Bul. 22, p. 27, 1890.
Diedrocephala noveboracensis Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 125, 1892.
Diedrocephala noveboracensis G. & B., Hemip. Colo., p. 82, 1895.
Diedrocephala noveboracensis O. & B., Proc. Ia. Acad. Sci., p. 177, 1897.
Dræculacephala noveboracensis Ball, Proc. Ia. Acad. Sci., viii, p. 71, pl. 7, fig. 6, 1901.
Dræculacephala noveboracensis Osb., 20th Rept. N. Y. St. Ent., 5, 511, 1905.
Dræculacephala noveboracensis Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 59, 1912.
Dræculacephala noveboracensis Osb., Me. Agr. Exp. Sta., Bul. 238, p. 101, 1915.
Dræculacephala noveboracensis Van D., Ent. News, xxvi, p. 179, 1915.
Dræculacephala noveboracensis Van D., Cat. Hemip. N. A., p. 605, 1917.
Dræculacephala noveboracensis Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 6, 1918.
Dræculacephala noveboracensis Weiss, Ent. News, xxix, p. 309, 1918.
Dræculacephala noveboracensis Ols., Bul. Brooklyn Ent. Soc., xiii, p. 121, 1918.

This species has not yet been reported from Kansas, but should be found in the eastern and northern portion. It is a rather large, stout species, 8 mm. long, with a shorter vertex than the preceding species. The vertex, when seen from above has slightly rounding margins, and the profile of the face is slightly rounding. It occurs, according to Osborn, on the coarse grasses of low ground.

Dræculacephala reticulata (Sign.).

(Pl. 9, figs. 8-9.)

Tettigonia reticulata Sign., Ann. Soc. Ent. Fr., ser. 3, p. 22, pl. 2, fig. 10, 1854.
Diedrocephala flaviceps Ril., Am. Ent., iii, p. 78, 1880.
Tettigonia flaviceps Johns. & Fox, Ent. News, iii, p. 60, 1892.

Tettigonia diducta Fowl., Biol. Centr. Am., Homop., ii, p. 274, pl. 18, fig. 17, 1900.
Drœculacephala reticulata Ball, Proc. Ia. Acad. Sci., viii, p. 73, pl. 6, fig. 8, 1901.
Drœculacephala reticulata Osb., Ohio Nat., ix, p. 463, 1909.
Drœculacephala reticulata Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 52, 1912.
Drœculacephala reticulata Van D., Ent. News, xxiv, p. 179, 1915.
Drœculacephala reticulata DeL., Tenn. St. Bd. Ent., Bul. 17, p. 27, 1916.
Drœculacephala reticulata Van D., Cat. Hemip. N. A., p. 606, 1917.
Drœculacephala reticulata Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 6, 1918.
Drœculacephala reticulata Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 38, 1919.

Form: Smallest of the members of this genus that occur in the state. Length, 4.5 to 5.5 mm. Vertex blunt, much broader than long. Face in profile convex. Pronotum longer proportionally than in other members of the genus, humeral margins longer than lateral margins, posterior margin distinctly emarginate. Elytra characteristic because of the numerous apical reticulations.

Color: Face lacks the dark arcs characteristic of the three preceding species, being yellow or orange-yellow, as is the vertex, except for two light spots which include the ocelli. Anterior portion of pronotum and scutellum yellow. Disc of pronotum and scutellum grayish green with nervures and costal margin light.

External genitalia: Female, last ventral segment slightly wider than long, lateral margins slightly tapering posteriorly, posterior margin with median half roundingly produced; pygofers are long but rather stout, equalling the tip of the ovipositor and bearing a very few stout scattered hairs. Male, valve rounded on posterior margin; plates long, tapering regularly to acute tips from broad base, almost equalling pygofers.

Internal male genitalia: Styles of same type as in *mollipes*, but shorter and stouter; connective T-shaped, but with cross piece distinctly curved; œdagus much as in *mollipes* though smaller.

Distribution: Should be found in the southern part of the state.

Hosts: A general grass feeder. De Long reports it from Bermuda grass. It has been reported on oats and wheat.

Subfamily GYPONINÆ (Stal).

The members of this subfamily are for the most part large forms, having a broad, somewhat flattened body. Their flattened form, together with the fact that the ocelli are situated on the disc of the vertex, is enough to separate them from the other subfamilies. Three of the four United States genera are known to occur in Kansas.

KEY TO GENERA

A. Very short and broad, clavus truncate at tip. *Penthimia.*
AA. Elongate forms, clavus not truncate at tip.
  B. Head with sharp narrow margin, elytra oblique at apex. *Gypona.*
  BB. Head with broad flat margin, elytra perpendicular at apex. *Xerophloea.*

Genus PENTHIMIA Germ.

The members of this genus are short, ovate, Cercopid-like insects. The head is narrower than the pronotum, the vertex being very broadly rounded. Pronotum is widened posteriorly, distinctly transversely striated, and with the posterior margin broadly concave. The elytra, though exceeding the abdomen, are very short and broad and the broadly truncate apex of the clavus is very noticeable. There is a distinct appendix.

The single American species of this genus has been taken in Kansas.

Penthimia americana Fh.

Penthimia americana Fh., Homop. N. Y. St. Cab., p. 57, 1851.
Penthimia vicaria Walk., List Homop., iii, p. 841, 1851.
Penthimia picta Prov., Nat. Can., p. 352, 1872.
Penthimia americana G. & B., Hemip. Colo., p. 83, 1895.
Penthimia americana Osb., 20th Rept. N. Y. St. Ent., p. 514, 1905.
Penthimia americana Osb., Me. Agr. Exp. Sta., Bul. 238, p. 100, 1915.
Penthimia americana DeL., Tenn., St. Bd. Ent., Bul. 17, p. 29, 1916.
Penthimia americana Van D., Cat. Hemip. N. A., p. 610, 1917.
Penthimia americana Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 41, 1919.

Form: The above generic description gives the form of this species. Length, 5 to 6 mm.

Color: Varies from reddish-brown to black.

External genitalia: Female, last ventral segment long, posterior corners rounded, posterior margin slightly concave on either side of a median lobe which itself is slightly or sometimes distinctly emarginate, forming two teeth; pygofers very short and broad, slightly exceeded by ovipositor. Male, valve triangular; plates broad at base, tapering to acute apex, bearing fine hairs on margins, as long as very short pygofers.

Distribution: Taken only in Pottawatomie county.

Hosts: Osborn records this species as occurring on hickory, maple and other trees and shrubs. De Long reports it from oak.

Genus GYPONA Germ.

This genus contains some of our largest *Cicadellidæ.* They are more elongate than *Penthimia* and differ from *Xerophloea* in lacking the broad thin-margined head of the latter. The head is short and broadly rounded on the anterior margin. The pronotum has distinct lateral and humeral margins and is narrowed anteriorly. Its anterior margin is broadly rounded, while the posterior margin is broadly, though slightly, concave.

The five members of the genus listed below are known to occur in the state.

KEY TO SPECIES.

A. With longitudinal stripes on vertex, pronotum and scutellum. *octo-lineata.*

AA. No longitudinal stripes on vertex, pronotum and scutellum.

B. Very broad species, green or black. *melanota.*

BB. More slender species, gray or brown, usually spotted.

C. Brownish species, veins not punctate laterally.

D. Without submarginal spots on pronotum; not irrorate with red. *pectoralis.*

DD. With four, anterior, submarginal spots on pronotum; often irrorate with red. *puncticollis.*

CC. Grayish species, veins distinctly punctate laterally. *cinerea.*

Gypona octo-lineata (Say).

(Pl. 10, figs. 1-2.)

Tettigonia octo-lineata Say, Jl. Acad. Nat. Sci. Phila., iv, p. 340, 1824; Compl. Writ., ii, p. 257.

Gypona striata Burm., Genera Ins., i, pl. 16, No. 9, 1838.

Gypona cana Burm., Genera Ins., i, pl. 16, No. 10, 1838.

Gypona flavilineata Fh., Homop. N. Y. St. Cab., p. 57, 1851.

Gypona quebecensis Prov., Nat. Can., iv, p. 352, 1872.

Gypona flavilineata Spangb., Spec. Gyponæ, p. 8, 1878.

Gypona scrupulosa Spangb., Spec. Gyponæ, p. 9, 1878.

Gypona olivacea Spangb., Ent. Tidskr., p. 24, 1881.

Gypona octo-lineata Uhl., Stand. Nat. Hist., ii, p. 247, 1884.

Gypona octo-lineata Van D., Psyche, v, p. 390, 1890.

Gypona octo-lineata O. & B., Proc. Ia. Acad. Sci., iv, p. 179, 1897 (part).

Gypona octo-lineata Osb., 20th Rept. N. Y. St. Ent., p. 512, 1905.

Gypona flavilineata Osb., Me. Agr. Exp. Sta., Bul. 238, p. 105, 1915.

Gypona octo-lineata DeL., Tenn. St. Bd. Ent., Bul. 17, p. 31, 1916.

Gypona octo-lineata Van D., Cat. Hemip. N. A., p. 611, 1917.

Gypona octo-lineata Gibs., Proc. U. S. Natl. Mus., lvi, p. 90, 1919.

Gypona octo-lineata Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 41, 1919.

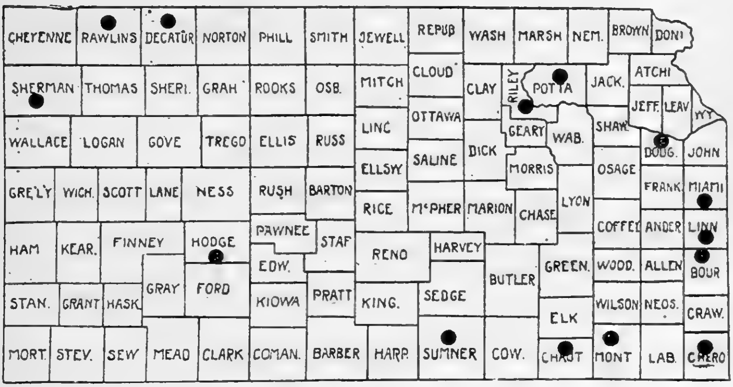
Form: A large oval species. Length, 7 to 10 mm. Vertex broadly rounded, thin-margined, over half as long as basal width. Pronotum characteristic of the genus, narrowed anteriorly, anterior margin broadly though slightly convex, posterior margin about equally concave, lateral margins long, humeral margins shorter. Scutellum large. Elytra long, tapering posteriorly, sometimes reticulately veined, including the clavus.

Color: Light green usually, often darker. Vertex with six yellowish or red longitudinal lines, pronotum with eight, scutellum with four. Nervures of elytra varying from yellow to red. The red stripes and veins give the brightly-colored forms a distinct reddish look.

External genitalia: Female, last ventral segment longer than preceding segment, narrowed posteriorly, longest laterally partially due to posterior margin being turned downward and forming a broad, rounded, median excision extending a third of the distance to the base; pygofers broad and long, exceeding ovipositor, bearing a few stout hairs on apical third. Male, last ventral segment very long, slightly notched medially, concealing valve; plates long and narrow, longer than last ventral segment, widely separated at base, overlapping apically, nearly or quite equalling the short pygofers.

Internal male genitalia: Styles very large, thickest just beyond the middle, apical third bent laterad, terminating in a foot-like form, toothed on inner margin apically; connective broad and stout, with a short stout median process to œdagus; œdagus V-shaped, very heavy basally, terminal portion tapering, long and slender, terminating bluntly and bearing near apex a pair of long, slender lateral processes.

Distribution: Our commonest member of the genus. Is found all over the state as shown by the following map:



Hosts: Occurs on a great variety of weeds, grasses, shrubs and trees. The writer has observed the nymphs very commonly on *Carya ovata* around Lawrence.

Gypona melanota Spangb.

Gypona melanota Spangb., Spec. Gyponæ, p. 19, 1878.
Gypona bipunctulata Woodw., Bul. Ill. St. Lab. Nat. Hist., iii, p. 30, 1887.
Gypona nigra Woodw., Bul. Ill. St. Lab. Nat. Hist., iii, p. 31, 1887.
Gypona bipunctulata O. & B., Proc. Ia. Acad. Sci., iv, p. 181, 1897.
Gypona melanota Van D., Trans. Am. Ent. Soc., xxix, p. 112, 1903.
Gypona melanota Van D., 20th Rept. N. Y. St. Ent., p. 513, 1905.
Gypona bipunctulata Osb., 20th Rept. N. Y. St. Ent., p. 513, 1905.
Gypona melanota Smith, Cat. Ins. N. J., end. 3, p. 101, 1910.
Gypona melanota Van D., Cat. Hemip. N. A., p. 613, 1917.
Gypona melanota Gibs., Proc. U. S. Natl. Mus., lvi, p. 95, 1919.
Gypona bipunctulata Gibs., Proc. U. S. Natl. Mus., lvi, p. 98, 1919.

Form: This species is the most robust looking of the members of this genus, being very broad and flat in proportion to its length. Length of female, 9 to 11 mm.; male, 8.25 mm. Vertex, about twice as long medially as next to the eye, anterior margin broadly rounding, slightly concave preapically, the oblique striations very distinct. Pronotum about twice as long as vertex, distinctly transversely striated. Elytra very broad, slightly exceeding abdomen.

Color: The females are all greenish, frequently bearing a pair of black spots laterally on the pronotum not quite half way back, and a black spot on base of each elytron, just under outer edge of pronotum. The males may be of the same color as the females, or they may be black forms. In the latter, the vertex may be partly or entirely black except for light marks around the ocelli, a pair of light spots on the posterior margin a little further apart than the ocelli and another pair of light spots near the anterior margin a little in front of the eyes. The pronotum may have the disc blackened, showing the pair of black dots, or it may be entirely black except for a strip of light along the lateral margins. The scutellum may have the disc blackened, or it may be entirely black except for touches of light markings near the apex. The elytra are very smoky, but are usually light and hyaline enough to let the black abdomen show through, showing the black spot at the base, as in the female.

External genitalia: Female, last ventral segment long, longest at lateral angles, shortest medially, posterior margin broadly concave with a very small median lobe; pygofers broad and long, slightly exceeding ovipositor and bearing, especially on apical half, a few coarse hairs. Male, valve hidden by last ventral segment; plates broad, obliquely truncate and overlapping apically, exceeded by the large pygofers which bear a few stout hairs laterally.

Distribution: Specimens have been taken in Pottawatomie and Douglas counties.

Hosts: Seemingly confined to native grasses.

In 1905 Professor Osborn suggested that *G. melanota* Spangb. might be a melanotic form of *G. bipunctulata* Woodw. Dr. Ball is of the opinion that such is the case and in his collection are to be seen the large females and the smaller males of both colors. Many of these were taken together, so there seems to be no doubt as to the synonomy of these two forms.

Gypona pectoralis Spangb.

Gypona pectoralis Spangb., Spec. Gyponæ, p. 46, 1878.
Gypona pectoralis Spangb., Ent. Tidskr., i, p. 33, 1881.
Gypona albimarginata Woodw., Bul. Ill. St. Lab. Nat. Hist., iii, p. 31, 1887.
Gypona hullensis Prov., Pet. Faune Ent. Can., iii, p. 269, 1889.
Gypona pectoralis Wirtn., Ann. Carn. Mus., iii, p. 220, 1904.
Gypona pectoralis Van D., Ottawa Nat., xxvi, p. 68, 1912.
Gypona pectoralis Van D., Cat. Hemip. N. A., p. 614, 1917.
Gypona pectoralis Gibs., Proc. U. S. Natl. Mus., lvi, p. 94, 1919.

Form: Not as broad as preceding species. Length, 8.5 to 10.24 mm. Vertex less than twice as long medially as next to the eye, broadly rounded. Pronotum characteristic of the genus. Elytra long, well exceeding the abdomen, subcoriaceous.

Color: Brownish; vertex and pronotum having a mottled appearance as does anterior portion of scutellum. Posterior portion of scutellum lighter. Elytra darker than other parts, often having large or small dark spots on the cross veins and sometimes on the cells.

External genitalia: Female, last ventral segment broad, slightly longer than preceding segment, posterior margin truncate, with a small median excision; pygofers broad and long, exceeding ovipositor, and bearing, chiefly on distal half, quite a few large coarse hairs. Male, last ventral segment long, semicircular, covering the valve; plates very broad and obliquely truncate apically with the outer angles more prominent than the rounding inner angles; pygofers about as long as the plates, narrow, and covered with numerous very large hairs.

Distribution: Taken in Douglas, Pottawatomie, Sumner and Montgomery counties.

Hosts: Probably a grass-feeding species.

Gypona puncticollis Spangb.

Gypona puncticollis Spangb., Spec. Gyponæ, p. 54, 1878.
Gypona puncticollis DeL., Tenn. St. Bd. Ent., Bul. 17, p. 30, 1916.
Gypona puncticollis Van D., Cat. Hemip. N. A., p. 615, 1917.
Gypona puncticollis Gibs., Proc. U. S. Natl. Mus., lvi, p. 98, 1919.

Form: As in preceding species. Length, 8 to 9 mm.

Color: Reddish brown with vertex, pronotum and scutellum lighter than the elytra, the scutellum the lightest. Head, pronotum and basal and costal portion of elytra often irrorate with red. Spot behind each ocellus light brown. Pronotum with four black spots near the margin. Elytra with black spot on humerus, on some of the cross veins and also in some cells.

External genitalia: Female, last ventral segment broad and long, posterior margin sinuate, lobe on median third with a median notch; pygofers broad and long, exceeding ovipositor and with coarse hairs on apical half. Male, genitalia as in preceding species except that last ventral segment is more produced medially and the plates are longer and further apart.

Distribution: Taken only in Pottawatomie and Riley counties.

Hosts: De Long gives *Elymus virginicus* as one of the grass hosts of this species.

Gypona cinerea Uhl.

Gypona cinerea Uhl., Bul. U. S. Geol. Geog. Surv., iii, p. 460, 1877.
Gypona cinerea Woodw., Bul. Ill. St. Lab. Nat. Hist., iii, p. 32, 1887.
Gypona cinerea Will., Kan. Univ. Sci. Bul., viii, p. 223, 1913.
Gypona cinerea Van D., Cat. Hemip. N. A., p. 615, 1917.
Gypona cinerea Gibs., Proc. U. S. Natl. Mus., lvi, p. 100, 1919.

Form: This species varies very greatly in size. Length of females 6 to 11 mm., males 5 to 9 mm. Vertex produced more than in other members of the genus, about three times as long medially as next the eyes and almost as long as the pronotum. Pronotum twice as broad as long. There are long- and short-winged forms in both sexes. In the long-winged females the elytra just exceed the abdomen; in the short-winged forms they are exceeded by the abdomen. The elytra of the long-winged males greatly exceed the abdomen, whereas in the short-winged males the elytra are shorter than the abdomen. In any case the elytra are quite broad.

Color: The color varies from a light, brownish-gray to a dark cinerous. Vertex and pronotum densely punctate with black. Vertex with pair of black spots on posterior margin, a little further apart than the ocelli. Pronotum often with series of anterior, submarginal dark spots. Scutellum slightly punctate with fuscous, the basal angles dark. Elytra very characteristically marked with fuscous, with impressed punctures on either side of the nervures, and frequently having small fuscous spots in the cells. Head, pronotum and scutellum sometimes lightly irrorate with red.

External genitalia: Female, last ventral segment longer than preceding, posterior margin with a large excavation, reaching one-third of the distance to the base, the base of which bears a distinct, obtusely-pointed or rounded lobe; pygofers are broad and long, exceeding the ovipositor, broadest at the middle, each bearing preapically a lateral, black, impressed line. In the long-winged male the last ventral segment is somewhat longer than the preceding one and the posterior margin is slightly concave and elevated; plates are long and narrow, overlapping apically, about equalling the ovipositors which bear a few stout hairs on apical half. In the short-winged male, the plates seem to be further covered by a relatively longer last ventral segment, so that they appear shorter. In the specimens examined they were not found to overlap apically.

Distribution: Taken in Grant and Pottawatomie counties.

Hosts: Williams records this species as common on Buffalo grass in Kansas.

Genus XEROPHLŒA Germ.

The members of this genus differ from the other members of the *Gyponinæ* in having a much flatter head, with broad thin margins. They also have the apices of the elytra perpendicular in position rather than in the more horizontal position characteristic of the other genera.

One of the two United States' species has been taken in the state.

Xerophlœa viridis (Fabr.).

(Pl. 10, figs. 5-6.)

Cercopis viridis Fabr., Ent. Syst., iv, p. 50, 1794.
Xerophlœa grisea Germ., Zeits. f. Ent., i, p. 190, 1839.
Xerophlœa virescens Stal, Of. Vet. Akad. Forh., xi, p. 253, 1854.
Xerophlœa viridis Stal, Hemip. Fabr., ii, p. 59, 1869.
Parapholis peltata Uhl., Bul. U. S. Geol. Geog. Surv., iii, 461, 1877.
Xerophlœa peltata G. & B., Hemip. Colo., p. 82, 1895.
Xerophlœa viridis O. & B., Proc. Ia. Acad. Sci., iv, p. 179, pl. 19, fig. 1, 1897.
Xerophlœa viridis Osb., 20th Rept. N. Y. St. Ent., p. 512, 1905.
Xerophlœa viridis DeL., Tenn. St. Bd. Ent., Bul. 17, p. 28, 1916.
Xerophlœa viridis Van D., Cat. Hemip. N. A., p. 616, 1917.
Xerophlœa viridis Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 40, 1919.

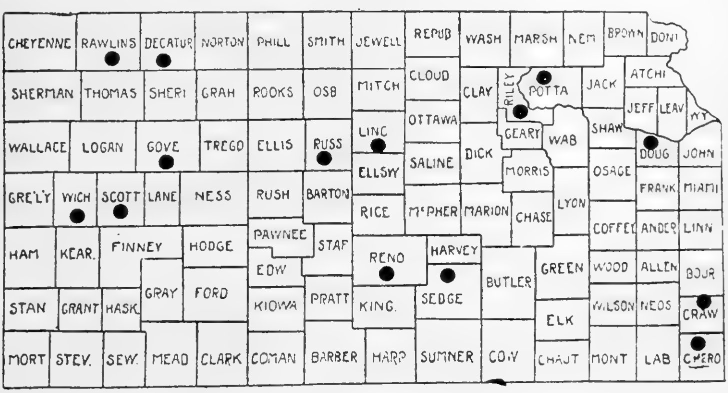
Form: Wedge-shaped, robust. Length, 6 to 7.25 mm. Head very flat and thin, narrower than pronotum. Vertex about twice as broad as long, obtusely angular apically. Pronotum broadest at posterior lateral angles, humeral margins longer than the lateral margins, sinuate, roundingly angled with the posterior emarginate margin, anterior margin quite convex. Apex of scutellum long and acute. Elytra broad and long, much exceeding abdomen and perpendicular apically. Entire dorsal surface coarsely and deeply pitted.

Color: Female bright green, elytra faded apically. Occasionally a female will be very light green, very irregularly mottled all over with dark brown, giving her a brownish rather than a greenish color. Males are usually a dirty yellowish-green. The vertex bears a broad brown median stripe which extends on to the pronotum and makes the disc and posterior margin brown. Elytra with a brown spot before the clavus and often with a series of smaller spots along sutural margin to the apex.

External genitalia: Female, last ventral segment very long, as long as wide, and incised medially clear to the base, forming two large approximate lobes; pygofers are broad and long, slightly exceeded by ovipositor, and bearing short appressed hairs. Male, last ventral segment long, posterior margin somewhat convex, hiding the valve; plates very long and narrow, pointed apically, exceeding the short pygofers.

Internal male genitalia: Styles large and very characteristic, basal half club-shaped, then suddenly narrowed and gradually thickening to a broad truncate apex with a distinct inner acutely pointed angle, the outer angle being rounded; the connective is broad basally, tapering sinuately to the apex; the œdagus has a small basal, dorsally directed process followed by a sharp constriction, and terminates in a bluntly pointed process, which, viewed laterally, appears triangular.

Distribution: A common form found throughout the state as shown by the following map:



Hosts: A grass feeding species. De Long records it as especially abundant on *Aristida gracilis.*

Subfamily JASSINÆ (A. & S.).

In this subfamily are included a great variety of forms and more than three times as many species as in the preceding subfamilies combined. It is rather hard to give distinct characteristics for the group for it contains a very heterogeneous mass of species. The members of one of its tribes frequently lack ocelli, a condition not found in the other subfamilies. In the other tribes the ocelli are on or very near the margin of the vertex and thus these two tribes differ from the members of the other subfamilies where the ocelli are either on the front, below the margin of the vertex, or on the disc of the vertex, above the margin.

KEY TO THE TRIBES.

A. Ocelli either just above margin of vertex or distant from the eyes. *Acucephalini.*

AA. Ocelli, if present, on margin of vertex and not distant from the eyes.

B. Nervures of elytra branching on disc. *Jassini.*

BB. Nervures of elytra not branching on disc. *Typhlocybini.*

Tribe ACUCEPHALINI (Dohrn).

The members of this tribe are in the main broad, robust forms in which the ocelli are either situated just above the margin of the vertex, or on the margin, but much further from the eyes than is normally their situation for the members of the tribe *Jassini.*

KEY TO GENERA.

A. Head flattened, vertex long, distinctly angled apically. *Memnonia.*

AA. Head conical, vertex shorter, rounded apically.

B. Head moderately long, pronotum not produced beyond anterior margin of eyes. *Xestocephalus.*

BB. Head short, pronotum produced beyond anterior margin of eyes. *Nionia.*

Genus MEMNONIA Ball.

The following is the original description of the genus: "General form of *Acucephalus,* vertex convex, sloping, nearly right angled, about half as long as the width across the eyes, the anterior margin thick, ocelli on the margin above the frontal sutures, distant from the eyes; face convex, forming an acute angle with the vertex, front above broad, narrowing below and abruptly rounding to the parallel margined clypeus; pronotum as long or longer than vertex, strongly, transversely wrinkled, the lateral margins less than half the middle length, anterior and posterior margins nearly parallel; elytra *macropterous,* covering the abdomen in the male and all but the ovipositor in the female, with long apical cells and a narrow appendix, or *brachypterous,* covering about two-thirds of the abdomen, the apical cells very small; under wings rudimentary; venation, the inner branch of the first sector tied to the second sector near its origin, again forking near the middle, its outer form tied to the outer branch beyond its middle, anteapical cells of very different lengths."

One of the two American forms has been taken in Kansas, but both are likely to be found.

KEY TO SPECIES.

A. Females larger, 4 mm. or more, greenish-brown, ovipositor well exserted; males 3 mm. long, black. *consobrina.*

AA. Females smaller, 3.5 mm. or less, creamy buff, ovipositor shorter, male similar to female in size and color. *fraterna.*

Memnonia consobrina Ball.

Memnonia consobrina Ball, Rept. Ia. Acad. Sci. for 1899, p. 66, pl. 5, figs. 6-10, 1900.
Memnonia consobrina Van D., Cat. Hemip. N. A., p. 621, 1917.

Form: Females larger than males. Former robust, widest at beginning of posterior half. Length, 4 to 4.25 mm. Males smaller. Length, 3 mm. Vertex twice longer on middle than against eyes, more pointed in males. Pronotum twice wider than long. Elytra covering the abdomen in the males and in some females, leaving part of abdomen exposed in other females.

Color: Females, vertex, pronotum and scutellum yellowish-green, elytra brownish. Males black with white spots in a row across the anteapical cells.

External genitalia: Female, last ventral segment nearly three times as long as preceding, posterior margin emarginate, with a distinct median lobe; pygofers tapering greatly caudad and much exceeded by the ovipositor which bears a few hairs apically. Male, valve small, triangular, plates together about half as wide as ultimate segment, long, tapering to acute tip; pygofers slightly exceeding plates, bearing large coarse hairs on margins.

Distribution: Has not yet been taken in the state.

Hosts: Ball reports this species as breeding on *Schedonnardus texanus* and *Muhlenbergia gracillima.*

Memnonia fraterna Ball.

Memnonia fraterna Ball, Rept. Ia. Acad. Sci. for 1899, p. 67, 1900.
Memnonia fraterna Van D., Cat. Hemip. N. A., p. 621, 1917.

Form: Smaller than *consobrina,* all forms brachypterous. Length, 3 to 3.5 mm. Vertex about two-thirds as long as basal width, pronotum of about the same length. Elytra broad and short, exposing last abdominal segment and pygofers.

Color: Creamy buff, seemingly covered with a whitish bloom; apical nervures and posterior margin of abdominal segments fuscous.

External genitalia: Female, last ventral segment slightly larger than in *consobrina;* ovipositor usually but slightly exceeding the posteriorly tapered pygofers. Male, valve small, triangular, plates similar to *consobrina* but shorter, much exceeded by the stout pygofers which bear a few stout spines on the apical half.

Distribution: Taken only in Reno county.

Hosts: Doctor Ball reports this species on the same plants as *consobrina.*

Genus XESTOCEPHALUS Van D.

The members of this genus are ovate in form with the head narrower than the pronotum, subconical, the vertex sloping, and with the ocelli on the rounded anterior margin of the head, distant from the eyes. Pronotum narrow, over twice as wide as long, anterior and posterior margins about parallel and with distinct lateral and humeral margins. Scutellum large, nearly as long as the pronotum. Elytra almost coriaceous, long, greatly exceeding the abdomen.

Two of the three species of this genus which likely occur in Kansas have been collected in the state.

KEY TO SPECIES.

A.	Vertex marked with distinct yellow lines.	*pulicarius.*
AA.	Vertex without distinct yellow lines.	
B.	Vertex practically unicolorous.	*superbus.*
BB.	Vertex irrorate, brown and yellow.	*tessellatus.*

Xestocephalus pulicarius Van D.

Xestocephalus pulicarius Van D., Bul. Buf. Soc. Nat. Sci., v, pp. 197, 215, 1894.
Xestocephalus pulicarius O. & B., Proc. Ia. Acad. Sci., iv, p. 284, 1897.
Xestocephalus pulicarius Osb., 20th Rept. N. Y. St. Ent., p. 515, 1905.
Xestocephalus pulicarius Osb., Me. Agr. Exp. Sta., Bul. 238, p. 109, 1915.
Xestocephalus pulicarius DeL., Tenn. St. Bd. Ent., Bul. 17, p. 35, 1916.
Xestocephalus pulicarius Van D., Cat. Hemip. N. A., p. 621, 1917.
Xestocephalus pulicarius Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 46, 1919.

Form: The smallest of the three species mentioned. Length, 2.5 to 3 mm. Head subconical, vertex rounded, more than twice as broad as long. Pronotum twice as broad as long, half longer than vertex. Elytra large, broad and very long, greatly exceeding abdomen.

Color: Brown, marked with yellow. Vertex with yellow spots on apex and next each eye, latter connected by an m-shaped line on the disc of the vertex, posterior margin yellow. Pronotum with four yellow anterior submarginal spots and scattered spots on disc. Scutellum with two anterior median yellow spots. Elytra with many yellow spots of various sizes.

External genitalia: Female, last ventral segment over twice as long as preceding one, with posterior margin broadly though shallowly emarginate; pygofers broad but short, bearing only coarse spines, especially on apical half, exceeded by the ovipositor. Male, last ventral segment longer laterally than medially; valve very small; plates about twice as long as last ventral segment, broad basally, tapering apically to obtuse apices, bearing many long fine hairs and a few stout spines, slightly exceeded by the pygofers.

Distribution: This species has been taken in Cherokee, Douglas, Pottawatomie and Hodgeman counties.

Hosts: Van Duzee reports this species from swampy pastures where *Carex vulpinoidea* abounds. De Long reports it on grasses throughout Tennessee.

Xestocephalus superbus (Prov.)

Deltocephalus superbus Prov., Pet. Faune Ent. Can., iii, p. 339, 1890.
Xestocephalus fulvocapitatus Van D., Bul. Buf. Soc. Nat. Sci., v, pp. 197, 215, 1894.
Xestocephalus fulvocapitatus Osb., 20th Rept. N. Y. St. Ent., p. 515, 1905.
Xestocephalus superbus Van D., Can. Ent., xliv, p. 329, 1912.
Xestocephalus fulvocapitatus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 109, 1915.
Xestocephalus fulvocapitatus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 35, 1916.
Xestocephalus superbus Van D., Cat. Hemip. N. A., p. 622, 1917.

Form: Larger and more robust than *pulicarius*. Length of female, 3.5 mm., length of male, 2.25 mm. or more. Otherwise like *pulicarius*.

Color: Head, pronotum and scutellum almost unicolorously brown. Elytra distinctly marked with semi-transparent spots on corium and apically, latter more or less coalescent.

Genitalia: As in *pulicarius*.

Distribution: Taken in Douglas and Pottawatomie counties.

Hosts: This is also reported as living on *Carex*.

Xestocephalus tessellatus Van D.

Xestocephalus tessellatus Van D., Bul. Buf. Soc. Nat. Sci., v, p. 216, 1894.
Xestocephalus tessellatus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 35, 1916.
Xestocephalus tessellatus Van D., Cat. Hemip. N. A., p. 622, 1917.
Xestocephalus tessellatus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 47, 1919.

Form: The largest of the species of this genus that should occur in Kansas. Length, 4 mm. Otherwise form of preceding species.

Color: Vertex and pronotum brown, irrorate with white. Scutellum with basal angles dark. Elytra with nervures alternating brown and white and with two large brown spots on costal margin and five large apical spots.

External genitalia: Female, last ventral segment with posterior margin slightly concave and slightly notched medially. Male, valve hidden by last ventral segment; plates strongly narrowed from near the base to a slender point.

Distribution: Not yet reported from this state.

Hosts: Gibson and Cogan report taking specimens from elm leaves.

Genus NIONIA Ball.

In this genus the vertex is very short, produced medially till twice as long as next the eye. Ocelli distant from eyes. Pronotum long, anterior margin produced beyond anterior margin of eyes, posterior margin emarginated medially, coarsely punctured. Elytra moderately long, slightly exceeding abdomen, veins margined with lines of coarse deep punctures.

Nionia palmeri (Van D.).

Goniagnathus palmeri Van D., Can. Ent., xxiii, p. 171, 1891.
Goniagnathus palmeri Osb., 20th Rept. N. Y. St. Ent., p. 529, 1905.
Goniagnathus palmeri Osb., Ohio Nat., v, p. 274, 1905.
Nionia palmeri Ball, Proc. Biol. Soc. Wash., xxviii, p. 166, 1915.
Goniagnathus palmeri DeL., Tenn. St. Bd. Ent., Bul. 17, p. 33, 1916.
Nionia palmeri Van D., Cat. Hemip. N. A., p. 622, 1917.
Nionia palmeri Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 46, 1919.

Form: Much like a *Macropsis* in general appearance but stouter. Length, 4 mm. Vertex very short except medially where it is produced till twice as long as next the eye. Pronotum with anterior margin greatly produced, reaching far beyond anterior margin of eyes, lateral margins practically none, posterior margin emarginate. Scutellum large, about as long as wide, punctate. Elytra broad and moderately long, nervures margined with coarse punctures.

Color: Shining black except for brownish apices of elytra, antennæ and tarsi.

External genitalia: Female, last ventral segment twice as long as preceding, posterior margin slightly produced medially; pygofers broad and short, exceeded by the ovipositor. Male, valve covered by last ventral segment, plates tapering to acute apices.

Distribution: Reported from Cherokee, Pottawatomie and Riley counties.

Hosts: Definite host unknown.

Tribe JASSINI (Dohrn).

This is a very heterogeneous tribe, but all its members have the ocelli on the margin of the vertex near the eyes, and the nervures of the elytra branch on the disc.

Of the 34 genera of the tribe known to occur in America north of Mexico, we have 24 genera in Kansas.

KEY TO GENERA.

A. Head flattened, anterior margin thin, sharp, or foliaceous.
  B. Head, at least in female, strongly foliaceous.
    C. Head about twice as long as width across the eyes; head of both male and female foliaceous. *Dorycephalus*
    CC. Head about as long as width across the eyes; head of male distinctly less foliaceous than head of female.

A. Head flattened—*concluded.*

D. Species unstriped or with longitudinal yellow stripes on vertex and pronotum; females brachypterous. *Hecalus.*

DD. Species with converging red lines on vertex and pronotum, both sexes macropterous. *Spangbergiella.*

BB. Head thin but not foliaceous.

C. Greenish species, elytra not ramosely pigmented. *Parabolocratus.*

CC. Brownish species, elytra more or less ramosely pigmented. *Dicyphonia.*

AA. Head not flattened, anterior margin neither sharp nor foliaceous.

B. Vertex longer than wide or not much wider than long, disc flattened, separated from front by more or less of a distinct margin.

C. Elytra with three anteapical cells.

D. One cross vein between sectors of elytra. *Scaphoideus.*

DD. Usually two cross veins between the sectors of elytra.

E. Vertex greatly produced and acutely angled, front long and narrow. *Platymetopius.*

EE. Vertex moderately produced, front broad, clypeus narrowed at tip. *Deltocephalus.*

CC. Elytra with two anteapical cells. *Lonatura.*

BB. Vertex usually much wider than long, disc sloping and margin rounding to front.

C. Inner sector of elytra twice forked, elytra with three anteapical cells.

D. Inner branch of first sector forking on disc of corium.

E. Elytra usually short, seldom longer than abdomen, often very short, vertex large.

F. Ovipositor long, exceeding pygofers.

G. Gray, or with golden iridescence. *Aconura.*

GG. Black or dark species. *Driotura.*

FF. Ovipositor short, seldom exceeding pygofers. *Euscelis.*

EE. Elytra longer, usually distinctly exceeding abdomen; vertex smaller.

F. Elytra marked with fine ramose pigment lines, or, if not, with transverse furrow on vertex.

G. Ramose lines, if present, restricted to a cross band behind middle of elytra.

H. Elytra with one cross nervure between sectors. *Eutettix.*

AA. Head not flattened—*concluded.*

HH. Elytra with two cross nervures between the sectors or supernumerary veinlets to costa or both.

I. Anterior margin of vertex rounding to front, no black line under vertex. *Aligia.*

II. Anterior margin of vertex acutely angled with front, black line under vertex. *Mesamia.*

GG. Ramose lines always present, not restricted to transverse band. *Phlepsius.*

FF. Elytra not marked with ramose pigment lines.

G. Elytra with apex pointed. *Acinopterus.*

GG. Elytra with apex rounded.

H. Vertex usually distinctly longer medially than next the eye, sides of pronotum short; species usually slender. *Thamnotettix*

HH. Vertex usually not much longer medially than next the eye, sides of pronotum longer; species usually broad and green. *Chlorotettix.*

DD. Inner branch of first sector not forked on disc of corium.

E. Vertex not produced, scutellum very large. *Jassus.*

EE. Vertex well produced, scutellum smaller. *Neocœlidia.*

CC. Inner sector of elytra not forked, elytra with two anteapical cells.

D. Wing with 3 apical cells. *Cicadula.*

DD. Wing with 2 apical cells.

E. Head narrower than pronotum. *Balclutha.*

EE. Head wider than pronotum. *Eugnathodus.*

Genus DORYCEPHALUS Kirsch.

This genus is at once characterized by the unusually prolonged foliaceous vertex. They are grayish or brownish, stick-like insects, especially the brachypterous forms.

Both the North American species occur in Kansas.

KEY TO SPECIES.

A. Head broadly foliaceous, elytra more than half the length of the abdomen in both sexes. *platyrhynchus.*

AA. Head narrowly foliaceous, elytra less than half the length of the abdomen in both sexes. *vanduzei.*

Dorycephalus platyrhynchus Osb.

Dorycephalus sp., Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 127, 1892.

Dorycephalus platyrhynchus Osb., Can. Ent., xxvi, p. 216, 1894.

Dorycephalus platyrhynchus O. & B., Proc. Ia. Acad. Sci., p. 185, pl. 20, fig. 1, 1897.

Dorycephalus platyrhynchus Ball, Ia. Acad. Sci., for 1899, p. 68, 1900.

Dorycephalus platyrhynchus Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 65, fig. 7, 1912.

Dorycephalus platyrhynchus Van D., Cat. Hemip. N. A., p. 623, 1917.

Form: Long forms, characterized by the very broad, flat head. Length, female, 14.5 mm.; male, 9 mm. Female, vertex about twice as long as width across eyes, very flat and with a longitudinal median carina. Prothorax more than twice as broad as long, with five elevated longitudinal ridges, anterior margin sinuate, lateral margins long and parallel, posterior margin emarginate medially. Elytra strongly veined, extending to fourth abdominal segment, or longer, extending to last segment, leaving only a part of the pygofers and ovipositor exposed. Abdomen long and tapering, ending in a long ovipositor. Male, vertex shorter, elytra long, equalling the tip of the pygofers.

Color: Female, pale yellow, with carina on vertex darker, the dark stripe sometimes extending on to the middle of the pronotum and the scutellum. Lateral portions of vertex and pronotum often mottled with brown. Visible abdominal segments with a pair of usually basal brown spots dorsally. Males darker, grayish-brown, vertex and pronotum mottled with brown in addition to the median dark line.

External genitalia: Female, last ventral segment longer than preceding, posterior margin truncate, somewhat sinuate, with a small, but distinct, rounded median tooth; pygofers very long, tapering from broad base to acute apex, much exceeded by the very long and stout ovipositor. Male, valve small, just visible from under the large last ventral segment; plates at base about half the width of the last ventral segment, tapering rapidly to the long and slender apices; pygofers broad at base but tapering regularly to acute apex, the two together forming a triangle about twice as long as the plates, bearing a scant covering of short hairs.

Distribution: Taken only in Gove and Sumner counties but should occur throughout the state.

Hosts: Osborn and Ball give *Elymus canadensis* and *virginicus* as the chief grass hosts. It also occurs on *Aristida.*

Dorycephalus vanduzei O. & B.

Dorycephalus vanduzei O. & B., Proc. Dav. Acad. Sci., vii, p. 74, pl. 6, fig. 2, 1898.
Dorycephalus vanduzei Ball, Rept. Ia. Acad. Sci. for 1899, p. 68, 1900.
Dorycephalus vanduzei Van D., Bul. Buf. Soc. Nat. Sci., ix, p. 216, 1909.
Dorycephalus vanduzei Van D., Cat. Hemip. N. A., p. 623, 1917.

Form: More slender than the preceding species, being about ten times as long as wide. Length, female, 13 to 14 mm.; male, 8.5 to 12 mm. Female, vertex about two and a half times as long as width across eyes, with three longitudinal carinæ. Pronotum nearly three-fourths as long as wide, with three longitudinal carinæ, and posterior margin not quite concave in front of scutellum. Elytra strongly veined, very short, reaching only to third abdominal segment. Abdomen very long and acutely tapering posteriorly. Male, smaller and narrower than the female, elytra very short, abdomen long and slender, terminated by the very long pygofers.

Color: Female, straw yellow, frequently unmarked, often with black median spots on anterior and posterior margins of pronotum and apex of scutellum and four on each abdominal segment, arranged in two dorsal and two more lateral rows. Male, darker than the female, vertex tipped with black and with basal black spot as well as with the spots on pronotum and scutellum, as in the female.

External genitalia: Female, last ventral segment about as long as the preceding, posterior margin slightly produced medially; pygofers remarkably long, their tips divergent below, and fringed with fine hairs. Male, last ventral segment short, about two-thirds as long as preceding, valve very small, triangular, plates nearly as broad at base as last ventral segment, very long and slender apically; pygofers very long and slender, over four times as long as the plates, divergent below for the greater part of their length, and covered with fine hairs.

Distribution: Reported from Pottawatomie and Hamilton counties.

Hosts: *Aristida purpurea* is given as the host plant by Osborn and Ball.

Genus HECALUS Stal.

In this genus the females have broad, rather parallel-margined heads which are quite foliaceous but not to the extent seen in the two members of *Dorycephalus.* The males have a much shorter and pointed head, not at all or much less foliaceous than in the females.

One member of this genus has been taken in the state, but two should occur.

KEY TO SPECIES.

A. Straw colored forms, rarely striped. *bracteatus.*
AA. Greenish forms, with longitudinal, yellowish or reddish stripes. *lineatus.*

Hecalus bracteatus Ball.

Hecalus bracteatus Ball, Can. Ent., xxxiii, p. 4, 1901.
Hecalus bracteatus Van D., Cat. Hemip. N. A., p. 624, 1917.

Form: Females long and oval, males smaller, resembling a long-headed *Deltocephalus*. Length, females, 7 mm.; males, 5 mm. Female, head not quite as long as width across the eyes, margin foliaceous. Pronotum over twice as broad as long, lateral margins long, posterior angles slightly produced, posterior margin slightly emarginate medially. Elytra short, covering first abdominal segment. Male, vertex roundingly triangular, one-third broader than long, margin not at all foliaceous. Elytra narrow and long, much exceeding abdomen.

Color: Females, straw colored, abdomen with narrow median fuscous line and four, broader, lateral lines which are bordered with fuscous lines. Male, milky white, often with five fuscous stripes on vertex and pronotum. Broad, whitish nervures of elytra thickly margined with fuscous dots.

External genitalia: Female, last ventral segment slightly longer than preceding, posterior segment broadly emarginate, with very small median lobe; pygofers widest at about one-third the distance from their base, then tapering to acute apex which equals the ovipositor. Male, valve large, triangular; plates broad at base; together forming a triangle about as long as broad, margins straight, armed with a row of stout spines; pygofers small, much exceeded by the plates.

Distribution: Should occur in western Kansas.

Hosts: A grass feeder, but definite host unknown.

Hecalus lineatus (Uhl.).

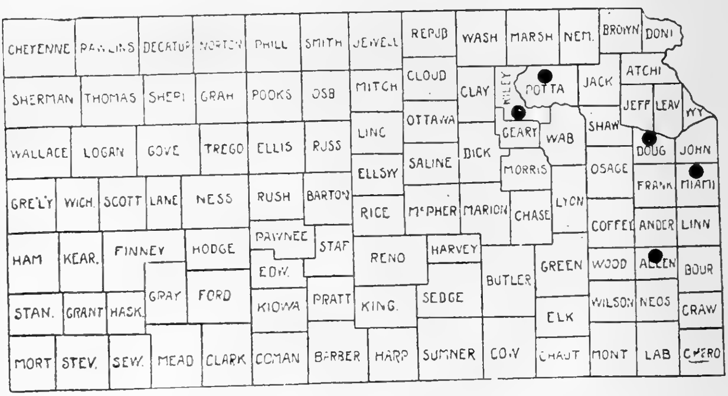
Glossocratus lineatus Uhl., Bul. U. S. Geol. Geog. Surv., iii, p. 463, 1877.
Glossocratus fenstratus Uhl., Bul. U. S. Geol. Geog. Surv., iii, p. 464, 1877.
Glossocratus fenstratus Sign., Ann. Soc. Ent. Fr., ser. 5, ix, p. 268, 1879; x, p. 42, pl. 1, fig. 37, 1880.
Hecalus lineatus Sign., Ann. Soc. Ent. Fr., ser. 5, ix, p. 267, pl. 7, fig. 25, 1879.
Hecalus lineatus O. & B., Proc. Ia. Acad. Sci., iv, p. 188, pl. 20, fig. 2, 1897.
Hecalus lineatus Ball, Rept. Ia. Acad. Sci., for 1899, p. 68, 1900.
Hecalus lineatus Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 64, fig. 6, 1912.
Hecalus lineatus Van D., Cat. Hemip. N. A., p. 624, 1917.

Form: Intermediate between *Dorycephalus* and *Spangbergiella*. Rather large, flat forms, with smaller males. Length, female, 10.5 to 13 mm.; male, 7 to 8 mm. Female, vertex about as long as width across eyes, slightly narrowed in front of eyes, then widening to spoon-shaped tip which is quite foliaceous and slightly reflexed. Pronotum over twice as broad as long, lateral margins long and parallel, posterior margin concave in front of scutellum. Scutellum broad and short. The elytra may be short, leaving last three segments of abdomen exposed, or long, exposing only the pygofers. In the smaller long-winged forms, the vertex does not widen in front of the eyes and is shorter. Ovipositor is long and exserted. Male, vertex not as long as width across eyes, more acute anteriorly and not as foliaceous as in the females.

Color: Bright green with four parallel orange-red lines on head, pronotum and scutellum. Nervures of elytra also orange-red and abdomen also striped. In the long-winged males there is a black band across the wings about medially and a larger apical one, between which is a white or hyaline area; the pygofers are black. In the short-winged males there is just a suggestion of a black band across the tips of the wings and the pygofers are often merely tipped with black.

External genitalia: Female, last ventral segment half longer than preceding segment, posterior margin sinuate on either side of a short, rounding, median lobe; pygofers broad at base, acute apically, greatly exceeded by the very long, apically haired ovipositor. Male, valve very small, triangular; plates wide at base, tapering regularly to long, acute, upturned and frequently overlapping tips; pygofers very characteristic of the species, being very long and style-like, ending in two widely separated and acute apices, finely serrate along inner margin and bearing, laterally, a brush of long spines in front of the middle, with a few along apical portion of dorsal margin and a brush at the apex.

Distribution: Occurs in the eastern portion of the state, as shown by the following map:



Genus Spangbergiella Sign.

This genus stands between *Hecalus* and *Parabolocratus*, the head not being as foliaceous as in the former genus, and thinner than in the latter. The head of the female is much produced and foliaceous, but in the male the head is shorter and thicker. Very characteristic of the genus are the bright red converging lines on the vertex and pronotum. The elytra are always long.

KEY TO SPECIES.

A. Head broadly rounded anteriorly, foliaceous in female, oblique stripes of pronotum not in line with those of vertex. *vulnerata.*

AA. Head distinctly acute, not foliaceous in female, oblique stripes of pronotum nearly in line with those of vertex. *mexicana.*

Spangbergiella vulnerata (Uhl.).

Glossocratus vulnerata Uhl., Bul. U. S. Geol. Geog. Surv., iii, p. 464, 1877.
Glossocratus lacertæ Sign., Ann. Soc. Ent. Soc. Fr., ser. 5, ix, pl. 8, fig. 29, 1879.
Spangbergiella vulnerata Sign., Ann. Ent. Soc. Fr., ser. 5, ix, p. 274, 1879.
Spangbergiella vulnerata Uhl., Stand. Nat. Hist., ii, p. 247, 1884.
Spangbergiella vulnerata Ball, Rept. Ia. Acad. Sci. for 1899, p. 68, 1900.
Spangbergiella vulnerata Osb., 20th Rept. N. Y. St. Ent., p. 516, 1905.
Spangbergiella vulnerata Van D., Cat. Hemip. N. A., p. 624, 1917.
Spangbergiella vulnerata Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 50, 1919.

Form: Larger than following species, broad. Length, female, 7.25 to 8 mm.; male, 5.5 mm. Vertex of female about as long as width across the eyes, broadly rounded apically and foliaceous. Vertex of male about two-thirds as long as basal width between eyes, rounded apically, not at all foliaceous. Pronotum twice as wide as long, posterior margin emarginate in front of scutellum, with distinct humeral margins. Elytra long, leaving only tip of ovipositor exposed and exceeding the abdomen in the male.

Color: Greenish or yellowish-green. Vertex with two converging red lines which start from near the eyes. Pronotum with median red line on posterior half and a pair of converging lines which start from the inner angle of the humeral margin and extend across to the anterior margin to points that divide the distance between the bases of the lines on the vertex into equal thirds. Scutellum either unicolorous or with three faint yellow stripes. Elytra either unicolorous or with nervures slightly orange-yellow.

External genitalia: Female, last ventral segment longer than preceding, truncate posteriorly; pygofers acutely tapering posteriorly, exceeded by ovipositor. Male, valve small, rounded, plates broad at base, tapering to long acute tips, margins with few spines near the base; pygofers acute apically, slightly longer than plates, covered with coarse spines.

Distribution: Collected in Labette county.

Hosts: Probably a grass feeder.

Spangbergiella mexicana Bak.

Spangbergiella mexicana Bak., Can. Ent., xxix, p. 157, 1897.
Spangbergiella mexicana Barb., Bul. Am. Mus. Nat. Hist., xxxiii, p. 533, 1914.
Spangbergiella vulnerata DeL., Tenn. St. Bd. Ent., Bul. 17, p. 36, 1916.
Spangbergiella mexicana Van D., Cat. Hemip. N. A., p. 625, 1917.
Spangbergiella mexicana DeL., Ohio Jl. Sci., xviii, p. 233, 1918.
Spangbergiella mexicana Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 50, 1919.

Form: Smaller than *vulnerata.* Length, 5 to 6.5 mm. Vertex about as long as basal width, shorter in the male, acutely pointed, not at all foliaceous. Pronotum about twice as broad as long, narrowed anteriorly, humeral margins distinct, posterior margin slightly concave. Elytra long, reaching ovipositor in female, exceeding abdomen in male.

Color: Pale or yellowish-green. Vertex with two oblique red lines, nearly in line with a pair on pronotum which also bears a median basal red line. Elytra with veins, except apical ones, yellow or red, with black dots at end of claval suture, a pair near inner and outer margins apically and sometimes one almost two-thirds back on costal margin.

External genitalia: Female, last ventral segment twice as long as preceding, posterior margin slightly rounding; acutely tapering pygofers much exceeded by ovipositor, both pygofers and ovipositor with a few stout spines. Male, last ventral segment broader and longer than preceding, widest posteriorly and with posterior margin broadly concave; valve small and triangular; plates about half as wide basally as last ventral segment, sinuately tapering to acute upturned apices, margined with stout spines; pygofers broad, much exceeding plates, separated ventrally at apex and covered with stout spines.

Distribution: Seemingly more abundant than preceding species. Specimens have been taken in Cherokee, Douglas, McPherson and Pottawatomie counties.

Hosts: Taken on grasses in rather open woods.

Genus PARABOLOCRATUS Fieb.

The members of this genus differ from the preceding genera of the *Dorydiaria* in not having foliaceous heads, which instead are parabolic in outline in the female, produced angularly, and in the male, wider than long. They are uniformly greenish or yellowish-green species, with both brachypterous and macropterous females and macropterous males.

Three of the North American species should occur in the state, two of which have been collected here.

KEY TO SPECIES.

A. Female vertex broadly rounded; male vertex with thin margins often lined with black beneath. *viridis.*

AA. Female vertex more or less angulate; male vertex with thicker margins and never lined with black beneath.

- B. Female vertex thin-margined; males yellowish-green, over 5 mm. in length. *flavidus.*
- BB. Female vertex thick margined; male brownish-green, less than 4 mm. in length. *brunneus.*

Parabolocratus viridis (Uhl.).

Glossocratus viridis Uhl., Bul. U. S. Geol. Geog. Surv., iii, p. 462, 1877.

Gypona reverta (Uhler MS.), Hayden's Surv. Tenn., Rept. for 1870, p. 472, 1872.

Parabolocratus viridis Sign., Ann. Soc. Ent. Fr., ser. 5, ix, p. 275, pl. 8, fig. 30, 1879.

Selenocephalus cyperacæ (Fitch MS.) Sign., Ann. Soc. Ent. Fr., ser. 5, ix, pp. 88, 275, 1879.

Parabolocratus viridis Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 175, 1892.

Parabolocratus viridis G. & B., Hemip. Colo., p. 84, 1895.

Parabolocratus viridis O. & B., Proc. Ia. Acad. Sci., iv, p. 189, pl. 21, fig. 1, 1897.

Parabolocratus viridis Ball, Rept. Ia. Acad. Sci. for 1899, p. 71, 1900.

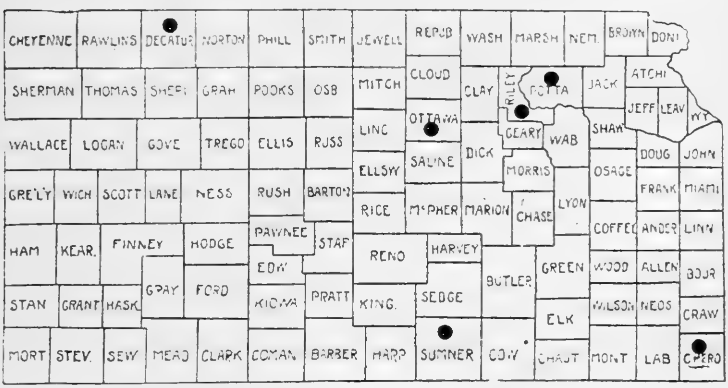
Parabolocratus viridis Osb., 20th Rept. N. Y. St. Ent., p. 515, 1905.
Parabolocratus viridis Gibs., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 68, fig. 8, 1912.
Parabolocratus viridis DeL., Tenn. St. Bd. Ent., Bul. 17, p. 37. 1916.
Parabolocratus viridis Van D., Cat. Hemip. N. A., p. 625, 1917.

Form: The largest of the members of this genus. Length, females, 6 to 8.25 mm.; males, 5 to 6 mm. Vertex of female broadly rounding, thin-margined, two-thirds as long as width between eyes. Vertex of male distinctly angular, thin-margined, about two-thirds as wide as long. Pronotum over twice as broad as long, lateral margins long and parallel, humeral margins distinct, posterior margin emarginate. Scutellum large and broad. Elytra of female either short and broad, exposing last two segments of abdomen, or long and narrower, just showing ovipositor, apically broadly rounded. Elytra of male long and narrow, exceeding abdomen.

Color: Yellowish-green, with nervures of elytra a bright green. Vertex of male often with black line under margin.

External genitalia: Female, last ventral segment longer than preceding, lateral margins parallel, posterior margin rounded, with sometimes a wide but very short lobe on median third; pygofers tapering acutely, exceeded by ovipositor. Male, last ventral segment longer than preceding, widest posteriorly; valve small and triangular; plates wide basally, tapering suddenly at basal third and then evenly to long acute tips, median half of lateral margins with coarse spines; pygofers broad, separated ventrally at the apices, exceeding the plates and covered with spines.

Distribution: Found throughout the northern and eastern portions of the state as shown by the following map:



Hosts: A grass feeder. Taken by the writer on coarse grasses on low land.

Parabolocratus flavidus Sign.

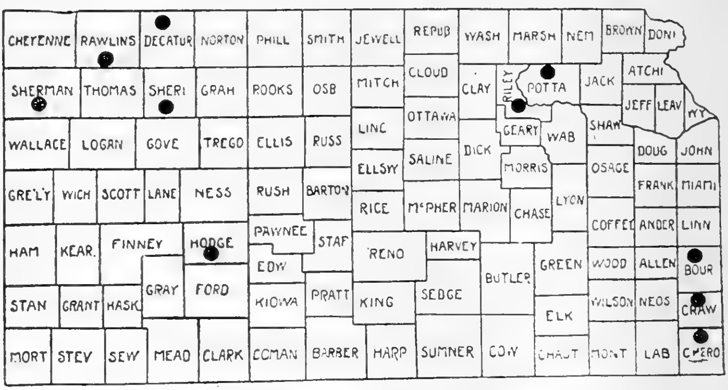
Parabolocratus flavidus Sign., Ann. Soc. Ent. Fr., ser. 5, ix, p. 276, pl. 8, fig. 31, 1879.
Parabolocratus flavidus Ball, Rept. Ia. Acad. Sci. for 1899, p. 71, 1900.
Parabolocratus flavidus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 37, 1916.
Parabolocratus flavidus Van D., Cat. Hemip. N. A., p. 625, 1919.
Parabolocratus flavidus Fent., Ohio Jl. Sci., xviii, No. 6, p. 183, 1918.
Parabolocratus flavidus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 48, 1919.

Form: Somewhat narrower than *viridis*. Length, 5 to 6.25 mm. Vertex in both sexes distinctly angularly produced, about three-fourths as long as wide, concave, margins rather sharp. Pronotum characteristic of the genus. Elytra long, exceeding the abdomen, frequently a black spot at tip of clavus and another at tip of inner apical cell.

Color: Yellowish-green. Elytra with greenish nervures and frequently with brownish apices. Tip of ovipositor reddish.

External genitalia: Female, last ventral segment very long, posterior margin roundingly produced; pygofers short, much exceeded by the spiny-tipped ovipositor. Male, valve very small, triangular; plates broad at base, spiny, lateral margins concavely tapering to long acute tips; pygofers much exceeding plates and thickly covered with long spines.

Distribution: Fairly common over the state, as shown by the following map:



Hosts: Taken on coarse grasses on low land.

Parabolocratus brunneus Ball.

Parabolocratus brunneus Ball., Rept. Ia. Acad. Sci. for 1899, p. 71, 1900.
Parabolocratus brunneus Van D., Hemip. N. A., p. 626, 1917.

Form: Smaller than other members of the genus. Length, female, 6 mm.; male, 3.5 to 4 mm. Vertex relatively shorter than in preceding species, but in both sexes the margin is quite thick. The elytra may either reach the last ventral abdominal segment, or, in some females, cover about two-thirds of the abdomen, the nervures always distinct.

Color: Female, pale green, nervures of elytra greenish, ovipositor tipped with red. Male, pale green, most of pronotum and elytra brownish, nervures of elytra darker brown.

External genitalia: Female, last ventral segment twice as long as preceding, posterior margin truncate, with a very small median lobe; pygofers longer than in *flavidus* but much exceeded by the ovipositor. Male, valve very small, triangular; plates tapering suddenly near base and then extending into long and slender apical processes, margins bearing a few spines; pygofers long, bearing many long brown spines.

Distribution: This species has not yet been reported from Kansas but should be taken in the western part of the state.

Hosts: Doctor Ball described this species from specimens taken from *Distichlis maritima.*

Genus DICYPHONIA Ball.

In this genus the head is as long or slightly longer than the width between the eyes. The vertex is narrower than in *Parabolocratus,* the apex obtusely rounding in the female, rather acute in the male, the disc concave, and the margins sharp. The pronotum is about twice as wide as long, broadly rounding in front, emarginate posteriorly, and with long lateral margins. The elytra are short in the female, long in the male. The genus includes brownish forms, due to ramose pigmentation.

The single species belonging to this genus occurs in Kansas.

Dicyphonia ornata (Bak.).

Platymetopius ornatus Bak., Can. Ent., xxxii, p. 49, 1900.
Dicyphonia ramentosa Ball, Rept. Ia. Acad. Sci. for 1899, p. 69, pl. 5, figs. 1-5, 1900.
Dicyphonia ornata Van D., Cat. Hemip. N. A., p. 626, 1917.

Form: Females large and robust. Length, 6.25 to 7 mm. Males smaller, like *Platymetopius* in general appearance. Length, 4 mm. Female, vertex long and narrow, longer than wide, obtusely-rounding apically, anterior margin elevated, disc concave. Pronotum over twice as wide as long. Elytra either covering abdomen entirely or only half way. Male, vertex a little longer than wide, more pointed than in female, elytra always completely covering abdomen, strongly flaring apically.

Color: Female, creamy yellow, vertex with a broad, irregular brown band which extends on to the pronotum and scutellum. These also have brown markings laterally, and the elytra show ramose, brown markings. Exposed portion of abdomen striped with brown. Males either like female except for dark brown apices of elytra, or, more usually, with all the markings much darker and heavier, giving the insect a dark brown or black appearance with triangular light markings, most conspicuous of which are three large costal and several smaller hyaline spots on the apical half of the elytra.

External genitalia: Female, last ventral segment twice as long as the preceding, posterior margin truncate except for small median projection; pygofers short, bearing a very few spines, much exceeded by the very long ovipositor. Male, valve hidden by last ventral segment; plates together about half as wide as last ventral segment, sinuately narrowed laterally to long, acute apices; pygofers together forming a triangle a little wider than long, bearing a few long spines.

Distribution: Occurs in western Kansas. Specimens have been taken in Decatur and Greeley counties.

Hosts: Doctor Ball gives *Sporobolus cryptandrus* as the host.

Genus SCAPHOIDEUS Uhl.

Prof. Herbert Osborn states that the most important characters of this genus are "the deeply sinuate occiput, the long antennæ, the large loræ, approximate to margin of cheeks (except in *sanctus* group), the narrow vertex, the width and length of which are usually about equal, and the recurved nodal or costal veins. The clypeus is usually widened at tip, and for the more typical members of the genus the outer anteapical cell is narrowed behind, becoming pointed, and, in some species, stylate."

Of the nine species keyed below, six have been taken and the other three should occur in the state.

KEY TO SPECIES.*

A. Loræ remote from the margin of the cheeks; common elytral picture cruciate; claval vein straight, meeting suture at acute angle. *sanctus.*

AA. Loræ contiguous to or merging with border of cheeks; elytral picture not cruciate, outer claval vein curved or hooked at the distal end.

- B. Postnodal cell scarcely widened distally.
  - C. Nodal vein arising from discal cell, transverse orange band on vertex and a black one just before. *auronitens.*
  - CC. Nodal vein arising from anteapical cell.
    - D. Vertex flat with transverse impressed line. *jucundus.*
    - DD. Vertex convex, without impressed line. *scalaris.*
- BB. Postnodal cell much widened distally.
  - C. Outer claval not strongly hooked at distal end, cross nervure to claval suture indistinct or wanting.
    - D. Outer claval sinuate, approaching inner near its middle, marked with fuscous. *productus.*
    - DD. Outer claval nearly straight and parallel to inner, curved at tip. *intricatus.*

* Adapted from key by Professor Osborn, Ohio Nat., xi, p. 250, 1910.

AA. Loræ contiguous—*concluded.*

CC. Outer claval strongly hooked at distal end, usually with distinct cross nervure from outer claval to claval suture.

D. No distinct cross veins between claval veins. *immistus.*

DD. A distinct cross vein between claval veins.

E. Outer claval approximating claval suture posteriorly, face blaek. *melanotus.*

EE. Outer claval remote from claval suture posteriorly, elytra entirely gray. *cinerosus.*

Scaphoideus sanctus (Say).

Jassus sanctus Say, Jl. Acad. Nat. Sci. Phila., vi, p. 307, 1831; Compl. Writ., ii, p. 383.
Scaphoideus picturatus Osb., Proc. Ia. Acad. Sci., v, p. 243, 1898.
Scaphoideus picturatus Osb., Jl. Cinc. Soc. Nat. Hist., xix, p. 193, 1900.
Scaphoideus sanctus Osb., Ohio Nat., xi, p. 251, 1910.
Scaphoideus sanctus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 55, 1916.
Scaphoideus sanctus Van D., Cat. Hemip. N. A., p. 629, 1917.

Form: Length, 4 to 5 mm. Vertex slightly shorter than width between the eyes, quite angulate. Pronotum about twice as wide as long, anterior margin convex, posterior margin truncate or slightly concave, lateral margins very short, humeral margins long. Elytra long, much exceeding the abdomen.

Color: Vertex whitish or yellowish with two small brown spots near apex, one back of each ocellus, and with a brown median line. Pronotum yellowish-brown except for white rectangular spot on disc, the posterior half darker. Scutellum yellow. Elytra white, with large brown cruciform mark on middle, the arms enclosing a white spot and extending to the costal margin; apical third irregularly marked with brown spots.

External genitalia: Female, last ventral segment twice as long as preceding, posterior margin with large, long, lateral lobes between which is a pair of shorter lobes separated by a median notch; pygofers long and narrow, widest at the middle, with spines on posterior two-thirds, slightly exceeded by ovipositor. Male, valve large, posterior margin roundingly produced; plates wide and long, exceeding pygofers, spined laterally and tapering to obtuse apices, each with a black disc basally; pygofers spiny and short.

Distribution: Not yet reported from the state, but should be taken in the eastern part.

Hosts: De Long reports taking specimens from wild rose.

Scaphoideus auronitens Prov.

Jassus areatus (Harris MS.) in Hitchcock, Geol. Mass., edn. 2, p. 580, 1835.
Scaphoideus auronitens Prov., Pet. Faune Ent. Can., iii, p. 277, 1889.
Scaphoideus auronitens Osb., Jl. Cinc. Soc. Nat. Hist., xix, p. 194, 1900.
Scaphoideus auronitens Osb., 20th Rept. N. Y. St. Ent., p. 524, 1905.
Scaphoideus auronitens Osb., Ohio Nat., xi, p. 254, 1910.
Scaphoideus auronitens Osb., Me. Agr. Exp. Sta., Bul. 238, p. 115, 1915.
Scaphoideus auronitens DeL., Tenn. St. Bd. Ent., Bul. 17, p. 56, 1916.
Scaphoideus auronitens Van D., Hemip. N. A., p. 630, 1917.
Scaphoideus auronitens Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 66, 1919.

Form: Length, 4.5 to 5.75 mm. Vertex wider than long, not as pointed apically as in *sanctus*. Pronotum about twice as wide as long, quite convex anteriorly, slightly concave posteriorly, lateral margins long, about the length of the humeral margins; elytra long, nodal vein arising from the discal cell, postnodal cell scarcely widened distally.

Color: Vertex yellowish-white with very characteristic broad orange band across middle in front of which is a short black band, and also a larger one parallel with the anterior margin. Pronotum with orange band on anterior margin and a fainter one on the posterior half, parallel to the posterior margin. Scutellum with the basal angles dull orange, the disc darkened medially. Elytra brownish, nervures darker, three spots on clavus along median suture, black.

External genitalia: Female, last ventral segment nearly four times as long as preceding one, cleft by broad excision, reaching nearly to the base, into two large rounding lateral lobes; the spiny pygofers are long and narrow, exceeded slightly by the ovipositor. Male, valve broad and short, truncate posteriorly, or with very small median tooth; plates large and broad, obtuse apically and with an impressed line parallel to the lateral margin which is covered with long silky hairs; long, membranous and hairy tail-like structures terminate the plates; spiny pygofers long and narrow, much exceeding plates.

Distribution: Taken in Douglas, Pottawatomie and Riley counties.

Hosts: Professor Osborn gives *Geranium Robertianum* as a host. De Long reports taking it on canebrake.

Scaphoideus jucundus Uhl.

Scaphoideus jucundus Uhl., Trans. Md. Acad. Sci., i, p. 34. 1889.
Scaphoideus jucundus Osb., Jl. Cinc. Soc. Nat. Hist., xix, p. 195, 1900.
Scaphoideus jucundus Osb., 20th Rept. N. Y. St. Ent., p. 524, 1905.
Scaphoideus jucundus Osb., Ohio Nat., xi, p. 254, 1910.
Scaphoideus jucundus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 114, 1915.
Scaphoideus jucundus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 56, 1916.
Scaphoideus jucundus Van D., Hemip. N. A., p. 630, 1917.
Scaphoideus jucundus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 68, 1919.

Form: Larger than preceding species. Length, 5 to 6 mm. Vertex wider than long, flat, with transverse impressed line, roundingly angled anteriorly. Pronotum twice as broad as long, lateral margins long, anteriorly convex, posteriorly slightly concave. Elytra long and somewhat flaring posteriorly, nodal vein arising from discal cell, postnodal cell scarcely widened posteriorly.

Color: Orange-yellow marked with white. Vertex with median line, six spots near anterior margin of pronotum, two spots on sides, apex and two lines on disc of scutellum and several spots on elytra, white.

External genitalia: Female, last ventral segment over twice as long as preceding one, posterior margin rounded and medially produced; pygofers long and narrow, slightly exceeded by ovipositor, spiny on posterior half. Male, valve triangular, narrow but long; plates long, somewhat fine haired, truncate tips bearing membranous tails which are much shorter than in *auronitens*, lateral margins spined; pygofers long and narrow, much exceeding plates, spiny on posterior half.

Distribution: This species though not yet taken in the state, should occur in the eastern portion.

Hosts: De Long reports it on oak.

Scaphoideus scalaris Van D.

Scaphoideus scalaris Van D., Ent. Am., vi, p. 51, 1890.
Scaphoideus scalaris Osb., Jl. Cinc. Soc. Nat. Hist., xix, p. 198, 1900.
Scaphoideus scalaris Osb., 20th Rept. N. Y. St. Ent., p. 523, 1905.
Scaphoideus scalaris Osb., Ohio Nat., ix, p. 464, 1909; xi, p. 255, 1910.
Scaphoideus scalaris Osb., Me. Agr. Exp. Sta., Bul. 238, p. 114, 1915.
Scaphoideus scalaris DeL., Tenn. St. Bd. Ent., Bul. 17. p. 56, 1916.
Scaphoideus scalaris Van D., Cat. Hemip. N. A., p. 631, 1917.
Scaphoideus scalaris Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 67, 1919.

Form: Length, 5 to 5.5 mm. Vertex as long as wide, quite angulate anteriorly. Pronotum with anterior margin very convex, posterior margin slightly concave. Elytra much exceeding abdomen, nodal vein rising from anteapical cell, postnodal cell scarcely widened distally.

Color: Grayish-brown. Vertex light, marked with brown lines, median spot near apex, preapical marginal lines and ocelli appearing white, as does the portion between the brown lines on the basal portion. Pronotum having mottled appearance. Scutellum frequently appearing to have six light spots. Elytra with three very characteristic light spots on claval suture, nervures dark.

External genitalia: Female, last ventral segment three times as long as preceding, lateral angles broadly rounding to nearly truncate, slightly excised posterior margin; pygofers long, widest near middle, spiny on distal half, slightly exceeded by ovipositor. Male, valve small, broadly triangular; plates wide and short, slightly haired marginally, about half as long as spiny pygofers and tipped with membranous tails reaching to tips of pygofers.

Distribution: Taken in Douglas and Pottawatomie counties.

Hosts: Osborn records a single specimen from Maine "on blueberry." It of course has some other host in Kansas.

Scaphoideus productus Osb.

Scaphoideus productus Osb., Jl. Cinc. Soc. Nat. Hist., xix, p. 200, 1900.
Scaphoideus productus Osb., Ohio Nat., xi, p. 258, 1910.
Scaphoideus productus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 115, 1915.
Scaphoideus productus Van D., Cat. Hemip. N. A., p. 632, 1917.
Scaphoideus productus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 68, 1919.

Form: Larger than preceding species. Length, 5.5 to 6 mm. Vertex nearly as long as wide, disc flat, apex acutely pointed. Pronotum more than twice as wide as long, anterior margin convex, posterior margin slightly concave, lateral margins slightly longer than humeral. Elytra with postnodal cell much widened distally, outer claval not strongly hooked at distal end and approaching inner claval near its middle.

Color: Vertex yellowish-white, with a broad brown band which is produced medially to meet a darker marginal band. Pronotum and scutellum whitish, irregularly marked with brown. Elytra whitish with fuscous patches and dark nervures, giving them a general brown appearance.

External genitalia: Female, last ventral segment over twice as long as preceding, lateral angles rounded, posterior margin produced medially and with a small median notch; pygofers long, slightly exceeded by ovipositor, bearing bunches of spines at middle and near apex. Male, valve short; plates broad and short, obliquely truncate, less than half the length of the long, somewhat spiny pygofers.

Distribution: Taken in Cherokee and Pottawatomie counties.

Hosts: Osborn reports sweeping specimens from blueberry in Maine. Kansas host unknown.

Scaphoideus intricatus Uhl.

Scaphoideus intricatus Uhl., Trans. Md. Acad. Sci., i, p. 34, 1889.
Scaphoideus intricatus Osb., Jl. Cinc. Soc. Nat. Hist., xix, p. 202, 1900.
Scaphoideus intricatus Osb., 20th Rept. N. Y. St. Ent., p. 525, 1905.
Scaphoideus intricatus Osb., Ohio Nat., xi, p. 258, 1910.
Scaphoideus intricatus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 58, 1916.
Scaphoideus intricatus Van D., Cat. Hemip. N. A., p. 632, 1917.

Form: Length, 4.75 to 6 mm. Vertex slightly longer than wide, flat, acutely pointed. Pronotum short, humeral margins long. Elytra with postnodal cell widened distally, outer claval nearly straight and parallel to inner.

Color: Vertex, pronotum and scutellum yellowish-white. Vertex with brown marginal and an irregular transverse band. Pronotum with large median brown band on anterior margin and two large brown ones on posterior margin. Scutellum with three basal brown spots. Elytra whitish or hyaline with brown spots and dark brown nervures, with three white spots on clavus along suture.

External genitalia: Female, last ventral segment nearly twice as long as preceding, truncate posteriorly, very slightly produced medially; pygofers long and narrow, nearly equalling ovipositor, a patch of brown bristles near the apex and whitish scattered bristles near the middle. Male, valve broad and roundingly angulate posteriorly; plates broad and long, nearly equalling pygofers, margined with a few silky hairs; pygofers with tuft of black bristles near apex.

Distribution: Taken in Pottawatomie county only.

Hosts: De Long has swept specimens from weeds. Professor Osborn mentions clover, *Cornus*, grape and *Cratægus* as host plants.

Scaphoideus immistus (Say).

(Pl. 11, figs. 1-2.)

Jassus immistus Say, Jl. Acad. Nat. Sci. Phila., vi, p. 306, 1831; Compl. Writ., ii, p. 382.
Scaphoideus immistus Uhl., Trans. Md. Acad. Sci., i, p. 33, 1889.
Scaphoideus immistus G. & B., Hemip. Colo., p. 94, 1895.
Scaphoideus immistus Osb., Jl. Cinc. Soc. Nat. Hist., xix, p. 204, 1900.
Scaphoideus immistus Osb. 20th Rept. N. Y. St. Ent., p. 525, 1905.
Scaphoideus immistus Osb., Ohio Nat., xi, p. 259, 1910.
Scaphoideus immistus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 116, 1915.
Scaphoideus immistus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 58, 1916.
Scaphoideus immistus Van D., Cat. Hemip. N. A., p. 632, 1917.
Scaphoideus immistus Fent., Ohio Jl. Sci., xviii, No. 6, p. 183, 1918.
Scaphoideus immistus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 69, 1919.

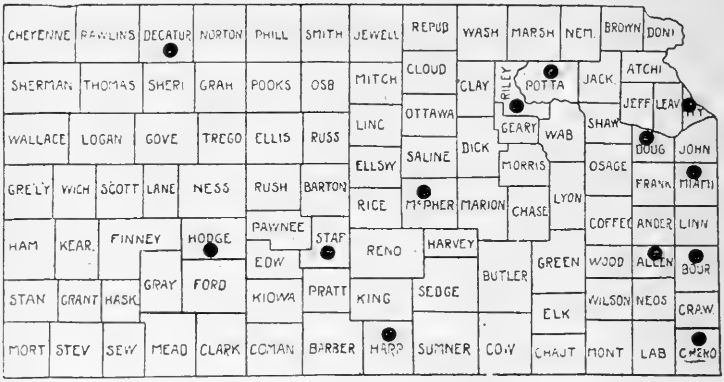
Form: Length, 4.75 to 6 mm. Vertex about as long as broad, flat, somewhat obtusely angled. Pronotum with anterior margin produced medially, twice as wide as long. Elytra with postnodal cell widened distally, with two to four oblique reflexed veins from outer anteapical cell to costal margin and with no distinct cross veins between claval veins.

Color: Vertex white with narrow black or brown marginal line and a broad, transverse, brown band with a median tooth. Face white, two black lines on upper part. Pronotum brown with faint whitish transverse band in front of middle. Scutellum white, with three fuscous bands, the apical half usually light. Elytra brown with darker nervures and scattered white spots, of which usually two are on the clavus along suture.

External genitalia: Female, last ventral segment twice as long as preceding, posterior margin somewhat produced, black, and often slightly notched medially; pygofers long and narrow, bearing a few scattered bristles till near the apex, where each bears two tufts of long black bristles; ovipositor exceeding the pygofers. Male, valve short, plates broad but short, obtusely pointed, spiny margined, much exceeded by the long pygofers, each of which bears two bunches of long, black bristles preapically.

Internal male genitalia: Styles short, with long process for attachment to connective equalling anterior end, a rounding lobe laterally past middle, terminating in an acute, outwardly curved apex; connective Y-shaped, the arms very short and curved, the stem long and thickened basally; œdagus with a short, thick, knobbed process for attachment to anal tube and two long obtusely pointed caudal processes.

Distribution: Our commonest member of the genus, well distributed over the state as shown by the following map:



Hosts: Van Duzee reports it on witch hazel. Professor Osborn gives willow as a host. This is its food in Kansas. It is frequently taken at lights.

Scaphoideus melanotus Osb.

Scaphoideus melanotus Osb., Jl. Cinc. Soc. Nat. Hist., xix, p. 206, 1900.
Scaphoideus melanotus Wirtn., Ann. Carn. Mus., iii, p. 224, 1904.
Scaphoideus melanotus Osb., Ohio Nat., xi, p. 259, 1910.
Scaphoideus melanotus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 59, 1916.
Scaphoideus melanotus Van D., Cat. Hemip. N. A., p. 633, 1917.

Form: Length, 5 to 5.25 mm. Vertex about as long as basal width, flat or slightly concave, apex obtuse. Pronotum over twice as broad as long, anterior margin strongly convex, posterior slightly concave, lateral margins short. Elytra with postnodal cell much widened distally, a distinct cross vein between clavals and the outer claval approximating claval suture posteriorly.

Color: Vertex white, with narrow brown marginal band, heavier brown transverse band which is produced medially, and a black border on posterior margin medially. Face black. Pronotum white with light brown anterior band and broken posterior band, with large dark brown spots laterally. Scutellum white with three large light brown basal spots and two small black preapical ones. Elytra brown with three large white spots along suture and others irregularly placed.

External genitalia: Female, last ventral segment over twice as long as preceding, posterior portion black, posterior margin produced, with narrow but distinct median notch; pygofers widest at the middle, much exceeded by ovipositor, sparsely bristled except for two preapical tufts. Male, valve barely visible from under broad and long last ventral segment; plates a little over half as long as pygofers, scarcely tapering to obtuse, separated apices, with few marginal bristles; pygofers long and slender, sparsely bristled.

Distribution: Taken in Douglas, Cherokee and Pottawatomie counties.

Hosts: Unknown.

Scaphoideus cinerosus Osb.

Scaphoideus cinerosus Osb., Jl. Cinc. Soc. Nat. Hist., xix, p. 525, 1905.
Scaphoideus cinerosus Osb., Ohio Nat., xi, p. 259, 1910.
Scaphoideus cinerosus Van D., Cat. Hemip. N. A., p. 633, 1917.

Form: Length, 4 to 4.5 mm. Vertex nearly as long as basal width, disc flat, apex rather acute. Pronotum about twice as wide as long. Anterior margin quite convex, posterior margin slightly concave, lateral margins rather short, humeral margins longer. Elytra with outer claval strongly hooked at distal end, and with cross veins to inner claval and claval suture, and not approximating claval suture posteriorly.

Color: Light ashy-gray. Vertex white with narrow black marginal line and a brown transverse line between the anterior margin of the eyes. Pronotum light gray, marked with brown on anterior margin and several brown spots along posterior margin. Scutellum white, with three broad brown stripes and two black spots on each lateral margin. Elytra whitish with dark brown nervures and several cells spotted or irrorate with the same color.

External genitalia: Female, last ventral segment over twice as long as preceding, posterior margin black medially, roundingly and medially produced and with a small median notch; pygofers long and narrow, exceeded by ovipositor, with scattered bristles and two tufts on each side near the apex.

Distribution: Taken in Pottawatomie county only.

Hosts: Unknown.

Genus Platymetopius Burm.

This genus is characterized by its long pointed vertex, narrow front, and characteristic venation. The elytra have three anteapical and five apical cells, two cross veins between the first and second sectors, and eight to ten oblique veins in the costal cell. They are also marked with fine brown pigment lines, and the cells, especially the anteapical and apical, may contain oval white spots.

Only five species of this genus have been taken in Kansas.

KEY TO SPECIES.*

A. Vertex flat, not channeled toward its apex, anterior margin rounding to the front; elytra without white areolar spots. *dorsalis.*

AA. Vertex more or less channeled toward the apex, anterior edge thin, acute or subacute.

B. Face pale or yellow, usually infuscated at base and sides.

C. Markings of vertex in the form of lineations, usually a pale median line and a faint, slightly divergent one either side.

D. Face distinctly infuscated at sides; elytral markings distinct; length, 5 mm. *acutus.*

DD. Face obscurely infuscated at sides; elytral markings indistinct; length, 4 mm. or less. *cinereus.*

CC. Markings of vertex in form of a broken transverse vitta, median line short and apical. *frontalis.*

BB. Face entirely brown or fuscous. *scriptus.*

Platymetopius dorsalis Ball.

Platymetopius frontalis var. dorsalis Ball, Ent. News, xx, p. 164, 1909.
Platymetopius dorsalis Van D., Ann. Ent. Soc. Am., iii, p. 224, 1910.
Platymetopius dorsalis Van D., Cat. Hemip. N. A., p. 637, 1917.

Form: Length, 4 mm. Vertex three-fourths as wide as long, flat, not channeled toward the apex, margins rounding. Pronotum nearly three times as wide as long, anterior margin convex, posterior margin slightly concave, lateral margins short, humeral margins long. Elytra broad and exceeding the abdomen.

Color: Yellow and fulvous; vertex creamy yellow, pronotum bright brown or fulvous with sides yellow, scutellum yellow, elytra bright fulvous with distal half of clavus and apices lighter. Face and below pale yellow.

External genitalia: Female, last ventral segment long, posterior margin roundingly and medially produced; sparsely spined pygofers are long and narrow, slightly exceeded by the ovipositor.

Distribution: The only specimens of this species taken are the type specimens from Pottawatomie county.

Platymetopius acutus (Say.).

(Pl. II, figs. 5-7.)

Jassus acutus Say, Jl. Acad. Nat. Sci., Phila., vi, p. 306, 1831; Compl. Writ., ii, p. 382.
Platymetopius acutus Uhl., Bul. U. S. Geol. Surv., iii, p. 473, 1877.
Platymetopius acutus Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 126, 1892.
Platymetopius acutus G. & B., Hemip. Colo., p. 84, 1895.
Platymetopius acutus O. & B., Proc. Ia. Acad. Sci., iv, p. 192, 1897.
Platymetopius acutus Van D., Ann. Ent. Soc. Am., iii, p. 219, 1910.

* Adapted from key by Van Duzee, Ann. Ent. Soc. Am., iii, p. 216, 1910.

Platymetopius acutus Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 69, fig. 9, 1912.
Platymetopius acutus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 111, 1915.
Platymetopius acutus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 39, 1916.
Platymetopius acutus Van D., Cat. Hemip. N. A., p. 635, 1917.
Platymetopius acutus Fent., Ohio Jl. Sci., xviii, No. 6, p. 183, 1918.
Platymetopius acutus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 53, 1919.

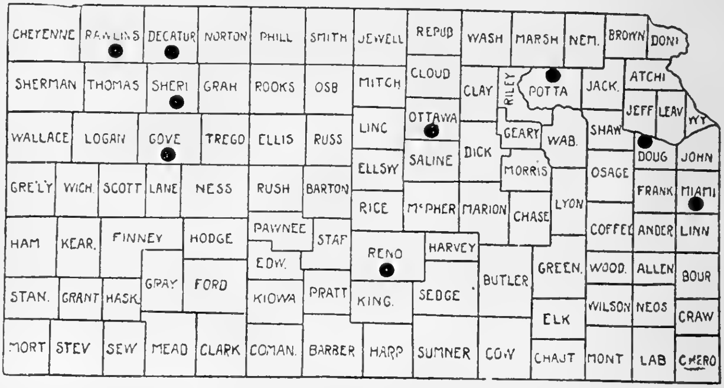
Form: Length, 4.5 to 5 mm. Vertex of male distinctly longer than width between the eyes, in female almost half longer than basal width. Pronotum twice as broad as long, anterior margin quite convex, posterior margin slightly concave, humeral margins longer than lateral margins. Elytra wide, exceeding abdomen.

Color: Vertex yellowish, irrorate with brown, an indistinct line near each eye, a pair on the disc, one on apical third, and four spots on posterior margin, whitish or yellowish. Pronotum brown, with five white longitudinal stripes. Scutellum brown, with two whitish longitudinal stripes. Elytra light brown with dark ramose lines and spots and distinct round or oval milky white spots. Face yellow, infuscated on base of front and outer portions of cheeks, former with broad, white, angular line which continues behind the eyes. Beneath black, marked with whitish.

External genitalia: Female, last ventral segment long, sinuate, narrowed posteriorly, lateral and posterior margins forming regular curve; pygofers long and narrow, scarcely exceeding ovipositor, sparsely bristled. Male, last ventral segment very short; valve very large, nearly as long as wide, broadly and obtusely angled posteriorly; plates long, nearly equalling sparsely bristled pygofers, widening after leaving base, then tapering regularly to subacute apices, lateral margins spiny.

Internal male genitalia: Styles broad basally, with large process for attachment to connective, terminating in a finger-like inner process about half the width of the middle portion; connective very characteristic of the genus, consisting of a broad, short-armed U-shaped piece from which there extend out, separated by a small process, two long styles which each curve entirely around the œdagus and extend far beyond it, ending in a somewhat flattened and then acutely pointed apex; œdagus viewed from the side is V-shaped, with two processes directed caudad for attachment to base of anal tube, the œdagus proper being a gently curving, obtusely pointed organ with its surface roughened or serrated, directed dorso-caudad.

Distribution: Occurs throughout the state, though more abundant in northern part as shown by the following map:



Hosts: Taken usually on grasses on which it seems to be a general feeder.

Platymetopius cinereus O. & B.

(Pl. II, figs. 3-4.)

Platymetopius cinereus O. & B., Proc. Ia. Acad. Sci., iv, p. 193, pl. 26, fig. 1, 1897.
Platymetopius cinereus Van D., Ann. Ent. Soc. Am., iii, p. 223, 1910.
Platymetopius cinereus Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 72, 1912.
Platymetopius cinereus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 39, 1916.
Platymetopius cinereus Van D., Cat. Hemip. N. A., p. 637, 1917.
Platymetopius cinereus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 56, 1919.

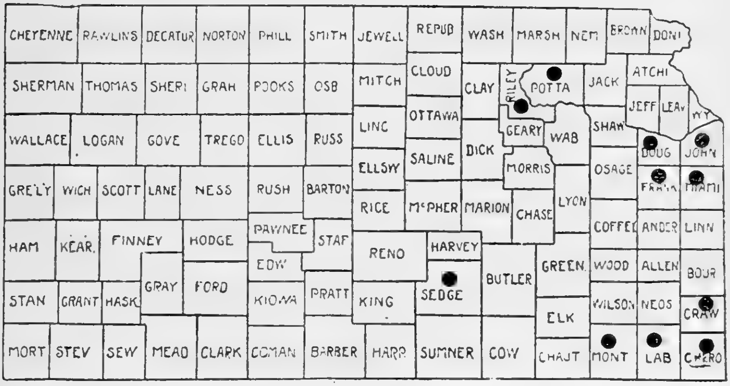
Form: Smallest member of genus in Kansas. Length, 3.5 to 4 mm. Vertex of female three-fifths as wide as long, in male nearly as wide as long. Pronotum characteristic of the genus, lateral margins short. Scutellum large. Elytra long and broad.

Color: Cinereous; vertex yellowish, irrorate with brown, with light lines on disc and median line on apical third. Pronotum of same color with five faint longitudinal lines. Scutellum yellowish, with basal and apical angles darker. Elytra light or hyaline with brown irrorations and with whitish hyaline spots, costal and apical veins black, especially in the male.

External genitalia: Female, last ventral segment long, narrowed posteriorly, posterior margin medially produced and with a slight median notch; pygofers long, widest at the middle, slightly exceeded by ovipositor. Male, posterior margin of last ventral segment obtusely and angularly incised; valve large, obtusely rounded at apex, over half the length of the spiny-margined and obtusely pointed plates; pygofers spiny, acute at apex, slightly exceeding plates.

Internal male genitalia: Styles much as in *acutus*, but differing in small details, especially the relatively longer terminal finger and the angle it makes with the rest of the style; connective in the shape of a flat "W" with all the bends rounded, distinctly flatter and smaller than in *acutus*, and with two long curling processes, flattened for a much longer distance than in *acutus* and ending in a sharp point; œdagus, viewed laterally, U-shaped with anterior arm straight and posterior curved, former extending beyond curve of U to form a short stem.

Distribution: Common in the eastern portion of the state as shown by the following map:



Hosts: Osborn and Ball give *Bouteloua* as the probable host. De Long reports it on "various grasses."

Platymetopius frontalis Van D.

(Pl. II, figs. 8-9.)

Platymetopius frontalis Van D., Can. Ent., xxii, p. 112, 1890.
Platymetopius frontalis Van D., Bul. Buf. Soc. Nat. Sci., v, p. 198, 1894.
Platymetopius frontalis O. & B., Proc. Ia. Acad. Sci., iv, p. 193, 1897.
Platymetopius frontalis Osb., 20th Rept. N. Y. St. Ent., p. 517, 1905.
Platymetopius frontalis Van D., Ann. Ent. Soc. Am., iii, p. 225, 1910.
Platymetopius frontalis Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 71, fig. 10, 1912
Platymetopius frontalis Osb., Me. Agr. Exp. Sta., Bul. 238, p. 113, 1915.
Platymetopius frontalis DeL., Tenn. St. Bd. Ent., Bul. 17, p. 40, 1916.
Platymetopius frontalis Van D., Cat. Hemip. N. A., p. 637, 1917.
Platymetopius frontalis Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 57, 1919.

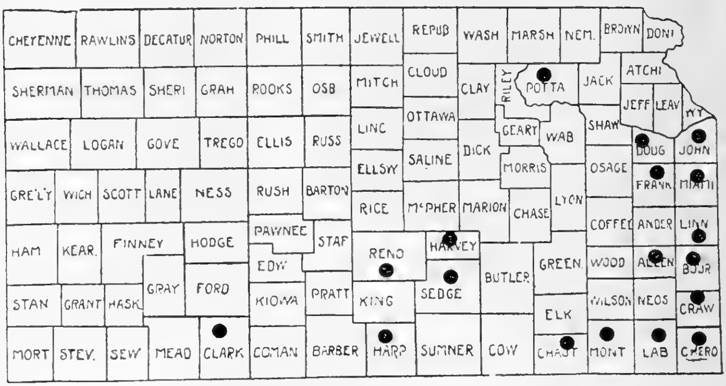
Form: Short and stout. Length, 3.5 to 4 mm. Vertex about one-fourth longer than wide in the male, slightly longer in the female, rather obtusely pointed and with a longitudinal depression. Pronotum obscurely and transversely wrinkled, short, over twice as broad as long.

Color: Dark brown or black; vertex with white apical line, transverse vitta of similar lines in front of the eyes and four basal white spots. Face yellow, infuscated at sides and base, angled line indistinct. Pronotum dark brown, showing five faint longitudinal lines. Scutellum with two faint longitudinal lines and apex white. Elytra with distinct milky white spots, costal area whitish with heavy black veins.

External genitalia: Female, last ventral segment broad, slightly keeled, posterior margin rounding and with a slight median notch; sparsely spined pygofers broad and slightly exceeded by the ovipositor. Male, last ventral segment distinctly and roundingly emarginate; valve large, slightly wider than long, rounded posteriorly; plates, spiny-margined, broad at base, subacute apically, about as long medially as the valve, somewhat exceeded by the spiny pygofers.

Internal male genitalia: Styles larger than in preceding species, broad at base, then of nearly uniform diameter to terminal finger-like process which is relatively long and slender; connective in the form of an arc with a slight median swelling on the inside and two small processes on the convex surface, between which arise two very long, slender and curving processes, which in the specimen dissected did not encircle the œdagus as in the two preceding species; œdagus much as in *cinereus*, but apically broadened rather than tapering and with distinct apical teeth dorsally.

Distribution: Our most abundant member of this genus, though seemingly largely confined to the eastern portion of the state, as shown by the following map:



Hosts: Taken commonly on grasses and weeds.

Platymetopius scriptus Ball.

Platymetopius scriptus Ball, Ent. News, xx, p. 165, 1909.
Platymetopius scriptus Van D., Ann. Ent. Soc. Am., iii, p. 228, 1910.
Platymetopius scriptus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 42, 1916.
Platymetopius scriptus Van D., Cat. Hemip. N. A., p. 638, 1917.

Form: Much like *frontalis.* Length, 3.5 to 4 mm. Vertex slightly longer than basal width, disc slightly convex but with distinct median longitudinal depression. Pronotum over twice as wide as long, anterior margin quite convex, posterior slightly concave, humeral margins nearly twice the length of the lateral. Elytra broad and rather short.

Color: About like *frontalis* except for the dark face. Vertex with three apical white lines and two faint basal and median ones, the latter between a pair of white spots near the apex, and another pair near their base. Face irrorate with brown, with short, light, oblique marginal lines. Pronotum irrorate with brown and with traces of five light, longitudinal lines. Scutellum brown with two large orange spots between which are two broken, white, longitudinal lines, the apex light. Elytra heavily irrorate with brown, costal region lighter, dark nervures usually narrowly light margined, many cells with white spots.

External genitalia: De Long describes the female genitalia as follows: "Last ventral segment of female long, slightly keeled, posterior margin roundingly produced, pygofers constricted near base, broad and rather short." Male, last ventral segment angularly excised posteriorly; valve large, nearly as long as broad, posteriorly roundingly pointed; plates broad basally, median length less than that of the valve, spiny-margined, subacute apically, completely hiding short pygofers.

Distribution: The only Kansas record for this species is that of the five male type specimens taken in Pottawatomie county.

Hosts: De Long records sweeping this species from weeds.

Genus DELTOCEPHALUS Burm.

To this genus belong medium-sized or small species characterized chiefly by the shape of the head in which the vertex is acutely triangular, usually longer than broad, though often wider than long, disc flattened or convex and separated from the front by more or less of a distinct margin. The front is broad and the clypeus is narrowed at the tip. The elytra may be long or short, usually having five anteapical and three apical cells, and two cross nervures between the sectors. All the members of this genus are grass feeders.

Twenty-one species of this genus have been taken in Kansas and five other probable native species are included in the key.

KEY TO SPECIES.*

A. Vertex rather angularly produced, disc flat or concave, definite margin between vertex and front.

  B. Pronotum short, more than twice broader than long, elytra without a distinct appendix.

    C. Elytra moderately long, two outer apical veinlets strongly reflexed, the next one meeting the costa at nearly right angles.

      D. Pronotum with distinct, black, longitudinal lines.

        E. Vertex longitudinally lined or spotted. *bilineatus.*

        EE. Vertex transversely lined before the eyes. *albidus.*

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* Adapted from keys by Osborn & Ball, Proc. Ia. Acad. Sci., iv, p. 198, 1897, and DeLong, Tenn. St. Bd. Ent., Bul. 17, p. 42, 1916.

A. Vertex rather angularly produced—*continued.*

DD. Pronotum cinereous, without distinct black lines.

E. Face usually entirely dark.

F. Vertex without median transverse bars.

G. Elytra with large, black median spot, face entirely black. *areolatus.*

GG. Elytra without black median spot, face sometimes with light spot on apex of front. *imputans.*

FF. Vertex with median transverse bars. *visendus.*

EE. Face dark above, light below.

F. Face fuscous above, shading out below, no sharp line of demarcation; species nearly unicolorous above. *inflatus.*

FF. Face black above, light below, line of demarcation sharp. Species marked with fuscous. *reflexus.*

CC. Elytra shorter, two outer apical veinlets short, at nearly right angles to the costa, third veinlet running distinctly to the posterior margin.

D. Size larger, over 3 mm.; female segment distinctly emarginate, plates of male produced with almost parallel margins. *sayi.*

DD. Size smaller, 3 mm. or less; female segment produced or truncate, plate of male short, rapidly narrowing to acute apices. *misellus.*

BB. Pronotum longer, hardly twice broader than long, elytra long, with appendix, costal veinlets never reflexed.

C. Front with numerous black arcs; central anteapical cell distinctly constricted. *signatifrons.*

CC. Front without black arcs; central anteapical cell not distinctly constricted.

D. Elytra distinctly green.

E. Form slender; length 3 mm. or less.

F. Vertex unlined; female segment black-tipped, medially notched, valve of male large and obtuse. *minimus.*

FF. Vertex with two oblique lines; female segment unicolorous and broadly rounded, male valve smaller and acute. *parvulus.*

EE. Form stouter; length 3.25 mm. or more.

F. Vertex acutely angled, usually longer than broad. *debilis.*

FF. Vertex obtusely angled, as wide as long. *collinus.*

DD. Elytra not distinctly green, hyaline yellowish, or with nervures fuscous margined.

E. Male valve enlarged, inflated, covering all but tips of plates; female segment slightly angularly excavated. *affinis.*

A. Vertex rather angularly produced—*concluded.*

EE. Male valve normal, less than half the length of the plates; female segment produced, more or less notched.

F. Yellow species; male plates not longer than broad. *oculatus.*

FF. Greenish species, marked with fuscous; male plates longer than broad. *sylvestris.*

AA. Vertex short, disc convex or sloping, more or less rounding to front, without well-defined margin.

B. Black species with white points on vertex, costa yellow. *flavicosta.*

BB. Lighter species, marked with black.

C. Clavus reticulated between outer claval vein and suture.

D. Species small, not exceeding 3.5 mm.

E. Vertex acutely produced in the middle; elytra longer than abdomen; male plates convexly pointed. *weedi.*

EE. Vertex more obtusely rounding.

F. Markings dull, elytra usually longer than abdomen. Male plates convexly narrowed; over 3 mm. *obtectus.*

FF. Markings bright, elytra not exceeding abdomen. Male plates concavely narrowed; 2.75 mm. long. *compactus.*

DD. Species larger, 4.5 mm. or over. *inimicus.*

CC. Clavus not reticulated between outer claval vein and suture.

D. Species large, about 5 mm. long. *osborni.*

DD. Species smaller, length 4 mm. or less.

E. Vertex with two large black spots. *punctatus.*

EE. Vertex with four smaller black spots.

F. Broader robust species; face with black arcs. *nigrifrons.*

FF. More slender species; face with light arcs. *sonorus.*

Deltocephalus bilineatus G. & B.

Deltocephalus bilineatus G. & B., Hemip. Colo., p. 85, 1895.
Deltocephalus bilineatus Bak., Psyche, viii, p. 115, 1897.
Deltocephalus bilineatus O. & B., Proc. Ia. Acad. Sci., iv, p. 200, 1897.
Deltocephalus bilineatus Van D., Cat. Hemip. N. A., p. 640, 1917.

Form: Rather long and narrow. Length, 3.5 to 4 mm. Vertex as long as wide, subacute at apex. Pronotum a little over twice as broad as long, anterior margin strongly convex, posterior slightly concave, lateral margins short, humeral margins long. Elytra long and narrow, exceeding abdomen, two outer apical veinlets strongly reflexed.

Color: Ashy or yellowish-white, marked with brown or black. Vertex, pronotum and scutellum with two broad longitudinal bands, a similar oblique pair laterally on pronotum and elytra, just inside the outer claval vein. Vertex white, with brown bands margined with two long black stripes and two short outer ones, also with short median stripe. Pronotum whitish with four brown stripes. Scutellum yellowish to black. Elytra whitish with white nervures margined with brown or black, especially along the suture, apically, and along the reflexed nervures, with some of the cells brownish.

External genitalia: Female, last ventral segment long, narrowed posteriorly, posterior margin deeply and angularly excavated, the sides of the notch slightly sinuate; pygofers narrowed basally, long, and covered, especially on apical half, with long bristles, equalling or only slightly exceeded by the ovipositor. Male, last ventral segment short; valve broad and roundingly produced posteriorly; plates broad, margined with long fine hairs clear to the broad, truncate, black-spotted apices; pygofers acute posteriorly, long-bristled, much exceeding plates.

Distribution: Though not yet taken in Kansas, it should be found in the northern part of the state.

Hosts: Baker took the type specimens from *Carex.*

Deltocephalus albidus O. & B.

Deltocephalus albidus O. & B., Proc. Ia. Acad. Sci., iv, p. 201, pl. 23, fig. 1, 1897.
Deltocephalus albidus Psyche, viii, p. 115, 1897.
Deltocephalus albidus Gibs. & Cog., Ohio Jl. Sci., xvi, p. 75, 1915.
Deltocephalus albidus Van D., Cat. Hemip. N. A., p. 640, 1917.

Form: More robust than *bilineatus.* Length, 4 to 5 mm. Vertex slightly longer than width between the eyes, acute apically. Pronotum a little more than twice as wide as long, convex anteriorly, distinctly concave posteriorly, humeral and posterior margins rounding into each other, lateral margins short. Elytra short or moderately long, flaring, two outer apical veinlets strongly reflexed.

Color: White; vertex with a broken median line, a preapical brown transverse line, and two narrow lines extending from ends of latter to apex. Pronotum with six brown longitudinal stripes, the middle pair extending forward on to vertex and backward across the scutellum. Elytra with sutural and apical margins and reflexed nervures lined with brown and also with two broken brown lines, one on clavus, the other extending from the humeral angle to the middle. Tergum with two pairs of stripes, the outer pair meeting in a V on the pygofers.

External genitalia: Female, last ventral segment twice as long as preceding, much narrowed posteriorly, lateral angles prominent, with a distinct median lobe which is medially notched; pygofers sparsely bristled, short and broad, equalling ovipositor. Male, last ventral segment narrower than preceding; valve triangular, broad and long, acutely pointed; plates the width of valve basally, laterally spined, apices subacute, nearly equalling the short, bristly pygofers.

Distribution: Taken in Pottawatomie and Ottawa counties.

Hosts: Taken in pastures where *Bouteloua* and *Buchloë* abound.

Deltocephalus areolatus Ball.

Deltocephalus areolatus Ball, Can. Ent., xxxi, p. 188, 1899.
Deltocephalus areolatus Osb., 20th Rept. N. Y. St. Ent., p. 520, 1905.
Deltocephalus areolatus Van D., Cat. Hemip. N. A., p. 640, 1917.

Form: Short, robust, wedge-shaped, the head forming the apex of the wedge. Length, 2.75 to 4 mm. Vertex nearly twice as long as width between the eyes, apex roundingly acute. Pronotum over twice as broad as long, lateral margins very short, humeral margins rounding into slightly concave posterior margin, anterior margin strongly convex; elytra short, flaring, two outer apical veinlets strongly reflexed.

Color: Olive-green or yellowish; vertex with two black spots apically, elytra with large dark brown spot back of cross nervure, margin of third apical cell and anterior margin of reflexed veinlets dark brown. All but tarsi and part of genitalia below, black.

External genitalia: Female, last ventral segment twice as long as preceding, strongly narrowed posteriorly, lateral angles strong, posterior margin broadly and deeply excavated with a large, medially cleft tooth which equals the lateral angles; sparsely spined pygofers broad, equalling ovipositor. Male, last ventral segment shorter than preceding, slightly concave posteriorly, valve broad, triangular, posterior margin rounding medially; plates the width of the valve basally, twice as long as valve, spiny and slightly concave margins narrowing to slightly divergent apices which are slightly exceeded by the spiny pygofers.

Distribution: Reported by Van Duzee from Kansas. Taken in Riley county.

Host: Specific host unknown. Probably a grass feeder.

Deltocephalus imputans O. & B.

Deltocephalus imputans O. & B., Proc. Dav. Acad. Sci., vii, p. 75, 1898.
Deltocephalus imputans DeL., Tenn. St. Bd. Ent., Bul. 17, p. 43, 1916.
Deltocephalus imputans Van D., Cat. Hemip. N. A., p. 640, 1917.
Deltocephalus imputans Fent., Ohio Jl. Sci., xviii, No. 6, p. 184, 1918.

Form: Wedge-shaped like *areolatus*. Length 3.5 to 4 mm. Vertex about one-third longer than basal width, acutely pointed, margin distinct. Pronotum as in *areolatus*. Elytra short, equalling abdomen, flaring, outer anteapical cell and second cross nervure sometimes wanting, two outer apical nervures strongly reflexed.

Color: Creamy yellow; vertex with two black spots apically, from which lines to ocelli and median line are reddish-brown. Elytra with anterior margin of reflexed veins and margin of third apical cell broadly black. Face black with sometimes a light spot on apex of front.

External genitalia: Female, last ventral segment half longer than preceding, narrowed posteriorly to acute lateral angles, posterior margin emarginate on either side of a wide, roundingly produced and medially notched median lobe; pygofers sparsely bristled, broad, equalling ovipositor. Male, last ventral segment about half as long as preceding, valve broad, two to three times as long as ultimate segment, subacute apically, lateral margins somewhat sinuate; plates long, sparsely bristled margins narrowed from base to divergent, rounded tips which are well exceeded by the bristled pygofers.

Distribution: Van Duzee reports this species from Kansas.

Hosts: Doctor Ball gives *Muhlenbergia* as the grass on which this species lives.

Deltocephalus visendus Crmb.

Deltocephalus visendus Crmb., Ann. Ent. Soc. Am., viii, p. 189, 1915.
Deltocephalus visendus Van D., Cat. Hemip. N. A., p. 641, 1917.

Form: That of *reflexus*. Length, 3.25 to 4.25 mm. Vertex flat, nearly one-fourth longer than width between the eyes, acutely angled. Pronotum over twice as broad as long, strongly convex anteriorly, slightly concave posteriorly, lateral margins short, humeral margins rounding into posterior margin. Elytra flaring, slightly exceeding abdomen.

Color: Pale cinereous. Vertex apically white with two black lines from which reddish lines extend to the ocelli; median line reddish, with a pair of dark median transverse bars. Pronotum with six faint, brownish longitudinal stripes. Elytra with black spots near anterior junction of claval veins and on the disc. The anterior margins of the reflexed nervures, the margin of the third apical cell and often the margins of other veins, brownish or black. Face black, becoming brownish below.

External genitalia: Female, last ventral segment twice as long as preceding, narrowed posteriorly, lateral angles acute, posterior margin emarginate on either side of a large, median, obtusely pointed and slightly notched lobe; sparsely spined pygofers broad, equalling ovipositor. Male, last ventral segment half as long as preceding; valve triangular, margins somewhat concavely narrowed to acute apex; plates about twice as long as valve, characteristic because of apices being separated by small median excavation; bristly pygofers exceeding plates and distinctly compressed from near the base.

Distribution: Taken in Douglas, Miami and Chautauqua counties.

Hosts: Swept from native grasses.

Deltocephalus inflatus O. & B.

Deltocephalus inflatus O. & B., Ia. Acad. Sci., iv, p. 202, pl. 22, fig. 2, 1897.
Deltocephalus inflatus Bak., Psyche, viii, p. 115, 1898.
Deltocephalus inflatus Van D., Bul. Buf. Soc. Nat. Sci., ix, p. 220, 1909.
Deltocephalus inflatus Van D., Cat. Hemip. N. A., p. 640, 1917.

Form: Not as strongly wedge-shaped as *reflexus*. Length, 4.25 to 4.75 mm. Vertex slightly longer than basal width, more obtusely pointed than in *reflexus*. Pronotum over twice as broad as long, lateral margins short. Elytra longer than in *reflexus*, flaring, two outer costal veinlets strongly reflexed.

Color: Yellowish-white; vertex with white apex margined with brown and with reddish line to ocelli, with a pair of spots on either side the center and a pair near the base, light brown. Pronotum with six faint longitudinal stripes, the median ones extending across the scutellum. Elytra subhyaline, nervures white, frequently margined with brown, especially the anterior margin of the reflexed veinlets, and with black spots near middle of clavus, on the first cross vein of sectors and in third apical cell. Face fuscous above, shading gradually to light below.

External genitalia: Female, last ventral segment twice as long as preceding, strongly narrowed posteriorly, lateral angles obtuse, apex in line with central third which is suddenly produced, slightly notched medially, and sinuate and darkened on either side of the notch; pygofers sparsely spined, narrowed basally, broad and equalling ovipositor. Male, last ventral segment nearly as long as preceding; valve triangular, subacute at apex, margins concave medially; plates short, about twice the length of the valve, apices acute, margins spiny; pygofers greatly exceeding plates, but tergite inflated and pressed laterally and terminally against the pygofers.

Distribution: Taken in Pottawatomie county only.

Hosts: A grass feeder. Specific host unknown.

Deltocephalus reflexus O. & B.

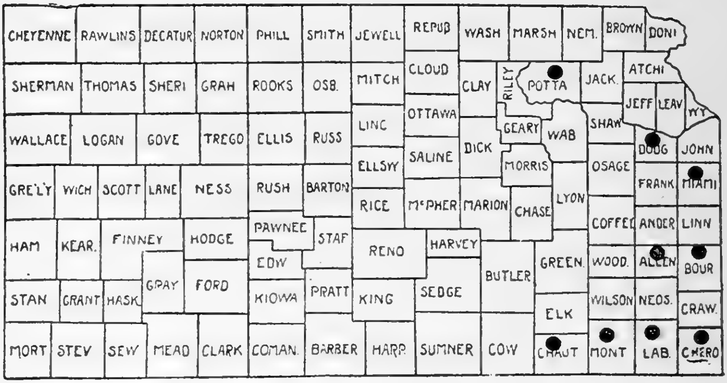
Deltocephalus reflexus O. & B., Proc. Ia. Acad. Sci., iv, p. 203, pl. 22, fig. 1, 1897.
Deltocephalus reflexus Bak., Psyche, viii, p. 115, 1897.
Deltocephalus reflexus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 44, 1916.
Deltocephalus reflexus Van D., Cat. Hemip. N. A., p. 641, 1917.
Deltocephalus reflexus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 61, 1919.

Form: Distinctly wedge-shaped. Length, 4 to 4.5 mm. Vertex half longer than wide, acutely angled. Pronotum as in preceding species except posterior margin more nearly truncate. Elytra strongly flaring, two outer costal veinlets strongly reflexed.

Color: Soiled white or yellowish; vertex with white apex encircled with dark brown, reddish-brown marginal lines to ocelli, pair of median transverse bars and two basal spots, brown. Pronotum yellowish with six faint longitudinal lines. Elytra with spot on clavus and corium, margins of veins, especially anterior margin of reflexed veins and third apical cell, brown. Face black above and light below.

External genitalia: Female, last ventral segment half longer than preceding, strongly narrowed posteriorly, posterior margin concave on either side of a notched median tooth; pygofers sparsely bristled, broad, equalling ovipositor. Male, last ventral segment three-fourths as long as preceding; valve triangular, broad, acutely pointed, spiny margined; plates a little more than twice the length of the valve, elongate, apices somewhat divergent, nearly equalling the spiny pygofers.

Distribution: Common throughout the eastern part of the state as shown by the following map:



Hosts: Grasses.

Deltocephalus sayi (Fh.).

(Pl. 12, figs. 7-8.)

Amblycephalus sayii Fh., Homop. N. Y. St. Cab., p. 61, 1851.
Tettigonia sayii Walk., List Homop., iv, p. 1158, 1852.
Deltocephalus sayi Uhl., Bul. U. S. Geol. Geog. Surv., iv, p. 511, 1878.
Deltocephalus sayi Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 126, 1892.
Deltocephalus sayi O. & B., Proc. Ia. Acad. Sci., iv, p. 207, pl. 23, fig. 2, 1897.
Deltocephalus sayi Osb., 20th Rept. N. Y. St. Ent., p. 519, 1905.
Deltocephalus sayi Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 84, fig. 20, 1912.
Deltocephalus sayi Osb., Me. Agr. Exp. Sta., Bul. 238, p. 117, 1915.
Deltocephalus sayi De L., Tenn. St. Bd. Ent., Bul. 17, p. 46, 1916.
Deltocephalus sayi Van D., Cat. Hemip. N. A., p. 642, 1917.
Deltocephalus sayi Fent., Ohio Jl. Sci., xviii, No. 6, p. 183, 1918.

Form: Short, robust forms, not distinctly wedge-shaped as preceding species. Length, 3.25 to 3.5 mm. Vertex a little longer than width between eyes, rather acutely pointed. Pronotum short, two and a half times as broad as long, humeral margins seemingly forming a part of the posterior margin. Elytra short and broad, almost truncate apically, exceeded by abdomen, outer costal veins not strongly reflexed.

Color: Brownish; vertex nearly reddish-brown with margins, tip, median and basal transverse lines and a median longitudinal line, light. Pronotum with six faint longitudinal lines. Elytra with lighter areas across base and a broader one across tip of clavus, the rest with the light nervures heavily margined with brown. Face light brown with heavy dark arcs.

External genitalia: Female, last ventral segment moderately long, posterior margin emarginate; broad spiny pygofers equalling or slightly exceeded by ovipositor. Male, last ventral segment as long as preceding;

valve, broad, obtusely produced posteriorly; plates broad basally then narrowed and running with parallel margins to obliquely truncate apices; margins with bristles on proximal two-thirds, exceeding the short pygofers.

Internal male genitalia: Styles very large, with large triangular process for attachment to connective, lateral margin broadly and deeply incised apically, incision bearing fine hairs forming a slender, curving apex, crenulated on extreme inner margin; connective narrow proximally, then widening, then narrowing to parallel-margined apical portion, hollowed for nearly entire length; œdagus very characteristic with broad base sending two short arms dorsad, then slightly tapering to apex where it widens and flattens out into two wings, from between which there extend dorsad two long slender processes with a pair of stout recurved spines cephalad of these.

Distribution: Taken in Douglas, Decatur and Pottawatomie counties.

Hosts: Blue grass seems to be the chief host.

Deltocephalus misellus Ball.

Deltocephalus misellus Ball, Can. Ent., xxxi. p. 191, 1899.
Deltocephalus misellus Barb., Bul. Am. Mus. Nat. Hist., xxxiii, p. 533, 1914.
Deltocephalus misellus Gibs. & Cog., Ohio Jl. Sci., xvi, p. 75, 1915.
Deltocephalus misellus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 117, 1915.
Deltocephalus misellus Van D., Cat. Hemip. N. A., p. 642, 1917.

Form: Resembling *sayi*, but smaller. Length, 2.75 to 3 mm. Vertex flat, as long as width between the eyes, obtusely angled apically. Pronotum over twice as wide as long, strongly convex anteriorly, posterior margin slightly emarginate, fusing with humeral margins, lateral margins very short. Elytra broad and short, broadly rounding apically, shorter than abdomen in female, exceeding abdomen in male.

Color: Cinereous, marked with brown; vertex white, with two oblique lines at apex whose base is joined by a brown line, two large brown spots on the disc, and two smaller ones at the base. Pronotum showing faintly four broad longitudinal lines, otherwise irregularly fuscous marked. Elytra cinereous with white nervures generally strongly margined with fuscous. Face fuscous marked with light arcs.

External genitalia: Female, last ventral segment half longer than preceding, somewhat narrowed posteriorly, posterior margin somewhat produced, especially medially; pygofers sparsely bristled, slightly exceeded by the ovipositor. Male, valve triangular, obtuse apically; plates together forming a triangle broader than long, spiny margins regularly tapering to the acute, slightly divergent apices; pygofers very short, very sparsely bristled, exceeded by the plates.

Distribution: This species has not yet been taken from this state but should be found in the northeastern portion.

Hosts: Professor Osborn reports it from Canadian blue grass.

Deltocephalus signatifrons Van D.

Deltocephalus signatifrons Van D., Trans. Am. Ent. Soc., xix, p. 305, 1892.
Deltocephalus signatifrons G. & B., Hemip. Colo., p. 89, 1895.
Deltocephalus signatifrons O. & B., Ia. Agr. Col. Exp. Sta., Bul. 34, p. 135, 1897.
Deltocephalus signatifrons Osb., Proc. Ia. Acad. Sci., iv, p. 215, pl. 25, fig. 1, 1897.
Deltocephalus signatifrons Van D., Cat. Hemip. N. A., p. 645, 1917.

Form: Males appearing rather slender, females more robust. Length, 3 to 3.5 mm. Vertex slightly sloping, broader than long, obtusely to roundingly produced apically. Pronotum less than twice as broad as long, strongly convex anteriorly, lateral margins very short, humeral margins distinct but rounding with slightly emarginate posterior margin. Elytra usually exceeding the abdomen, but only equalling it in some females, middle anteapical cell distinctly constricted.

Color: Ashy-gray tinged with fuscous; vertex slightly yellowish, with four large quadrate brown spots on the disc, a pair of smaller and darker ones at the apex and frequently a spot between the latter and the ocelli. Pronotum grayish, mottled with brown and with five faint, light, longitudinal lines. Scutellum with basal angles dark and disc irregularly mottled with brown. Elytra with nervures light, in some places milky white, and usually strongly margined with fuscous. Face heavily marked with black arcs and dots.

External genitalia: Female, last ventral segment a little longer than preceding, lateral angles prominent, posterior margin broadly excavated and bearing two prominent obtusely pointed teeth which are separated by an incision reaching about one-third of the distance to the base; pygofers broad, spiny, and equalling or slightly exceeded by the ovipositor. Male, last ventral segment about the length of the preceding; valve broad, short, broadly rounded posteriorly; plates very broad, a little over twice the length of the valve, very widely truncate apically, margined with moderately fine hairs; pygofers short, barely exceeding plates, bearing long bristles.

Distribution: Taken hitherto in four western counties, namely: Decatur, Sheridan, Wallace and Hodgeman.

Hosts: Gillette and Baker report this species from beans and alfalfa, while Osborn and Ball report it as infesting weedy places.

Deltocephalus minimus O. & B.

Deltocephalus minimus O. & B., Proc. Ia. Acad. Sci., iv, p. 211, pl. 24, fig. 4, 1897.
Deltocephalus minimus Metc., Jl. Elisha Mitchell Sci. Soc., xxxi, p. 24, 1915.
Deltocephalus minimus De L., Tenn. St. Bd. Ent., Bul. 17, p. 47, 1916.
Deltocephalus melsheimerii Van D., Cat. Hemip. N. A., p. 647, 1917.

Form: Small and slender. Length, 2.25 to 3 mm. Vertex a little longer than wide in the female, about as long as wide in the male, more rounded apically in the male. Pronotum not quite twice as broad as long, strongly convex anteriorly, lateral margins very short, long humeral margins rounding with very slightly concave posterior margin. Elytra long and narrow.

Color: Yellowish-green; disc of pronotum and basal portion of elytra darker green, distal portion of elytra lighter. Face fuscous with lighter arcs.

External genitalia: Female, last ventral segment longer than preceding, lateral margins narrowed posteriorly with slight lateral angles or rounding with posterior margin which is slightly convex, with three small median notches margined with black; pygofers bristly and long, equalling or slightly exceeded by ovipositor. Male, valve large, triangular, apex rather obtuse; plates broad, three times length of valve, regularly tapering to acute tips; pygofers long and narrow, exceeding plates, very bristly.

Distribution: Taken in Cherokee and Franklin counties.

Hosts: Grass feeders. Osborn and Ball suggest *Sporobolus* and *Stipa* as hosts.

After studying the types of this species in Professor Ball's collection, and comparing them with specimens of *Deltocephalus melsheimerii* Fh., sent him by Professor Osborn from Maine, it is impossible to agree with Mr. Van Duzee in making these species synonymous. The genitalia, both male and female, are entirely alike. *Deltocephalus minimus* has the female ultimate segment distinctly notched three times medially, and the lateral margins are distinctly narrowed posteriorly, so that the posterior margin is clearly narrower than the anterior. *Deltocephalus melsheimerii,* on the other hand, has a more truncate and unnotched posterior margin which is as wide as the anterior margin, for the lateral margins are not narrowed posteriorly, forming right angles with the posterior margin. In the male genitalia the differences are even more noticeable. In *Deltocephalus melsheimerii* the valve is shorter and more rounded posteriorly than in *Deltocephalus minimus.* The plates, however, are very characteristic. In the former they are very broad, and continue, almost parallel-margined to the broad, upturned, obtusely-pointed or truncate apices. In the latter the plates are longer, more slender, and tapering posteriorly to the acute apices which are not upturned.

Deltocephalus parvulus Gill.

Deltocephalus parvulus Gill., Colo. Agr. Exp. Sta., Bul. 43, p. 23, 1898.
Deltocephalus parvulus Van D., Cat. Hemip. N. A., p. 647, 1917.

Form: Much like preceding species. Length, 2.5 to 3 mm. Vertex slightly longer than wide in female, about as long as wide in male, subacute apically in female, more rounded in male. Vertex long, not twice as wide as long, strongly convex anteriorly, lateral margin very short, long humeral margins rounding to slightly concave, posterior margin. Elytra long and slender, exceeding abdomen.

Color: Greenish-yellow; vertex yellowish with two brown lines extending from apex to base. Pronotum yellowish-green, sometimes with two brown longitudinal lines. Scutellum yellow. Elytra yellowish-green, subhyaline, nervures brighter. Face pale fuscous with pale arcs.

External genitalia: Female, last ventral segment twice as long as preceding, narrowed posteriorly, posterior margin strongly and roundingly produced, unicolorous; pygofers long and narrow, equalling or slightly exceeded by ovipositor, sparsely bristled. Male, valve small, triangular, apex subacute, smaller and more acute than in *minimus*, plates long and narrow, spiny margined, apices acute.

Distribution: Collected in large numbers in Ottawa county.

Hosts: Professor Gillette reports this species on short prairie grasses. The writer swept them in abundance from pastures composed chiefly of *Bouteloua* and *Buchloë*.

Deltocephalus debilis Uhl.

Deltocephalus debilis Uhl., Bul. U. S. Geol. Geog. Surv., i, p. 360, 1876.
Deltocephalus melsheimeri Osb., Proc. Ia. Acad. Sci., l, pt. 2, p. 126, 1892.
Deltocephalus debilis O. & B., Proc. Ia. Acad. Sci., iv, p. 210, pl. 23, fig. 2, 1897.
Deltocephalus debilis Osb., 20th Rept. N. Y. St. Ent., p. 520, 1905.
Deltocephalus debilis DeL., Tenn. St. Bd. Ent., Bul. 17, p. 49, 1916.
Deltocephalus debilis Van D., Cat. Hemip. N. A., p. 646, 1917.
Deltocephalus debilis Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 65, 1919.

Form: Larger and more robust than two preceding species. Length, 3 to 4.75 mm. Vertex longer than wide, or width equal to length, acutely angled. Pronotum not over twice as broad as long, strongly convex anteriorly, lateral margins very short, humeral margins rounding into slightly concave posterior margin. Elytra varying in length, sometimes shorter, usually longer than abdomen.

Color: Greenish; vertex, anterior portion of pronotum and scutellum yellow, median line of vertex and ocelli black. Elytra subhyaline with veins light. Face brownish with pale arcs and median line.

External genitalia: Female, last ventral segment long, posterior margin rounded with narrow, deep, median notch or sometimes nearly truncate with a shallow notch between two small lobes; pygofers broad, broadest at middle, and sparsely spined, equalling or slightly exceeded by ovipositor. Male, last ventral segment shorter than preceding, valve roundingly produced posteriorly; plates together as broad at base as long, margins spined, each with a black spot, apices obtuse, exceeded by the acutely pointed and long-bristled pygofers.

Distribution: Collected in Douglas and Pottawatomie counties.

Hosts: Found on low grounds and in wooded regions.

Deltocephalus collinus Boh.

Deltocephalus collinus Boh., Kong. Vet. Akad. Handl. for 1850, p. 261.

Deltocephalus aridellus Boh., Kong. Vet. Akad. Handl. for 1850, p. 263.

Deltocephalus collinus Fieb., Verh. Zoöl.-Bot. Ges. Wien., xix, p. 216, pl. 6, fig. 42, 1869.

Deltocephalus collinus Edw., Hemip. Homop. Brit. Isds., p. 264, pl. 29, figs. 4, 5, 1896.

Deltocephalus collinus O. & B., Proc. Dav. Acad. Sci., vii, p. 80, 1898.

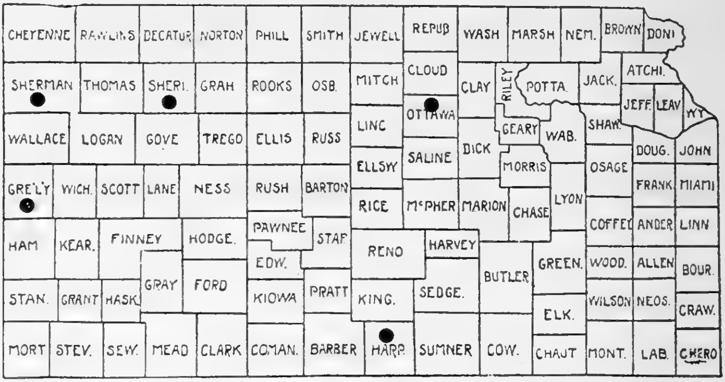
Deltocephalus collinus Van D., Cat. Hemip. N. A., p. 647, 1917.

Form: Robust and like *affinis*. Length, 3.25 to 4 mm. Vertex about as long as wide, sometimes wider, rather obtusely angled. Pronotum less than twice as broad as long, anterior margin strongly convex, lateral margins short, humeral margins rounding into slightly concave posterior margin. Elytra narrow, either short, reaching to base of penultimate segment and diverging from the tip of the clavus, or long in some females, exceeding the abdomen.

Color: Greenish-yellow, practically unicolorous; vertex sometimes marked with light brown on either side of a light stripe enclosing the dark, median, impressed line. Pronotum sometimes with signs of six fuscous longitudinal lines. Elytra with light nervures, tip hyaline, abdomen sometimes marked with fuscous stripes. Face fuscous marked with light median line and arcs.

External genitalia: Female, last ventral segment longer than preceding, narrowed posteriorly, posterior margin seemingly with five lobes, the two outer light colored ones small, and separated shallowly from the small black lobes next to them, and these in turn separated by a deeper excavation from the light colored median lobe; pygofers narrowed basally, long and narrowed, bristly, slightly exceeding the ovipositor. Male, last ventral segment two-thirds as long as preceding; valve large, nearly twice as wide as long, obtusely angulated posteriorly; plates broad, margins convex till near the apex, then concavely narrowing to the obtuse apices which are slightly exceeded by the spiny pygofers.

Distribution: Fairly common in western portion of the state, as shown by the following map:



Hosts: Osborn and Ball give *Sporobolus* as the host.

Deltocephalus affinis G. & B.

(Pl. 12, figs. 5-6.)

Deltocephalus affinis G. & B., Hemip. Colo., p. 84, 1895.
Deltocephalus melsheimerii Van D., Psyche, v, p. 390, 1890.
Deltocephalus debilis Osb., Ia. Agr. Col. Exp. Sta., Bul. 13, p. 100, 1891.
Deltocephalus debilis Osb., U. S. Dept. Agr., Div. Ent., Bul. 30, p. 45, 1893.
Deltocephalus melsheimerii O. & B., Proc. Ia. Acad. Sci., iv, p. 211, pl. 24, fig. 1, 1897.
Deltocephalus affinis Bak., Psyche, viii, p. 118, 1897.
Deltocephalus affinis Osb., 20th Rept. N. Y. St. Ent., p. 522, 1905.
Deltocephalus affinis Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 82, fig. 18, 1912
Deltocephalus affinis Osb., Me. Agr. Exp. Sta., Bul. 238, p. 122, 1915.
Deltocephalus affinis Van D., Cat. Hemip. N. A., p. 648, 1917.
Deltocephalus affinis Fent., Ohio Jl. Sci., xviii, No. 6, 184, 1918.

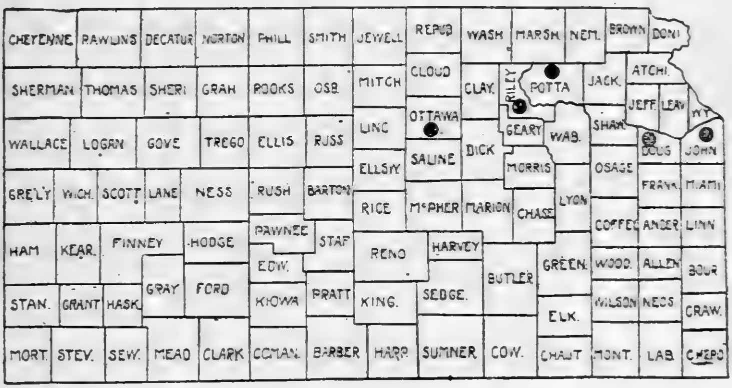
Form: Length, 3 to 4 mm. Vertex wider than long, obtusely pointed. Pronotum a little longer than the vertex, lateral margins short, humeral margins distinctly angled with the slightly emarginate posterior margin. Elytra long, barely exceeding the abdomen sometimes, and again greatly exceeding it.

Color: Pale ashy-green, usually marked with fuscous. Vertex and pronotum often unicolorous or mottled with fuscous, the latter sometimes showing five pale longitudinal stripes. Elytra often unicolorously greenish-brown, sometimes with nervures heavily bordered with fuscous. Face fuscous with light median line and arcs.

External genitalia: Female, last ventral segment long, slightly narrowed posteriorly, posterior margin broadly and angularly emarginate; pygofers spiny on distal half, broad, equalling ovipositor. Male, last ventral segment as long as preceding, valve very characteristic, large and inflated, concealing all but the obtuse and divergent apices of the short plates; pygofers very short, each with a tuft of long bristles.

Internal male genitalia: Styles with a very large and characteristic projection to meet the connective, main body of about uniform diameter till near the apex, then excavated laterally, forming an outwardly curved and knobbed apex, connective very long and slender, notched basally for nearly one-half its length; œdagus with a pair of lateral, dorsally projected processes, and a longer median and terminal process.

Distribution: Very abundant wherever its host occurs. The following map shows counties in which it has been taken:



Hosts: Blue grass.

Deltocephalus oculatus O. & B.

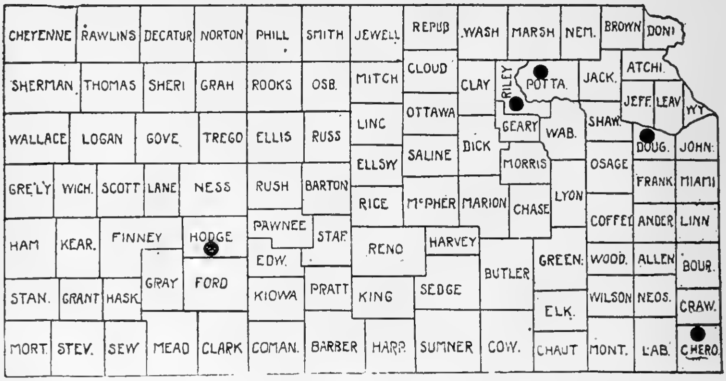
Deltocephalus oculatus O. & B., Ia. Acad. Sci., iv, p. 212, pl. 23, fig. 4, 1897.
Deltocephalus oculatus De L., Tenn. St. Bd. Ent., Bul. 17, p. 48, 1916.
Deltocephalus oculatus Van D., Cat. Hemip. N. A., p. 648, 1917.
Deltocephalus oculatus Fent., Ohio Jl. Sci., xviii, No. 6, p. 184, 1918.

Form: Like *affinis*, smaller. Length, 3.5 mm. Vertex slightly longer than width between eyes, obtusely pointed. Pronotum not twice as broad as long, lateral margins short. Elytra long and narrow, much exceeding abdomen.

Color: Distinctly yellow, face marked with fuscous arcs. Elytra not as bright yellow as vertex, pronotum and scutellum.

External genitalia: Female, last ventral segment about length of preceding, lateral angles acute, middle third of posterior margin truncately produced, dark, and thin lobed; pygofers bristly, broad, equalling ovipositor. Male, valve broad, triangular, acute apically; plates broad at base, much narrowed apically to the slender, produced apices; pygofers long and very acute at apices, exceeding plates and spiny.

Distribution: As shown by the map, this species is seemingly more abundant in the eastern part of the state.



Hosts: Osborn and Ball give *Andropogon scoparius* as a host, while De Long records it on *Aristida gracilis.*

Deltocephalus sylvestris O. & B.

Deltocephalus sylvestris O. & B., Proc. Ia. Acad. Sci., iv, p. 213, pl. 25, fig. 4, 1897.
Deltocephalus sylvestris Osb., Me. Agr. Exp. Sta., Bul. 238, p. 119, 1915.
Deltocephalus sylvestris DeL., Tenn. St. Bd. Ent., Bul. 17, p. 49, 1916.
Deltocephalus sylvestris Van D., Cat. Hemip. N. A., p. 49, 1917.
Deltocephalus sylvestris Fent., Ohio Jl. Sci., xviii, No. 6, p. 184, 1918.

Form: More slender than *oculatus.* Length, 3.5 mm. Vertex distinctly longer than wide, acutely pointed. Pronotum long, with short lateral margins and distinctly emarginate posterior margin. Elytra long and narrow, distinctly exceeding the abdomen.

Color: Greenish-yellow marked with fuscous; vertex greenish-yellow, with two brownish lines from apex towards each eye and with a dark median line. Pronotum with traces of five longitudinal lines; elytra greenish, nervures light, sometimes margined with fuscous. Face fuscous with median line and arcs pale.

External genitalia: Female, last ventral segment narrowed posteriorly, short, except for long median third which is strongly and abruptly produced and black. Male, valve broad, apex obtusely angulated; plates very broad, three times the length of valve, spines divergent and acute, margins spiny; bristly pygofers slightly exceeding plates.

Distribution: Taken only in Douglas and Cherokee counties.

Hosts: Osborn and Ball report this species from blue grass in wooded areas.

Deltocephalus flavicosta Stal.

(Pl. 12, figs. 3-4.)

Jassus (Deltocephalus) flavicosta Stal, Rio Jan. Hemip., ii, p. 53, 1862.
Deltocephalus flavicosta Van D., Can. Ent., xxiv, p. 116, 1892.
Deltocephalus retrorsus Uhl., Proc. Zoöl. Soc. Lond. for 1895, p. 78.
Deltocephalus harrisi (Fh. MS.) in collections.
Deltocephalus flavocostatus O. & B., Proc. Ia. Acad. Sci., iv, p. 217, 1897.
Deltocephalus flavicosta Bak., Psyche, viii, p. 117, 1897.
Deltocephalus retroversus (Uhl. MS.) Smith, Cat. Ins. N. J., edn. 2, p. 95, 1900.
Deltocephalus flavocostatus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 49, 1916.
Deltocephalus flavicosta Van D., Cat. Hemip. N. A., p. 645, 1917.
Deltocephalus flavicosta Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 64, 1919.

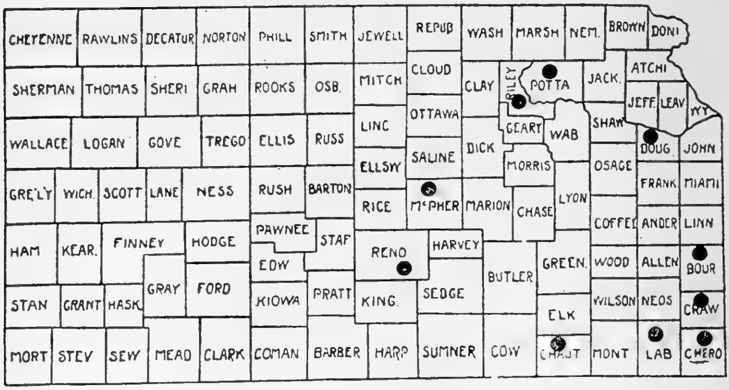
Form: Length, 2.5 to 3.5 mm. Vertex distinctly wider than long, anterior margin nearly round, disc convex and sloping, without well-developed margin. Pronotum long, strongly convex anteriorly, lateral margins very short, humeral margins long and rounding with slightly emarginate posterior margin. Elytra long and narrow, exceeding the abdomen.

Color: Dark brown to black; vertex with four apical spots in form of a square, three against each eye, and two at middle of posterior margin, yellow. Pronotum with five yellow spots on anterior portion and five faint longitudinal lines. Elytra very characteristic because of the yellow two-thirds of costal area and two outer costal veinlets sometimes broadly light.

External genitalia: Female, last ventral segment twice as long as preceding, narrowed posteriorly, posterior margin roundingly produced and sometimes with a small median notch; pygofers sparsely spined, broad and short, exceeded by the ovipositor. Male, last ventral segment as long as preceding; valve broad, triangular, margins slightly concave to obtuse or rounded apex; plates broad at base, longer than valve, margins with few spines, narrowing to acute apices which exceed the sparsely spined short pygofers.

Internal male genitalia: Styles acute at either end, apically toothed on inner margin and sending long, parallel-sided processes from near their middle length seemingly direct to the œdagus, which is semicircular when viewed laterally, and broad till near the apex, then greatly narrowed, but ending obtusely.

Distribution: Common throughout the eastern part of the state. Often attracted to lights. The following map shows counties furnishing specimens:



Hosts: Taken on weeds and grasses.

Deltocephalus weedi Van D.

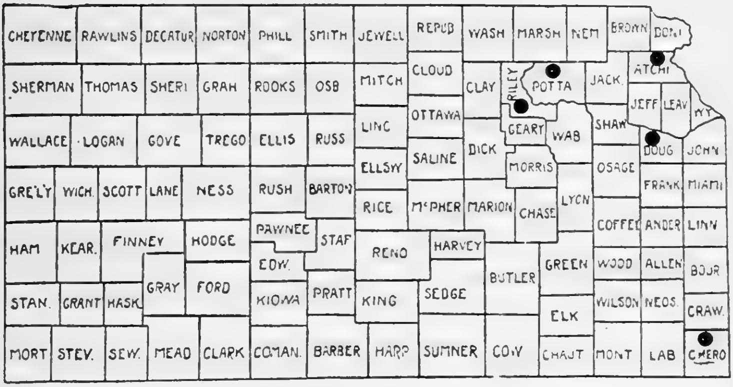
Deltocephalus weedi Van D., Trans. Am. Ent. Soc., xix, p. 306, 1892.
Deltocephalus weedi O. & B., Proc. Ia. Acad. Sci., iv, p. 216, pl. 25, fig. 2, 1897.
Deltocephalus weedi DeL., Tenn. St. Bd. Ent., Bul. 17, p. 52, 1916.
Deltocephalus weedi Van D., Cat. Hemip. N. A., p. 643, 1917.
Deltocephalus weedi Fent., Ohio Jl. Sci., xviii, No. 6, p. 184, 1918.
Deltocephalus weedi Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 62, 1919.

Form: Small and robust. Length, 3 mm. Vertex a little longer than wide, rather acutely pointed, at least more acute than in two following species. Pronotum long, not over twice as broad as long, strongly convex anteriorly, lateral margins very short, humeral margins long, broadly rounding with slightly concave posterior margin. Elytra slightly longer than the abdomen, somewhat flaring, the clavus well reticulated, the central anteapical cell divided.

Color: Brown; vertex with two triangular fuscous, apical spots, a black spot above each ocellus, a medially widened, transverse, broad band on the disc, with a pair of light fuscous basal spots and a dark median longitudinal line. Pronotum with five white longitudinal lines, two large fuscous apical spots and irregular fuscous spots posteriorly, parallel to anterior margin. Scutellum with dark basal angles. Elytra with nervures broadly white and uniformly bordered with fuscous, sometimes the cells entirely fuscous. Face black with white arcs.

External genitalia: Female, last ventral segment one-third longer than preceding, posterior margin broadly and roundly slightly concave; pygofers broad, bristled on distal half, slightly exceeded by the ovipositor. Male, last ventral segment as long as preceding, posterior margin distinctly concave, valve broad, broadly rounded posteriorly; plates together half broader than long, spiny margins rounding to obtuse apices; pygofers broad and short, equalling or slightly exceeding plates, and with long bristles.

Distribution: Found in the eastern part of the state, as shown by the following map:



Hosts: Taken when sweeping grasses and weeds.

Deltocephalus obtectus O. & B.

Deltocephalus obtectus O. & B., Proc. Dav. Acad. Sci., vii, p. 78, 1898.
Deltocephalus obtectus Osb., 20th Rept. N. Y. St. Ent., p. 521, 1905.
Deltocephalus obtectus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 118, 1915.
Deltocephalus obtectus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 53, 1916.
Deltocephalus obtectus Van D., Cat. Hemip. N. A., p. 643, 1917.
Deltocephalus obtectus Lathr., S. C. Agr. Col., Bul. 199, p. 63, 1919.

Form: Resembles *weedi,* slightly larger. Length, 3 to 3.5 mm. Vertex slightly wider than long, disc sloping and broadly rounding with front, vertex distinctly more obtuse than in *weedi.* Pronotum about the length of vertex, lateral margins very short. Elytra usually exceeding abdomen, flaring, clavus reticulated, central anteapical cell divided.

Color: Light gray marked with fuscous, duller colored than either *weedi* or *compactus.* Vertex whitish or yellowish, two brown dashes at apex, two brown curved lines outside these, a black spot inside each ocellus, back of these a dark transverse band on each side, from whose inner end short dark lines run back parallel to the dark median line, and with two large brown basal spots. Pronotum with large dark spots back of each eye, other smaller ones parallel with anterior margin, and with faint indications of the five longitudinal stripes. Scutellum with basal angles dark and often bearing a pair of dots on disc. Elytra with nervures broadly white and more or less margined with fuscous, with black spots on clavus, corium, and then on distal half of costal margin. Face brown with light arcs.

External genitalia: Female, last ventral segment consisting of two membranes, the lateral margins only of the inner one visible from under the outer membrane which is about half as long as it is wide, much narrowed to slightly rounded nearly truncate posterior margin; pygofers broad, distally spined and equalling the ovipositor. Male, last ventral segment as long as preceding, distinctly shortened medially by the broadly rounded excavation of the posterior margin; valve large, margins distinctly concave medially and then rounding to obtuse apex; plates broad, spiny margins quickly narrowing to the attenuate and acute tips; pygofers densely bristled, their acute tips exceeding the plates.

Distribution: Taken in Cherokee county only.

Hosts: De Long reports this species from small grasses.

Deltocephalus compactus O. & B.

Deltocephalus compactus O. & B., Proc. Ia. Acad. Sci., iv, p. 217, pl. 25, fig. 3, 1897.
Deltocephalus compactus Osb., 20th Rept. N. Y. St. Ent., p. 521, 1905.
Deltocephalus compactus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 52, 1916.
Deltocephalus compactus Van D., Cat. Hemip. N. A., p. 643, 1917.
Deltocephalus compactus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 63, 1919.

Form: Much like *weedi.* Length, 2.75 mm. Vertex with length equalling width or slightly longer, disc sloping and roundingly meeting front, quite obtuse apically. Pronotum as in *obtectus.* Elytra short, broad, sometimes nearly equalling abdomen, sometimes exceeding it, clavus reticulated, central anteapical cell divided.

Color: Very much like *weedi,* brown; vertex yellowish, with ocelli, a pair of spots inside them and a pair at apex, black, a large broad pair light brown and curved marginally, a pair of transverse median and median longitudinal lines, black. Pronotum brown with the five faint longitudinal lines. Scutellum with basal angles and two spots on disc, dark. Elytra brown with nervures broadly light and usually heavily margined with fuscous. Face black with light arcs.

External genitalia: Female, last ventral segment consisting of two membranes as in *obtectus,* the inner deeply and circularly emarginate behind, nearly covered by the outer membrane which is twice as broad as long, with its posterior margin roundingly and medially produced; pygofers broad, distally spined, exceeded by the ovipositor. Male, last ventral segment as long as preceding except medially, due to broad and angular excavation of the posterior margin; valve small, posterior margin slightly rounded; plates broad at base, but with spiny margins concavely narrowed to attenuated and acute apices, which exceed the short, bristly pygofers.

Distribution: Taken in Pottawatomie county.

Hosts: Osborn and Ball report this species from *Sporobolus hookeri;* De Long reports it as abundant on *Aristida gracilis.*

Deltocephalus inimicus (Say).

(Pl. 12, figs. 1-2.)

Jassus inimicus Say, Jl. Acad. Nat. Sci. Phila., vi, p. 305, 1831; Compl. Writ., ii, p. 382.
Amblycephalus inimicus Fh., Homop. N. Y. St. Cab., p. 61, 1851.
Tettigonia inimica Walk., List Homop., iv, p. 1158, 1852.
Jassus 6-punctatus Prov., Nat. Can., iv, p. 378, 1872.
Jassus inimicus Forbes, 14th Rept. Ill. St. Ent., pp. 22, 67, 1884.
Deltocephalus inimicus Van D., Can. Ent., xxi, p. 11, 1889.
Deltocephalus inimicus Osb., Ia. St. Agr. Soc., Rept. for 1892, p. 687.
Deltocephalus inimicus Osb., Insect Life, v, p. 113, 1892.
Deltocephalus inimicus Osb., U. S. Dept. Agr., Div. Ent., Bul. 30, p. 45, 1893.
Deltocephalus inimicus O. & B., Proc. Ia. Acad. Sci., iv, p. 215, pl. 24, fig. 3, 1897.
Deltocephalus inimicus Osb., 20th Rept. N. Y. St. Ent., p. 523, 1905.
Deltocephalus inimicus Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 72, fig. 11, 1912.
Deltocephalus inimicus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 123, 1915.
Deltocephalus inimicus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 51, 1916.
Deltocephalus inimicus Van D., Cat. Hemip. N. A., p. 644, 1917.
Deltocephalus inimicus Fent., Ohio Jl. Sci., xviii, No. 6, p. 184, 1918.

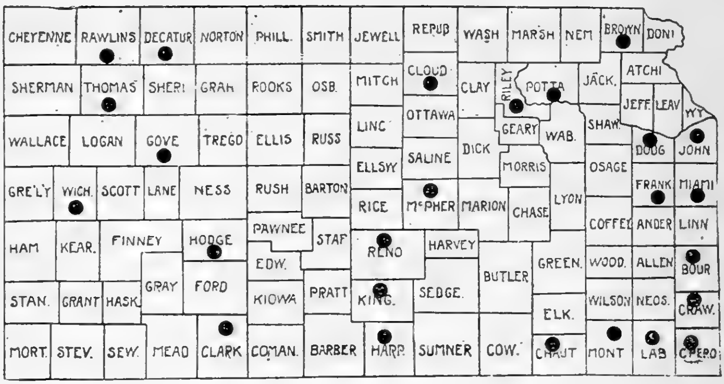
Form: A large, fairly robust species. Length, 2.75 to 5 mm. Vertex distinctly wider than long, disc slightly concave and rounding with front, very obtusely or roundingly angulate apically. Pronotum long, not twice as broad as long, lateral margins very short. Elytra long and rather narrow, exceeding the abdomen, clavus reticulate, middle anteapical cell constricted and divided.

Color: Grayish or light fuscous marked with brown. Vertex whitish or yellowish in light forms, fuscous in dark ones, with two small apical spots, a pair of large round black ones before the eyes and between and behind these a pair of smaller fuscous spots. Pronotum with two large black spots on anterior margin, sometimes others near anterior border, and with five faint, longitudinal, light lines. Scutellum with black basal angles. Elytra with the nervures broadly light, bordered with fuscous, especially in the apical region. Face fuscous with light median line and arcs. The color of this species varies very greatly from almost unmarked forms to very dark ones. The three pairs of spots, however, on vertex, pronotum and scutellum, are quite constant and thus readily distinguish the species.

External genitalia: Female, last ventral segment about as long as preceding, composed of two membranes, the inner broadly excavated posteriorly, only the rounded, lateral angles showing from under the outer membrane, which is suddenly narrowed posteriorly and terminates in a three-lobed posterior margin, which is about half the width of the broad anterior margin; spiny pygofers long and narrow, equalling or only slightly exceeded by ovipositor. Male, last ventral segment as long as preceding, posterior margin roundingly emarginate; valve short, triangular, apex obtuse, margins slightly concave; plates nearly as broad as valve at base, spiny margins concavely narrowed to attenuate and acute apices; pygofers broad, apically obtuse, sparsely spined, slightly exceeding plates.

External male genitalia: Styles triangular, with a long process to connective, lateral margin with a small, but distinct notch preapically, apex obtuse and granulated; connective flat, with middle portion cut away; œdagus long and robust, heavier basally, sinuate to obtusely rounded bifid apex, with a slightly chitinized basal, dorsally projecting process for attachment to the base of the anal tube.

Distribution: One of the commonest species as shown by the following map. Sometimes occurs in swarms at lights.



Hosts: Blue grass chiefly, among many grasses and weeds. Osborn records it as injurious to wheat and oats also. One of the most destructive of our leaf hoppers.

Deltocephalus osborni Van D.

Deltocephalus osborni Van D., Trans. Am. Ent. Soc., xix, p. 304, 1892.
Athysanus osborni O. & B., Proc. Ia. Acad. Sci., iv, p. 220, 1897.
Athysanus osborni O. & B., Ohio Nat., ii, p. 249, pl. 17, fig. 4, 1902.
Athysanus osborni Osb., 20th Rept. N. Y. St. Ent., p. 527, 1905.
Ahtysanus osborni Kirk., Haw. S. P. A., Exp. Sta. Bul., iii, p. 58, 1907.
Deltocephalus osborni Van D., Cat. Hemip. N. A., p. 649, 1917.

Form: Large and robust. Length, 4.5 to 5.5 mm. Vertex about one and a half times as wide as long, disc flat, rounding with front, apex obtusely or roundingly angled. Pronotum short, over twice as wide as long, lateral margins very short. Elytra usually longer than abdomen, sometimes shorter, flaring, clavus not reticulate, two cross nervures between the sectors, middle anteapical cell divided.

Color: Almost uniformly straw- or tawny-yellow; vertex with four black marginal spots, the middle ones larger. Pronotum with five pale longitudinal lines. Elytra with light nervures, often margined with fuscous. Face with pale median line and arcs.

External genitalia: Female, last ventral segment composed of two membranes, the rounded lateral corners of the deeply excavated inner one showing at the sides of the basally broad, posteriorly much narrowed outer membrane whose posterior margin is then lobed, the middle one being smaller than the lateral lobes; pygofers rather narrow, broadest at the middle, slightly exceeded by the ovipositor, and spined on distal half. Male, last ventral segment as long as preceding, posterior margin concave; valve very small, rounded posteriorly; plates broadly triangular, acute at tips, few spines on margins, exceeded by the basally broad, acutely-tipped, long bristled pygofers.

Distribution: Collected in Douglas and Pottawatomie counties.

Hosts: Van Duzee took this species from "grass and weeds near the borders of a low, swampy wood."

Deltocephalus punctatus (O. & B.).

Athysanus punctatus O. & B., Proc. Dav. Acad. Sci., vii, p. 94, 1898.

Deltocephalus punctatus Van D., Univ. Calif. Publ., Div. Ent., Tech. Bul., i, p. 249 1916.

Deltocephalus punctatus Van D., Cat. Hemip. N. A., p. 650, 1917.

Form: Short and rather robust. Length, 2.5 to 3.5 mm. Vertex slightly wider than long, disc sloping, apex obtuse. Pronotum longer than vertex, not twice as broad as long, lateral margins very short, humeral margins long, rounding with slightly emarginate posterior margin. Elytra long and narrow, exceeding abdomen and overlapping apically, or short and broad, reaching sixth abdominal segment, venation indistinct.

Color: Practically uniformly brown; vertex with two large black spots, dark median longitudinal line and ocelli and two apical spots reddish. Black abdomen showing through elytra.

External genitalia: Female, last ventral segment very long, sides broadly rounded to truncate posterior margin which has a slightly excavated median portion; pygofers broad apically, spiny, equalling or slightly exceeded by the ovipositor. Male, last ventral segment shorter than preceding, slightly concave posteriorly; valve very broad, broadly rounded posteriorly, three times as broad as long; plates broad basally, spiny margins concavely narrowing to acute tips, two and one-half times the length of the valve; pygofers broad at base, acute and long-bristled apically, equalling the plates.

Distribution: This species has not yet been taken in the state but should occur here, at least in the northeastern portion.

Hosts: Osborn and Ball took the type specimen on *Sporobolus*.

Deltocephalus balli Van D.

Deltocephalus balli Van D., Check List Hemip., p. 71, 1916.
Deltocephalus nigrifrons Van D., Trans. Am. Ent. Soc., xxi, p. 293, 1894.
Deltocephalus nigrifrons O. & B. Proc. Ia. Acad. Sci., iv, p. 218, 1897 (in part).
Deltocephalus nigrifrons Bak., Psyche, viii, p. 116, 1897.
Deltocephalus nigrifrons Osb., Me. Agr. Exp. Sta., Bul. 238, p. 122, 1915.
Deltocephalus nigrifrons DeL., Tenn. St. Bd. Ent., Bul. 17, p. 50, 1916.
Deltocephalus balli Van D., Cat. Hemip. N. A., p. 650, 1917.
Deltocephalus balli Fent., Ohio Jl. Sci., xviii, No. 6, p. 184, 1918.

Form: Length, 2.5 to 4 mm. Vertex over half wider than long, sloping, broadly rounding with front, obtusely angulated or broadly rounding apically. Pronotum distinctly longer than vertex, lateral margins very short, humeral margins long. Elytra long and narrow, much exceeding abdomen.

Color: Yellowish-green. Vertex yellowish with row of apical black spots. Pronotum showing five pale stripes. Scutellum with basal angles and apex reddish, and the transverse impressed line black. Elytra with light nervures, cells often fuscous. Face almost black with coalescing arcs.

External genitalia: Female, last ventral segment longer than preceding, narrowed posteriorly, posterior margin broadly emarginate; pygofers long and broad, broadest at middle, spined on distal half, nearly equalling ovipositor. Male, last ventral segment wider than preceding, concave posteriorly; valve broad but short, rounded posteriorly; plates broad at base, spined margins tapering to acute apices; pygofers bearing long spines, acute, and exceeding plates apically.

Distribution: Records are at hand only from Riley county, but it probably occurs well over the state.

Hosts: Grasses and weeds. De Long records it on wheat and rye.

Deltocephalus sonorus Ball.

Deltocephalus sonorus Ball, Can. Ent., xxxii, p. 344, 1900.
Deltocephalus sonorus Van D., Bul. Buf. Soc. Nat. Sci., ix, p. 220, 1909.
Deltocephalus sonorus Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 79, 1912.
Deltocephalus sonorus Van D., Cat. Hemip. N. A., p. 651, 1917.

Form: Like *balli* but more slender. Length, 3.25 mm. Vertex distinctly broader than long, sloping, broadly, rounded apically. Pronotum distinctly longer than vertex, lateral margins very short, humeral margins long. Elytra long and narrow, venation distinct.

Color: Fuscous; vertex pale yellow with six marginal black spots, the middle ones larger than the others, and back of each spot a light brown spot on disc. Pronotum greenish-yellow with five light longitudinal lines. Elytra subhyaline, nervures light, often margined with fuscous. Face fuscous with light median line and arcs.

External genitalia: Female, last ventral segment half longer than preceding, lateral margins narrowed posteriorly, posterior margin slightly emarginate medially; pygofers rather narrow and long, spiny on distal half, equalling the ovipositor. Male, last ventral segment as long laterally as preceding, but with posterior margin concave; valve broad but short, rounded broadly posteriorly; plates broad basally, spined margins tapering to acute tips; pygofers exceeding plates, armed with a few stout and many fine bristles.

Distribution: Taken in Pottawatomie county only.

Hosts: Osborn reports it as occurring on annual grasses.

Genus LONATURA O. & B.

The members of this genus have a conical head, over three times as wide across the eyes as the length of the vertex, which is obtusely angled. The pronotum is short, scarcely as long as the vertex, only slightly emarginate posteriorly, covering base of elytra and scutellum in brachypterous forms. Elytra with obscure venation and only two anteapical cells, long and narrow, with large appendix, or short and broad, covering only second abdominal segment.

At least three species of this genus should occur in Kansas, only one, however, having yet been taken.

KEY TO SPECIES

A. Forms small, less than 3 mm. *catalina.*

AA. Forms larger, 3 mm. or over.

B. Forms large, elytra covering only first two abdominal segments and each with at least one black spot. *noctivaga.*

BB. Forms smaller, elytra longer, covering all but two last segments of abdomen and without spots. *nebulosa*

Lonatura catalina O. & B.

Lonatura catalina O. & B., Proc. Dav. Acad. Sci., vii, p. 83, pl. 4, fig. 2, 1898.
Lonatura catalina DeL., Tenn. St. Bd. Ent., Bul. 17, p. 93, 1916.
Lonatura catalina Van D., Cat. Hemip. N. A., p. 651, 1917.
Lonatura catalina Fent., Ohio Jl. Sci., xviii, No. 6, p. 184, 1918.

Form: Very small, robust. Length of brachypterous form, 2.75 mm. Macropterous females slightly larger than macropterous males, vertex about as long as wide, sloping, broadly rounding to front, obtuse apically, whole surface distinctly granulose. Pronotum shorter than vertex, anterior margin strongly convex, lateral margins short, humeral margins distinct, broadly rounding with slightly emarginate posterior margin. Scutellum large. Elytra long and narrow, exceeding abdomen. Brachypterous forms have a slightly longer head, very short truncate elytra, the pronotum seemingly covering the base of the elytra and the scutellum, the latter appearing small, the abdomen of the male being shorter and more robust than that of the female.

Color: Macropterous females have yellowish vertex, pronotum, scutellum and elytra greenish-gray. Macropterous males have a yellow vertex, pronotum and scutellum yellowish-brown and elytra deep, smoky-brown. Brachypterous females are uniformly orange-yellow, except for dark eyes and ocelli. Brachypterous males of same color as brachypterous females, or dark, with vertex, pronotum and scutellum a yellowish-brown, elytra smoky-brown, and abdomen brownish-black.

External genitalia: Female, last ventral segment short, broad, slightly emarginate posteriorly and with a small, median, bilobed process; pygofers broad, slightly exceeded by black ovipositor, bristled apically. Male, last ventral segment about length of preceding, emarginate posteriorly; valve small, rounded posteriorly; plates broad basally, concavely narrowed to attenuate and acute tips which exceed the short, bristly pygofers.

Distribution: Though not yet reported from Kansas, this species surely occurs in the state.

Hosts: Osborn and Ball report it from *Sporobolus.* De Long took it in great numbers on *Aristida gracilis.*

Lonatura noctivaga Ball.

Lonatura noctivaga Ball, Can. Ent., xxxii, p. 342, 1900.
Lonatura noctivaga Van D., Cat. Hemip. N. A., p. 652, 1917.

Form: Large and robust. Length, 4 to 5.5 mm. Vertex at least one-fourth wider than long, sloping and broadly rounding with front, apex obtusely angled. Pronotum short, scarcely as long as vertex, anterior margin broadly convex, lateral margins long, humeral margins long, scarcely angled with the somewhat emarginate posterior margin. Elytra short and broad, obliquely truncate, covering first two abdominal segments, venation obscure and reticulate.

Color: Creamy-yellow; vertex with four large marginal black spots, the outer the larger, with a faint transverse band behind the latter, back of which may be irregular brownish spots, and with a dark median line. Pronotum with five light longitudinal lines. Elytra with nervures light, one or two black spots on posterior margin and often one or more between these and the scutellum. Abdomen dark olive with creamy stripes.

External genitalia: Female, last ventral segment one-third longer than preceding, strongly narrowed posteriorly, lateral angles broadly rounded, posterior margin twice notched, with a small median lobe; pygofers long and narrow, narrowed basally, sparsely spined, exceeded by the very long ovipositor. Male, last ventral segment longer than the preceding, posterior margin concave; valve very small, rounded posteriorly; plates broad and long, spiny margins tapering to acute tips which are slightly exceeded by the short, sparsely spined pygofers.

Distribution: This species has not yet been reported from Kansas but should occur in the northeastern portion of the state.

Hosts: Unknown.

Lonatura nebulosa Ball.

Lonatura nebulosa Ball, Can. Ent., xxxii, p. 341, 1900.
Lonatura nebulosa Van D., Cat. Hemip. N. A., p. 652, 1917.

Form: Distinctly smaller than *noctivaga.* Length, 3 to 3.5 mm. Vertex nearly one-third wider than long, sloping, broadly rounding with front, obtuse apically. Pronotum longer than vertex, strongly convex anteriorly, lateral margins short, humeral margins distinctly angulate with the slightly emarginate posterior margin. Elytra short, covering all but two segments of abdomen, rounded apically, not reticulate.

Color: Straw colored; vertex with four large marginal black spots back of which are two brown transverse bands, and a brown spot basally, near each eye. Pronotum with a pair of light brown spots on anterior margin and very faint trace of the five light longitudinal lines. Elytra subhyaline, unspotted. Abdomen with transverse row of fuscous dots on middle of each segment and sometimes with lateral black markings. Pygofers marked with black above.

External genitalia: Female, last ventral segment shorter than the preceding, composed of two membranes, the inner broadly concave medially, only its lateral rounded angles visible from under the outer basally broad, but apically narrowed membrane which has the posterior margin truncate or slightly produced, and the disc distinctly elevated; pygofers long and somewhat narrow, widest at the middle, very bristly apically and exceeded by the ovipositor. Male, last ventral segment as long as the preceding, valve small, broad but short, rounded posteriorly; plates broad basally, spiny margins concavely narrowed to long acute apices which exceed the very short, very bristly pygofers.

Distribution: Taken in Cherokee county.

Hosts: Unknown.

Genus ACONURA Leth.

The members of this genus are usually yellowish or grayish species, small and robust. The vertex is broad, obtusely angulate, transversely depressed and rounding to the front. The pronotum is short, usually shorter than vertex and with posterior portion transversely wrinkled. There are some macropterous forms, but usually the elytra are very short, and with weak venation. The ovipositor is very long, and the male genitalia are characteristic due to the abnormally large, chitinous styles and œdagus. Many males also possess a very large dorsal spine at the tip of the hind tibiæ which seems to vary for the different species.

Several undetermined species belonging to this genus have been taken in Kansas, but at present we have been able to make sure of only two species.

KEY TO SPECIES.

A. Robust forms; female segment with large median lobes, pygofers of male rounded. *robusta.*

AA. More slender forms; female segment with a very short or no median lobe in the broad excavation, pygofers of male acute, ending in long chitinous processes. *argenteolus.*

Aconura robusta (Bak.).

Athysanella robusta Bak., Psyche, viii, p. 187, 1898.
Aconura robusta Van D., Cat. Hemip. N. A., p. 653, 1917.

Form: Bread and robust. Length, 3 to 4 mm. Vertex short, half broader than long, transverse depression distinct, very obtusely angled. Pronotum short, nearly three times as wide as long, lateral margins long, humeral margins indistinct, appearing like part of the medially emarginate posterior margin, covering the base of the elytra and the scutellum, making the latter appear small. Elytra short, reaching just beyond third abdominal segment, rounded apically, venation weak.

Color: Grayish-yellow; vertex lighter than rest of body, with small to large brown spot near margin half way between eye and apex. Pronotum and elytra in specimens at hand unmarked. Abdomen usually with transverse row of dark spots on anterior portion of each segment and with faint longitudinal lines.

External genitalia: Female, last ventral segment deeply emarginate between the long acute lateral angles, with a distinct tooth in the emargination, which, in our forms, does not reach quite half way to the tips of the lateral angles; pygofers long and narrow, very sparsely bristled, greatly exceeded by the very long ovipositor. Male, last ventral segment posteriorly emarginate; valve small, obtusely angled; plates broad and short, diverging, broadly rounding apically; pygofers broadly rounding apically. Apex of hind tibiæ with a large, acutely pointed, dorsal spine, which reaches to about the middle of the first tarsal segment.

Distribution: Specimens are at hand from Ottawa county.

Hosts: Taken in pastures where buffalo grass and *Bouteloua* abound.

Aconura argenteolus (Uhl.).

Deltocephalus argenteolus Uhl., Bul. U. S. Geol. Surv., iii, p. 473, 1877.
Deltocephalus argenteolus Bak., Psyche, viii, p. 119, 1897.
Aconura argenteolus Horv., Ann. Mus. Natl. Hung., vi, p. 567, 1908.
Aconura argenteolus Van D., Cat. Hemip. N. A., p. 653, 1917.

Form: More slender than preceding species. Length, 2.75 to 4.5 mm. Vertex as long or slightly longer than wide, transversely depressed, more pointed apically than *robusta.* Pronotum shorter than vertex, anterior margin convex, lateral margins parallel and long, humeral margins fusing with slightly concave posterior margin. Elytra short, covering third abdominal segment, or long, reaching to pygofers, there being both macropterous and brachypterous forms in both sexes, venation weak.

Color: When alive this species is bluish-green and silvered. The dead specimens are yellowish, unmarked, or with the dark colors of the body showing through the pronotum and elytra, and each abdominal segment with a transverse row of dots on anterior portion.

External genitalia: Female, last ventral segment short, broadly and deeply emarginated medially and sometimes with a small tooth in the middle of the emargination; pygofers long and narrow but greatly exceeded by the very long ovipositor. Male, valve large, triangular, apex obtuse; plates large, diverging, outer margin sinuate, inner margin broadly rounding to meet outer margin in a subacute apex; pygofers drawn out into long black chitinous points which run down between the plates.

Distribution: Ottawa, Greeley and Lane counties.

Hosts: Taken in very large numbers with the preceding species in pastures where buffalo grass and *Bouteloua* are the chief grasses.

Genus DRIOTURA O. & B.

The members of this genus are very robust forms with short heads, vertex twice as wide as long, and parallel-margined. Face broad and short, twice as wide above as at parallel-margined clypeus. The pronotum is very short, a little longer than the vertex, transversely striated on posterior two-thirds. Elytra rarely long, reaching to ovipositor, usually short, coriaceous and coarsely rugose, barely covering second abdominal segment. Abdomen short in male, much inflated in female.

Two species and a variety of this genus have been taken in Kansas.

KEY TO SPECIES.

A. Color black or brownish, usually unicolorous. *gammaroidea.*
AA. Color gray, vertex and pronotum marked with white. *robusta.*

Driotura gammaroidea (Van D.).

Athysanus gammaroidea Van D., Bul. Buf. Soc. Nat. Sci., v, p. 209, 1894.
Driotura gammaroidea O. & B., Proc. Dav. Acad. Sci., vii, p. 89, pl. 4, fig. 3, 1898.
Driotura gammaroidea Osb., 20th Rept. N. Y. St. Ent., p. 529, 1905.
Anoterostemma gammaroidea Horv., Ann. Mus. Natl. Hung., vi, p. 568, 1908.
Driotura gammaroidea Osb., Me. Agr. Exp. Sta., Bul. 238, p. 132, 1915.
Driotura gammaroidea DeL., Tenn. St. Bd. Ent., Bul. 17, p. 64, 1916.
Driotura gammaroidea Van D., Cat. Hemip. N. A., p. 654, 1917.
Driotura gammaroidea Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 74, 1919.

Form: Short and robust. Length, 3 to 4 mm. Vertex twice as wide as long, front margin more convex than posterior, broadly rounding with front. Pronotum very short, over three times as wide as long, lateral margins distinct, in brachypterous forms humeral margins seemingly a part of the slightly emarginate posterior margin, more distinct in macropterous forms. Scutellum small. Elytra rarely long, reaching the ovipositor, usually short, covering second abdominal segment, coriaceous and coarsely rugose. Abdomen broad, inflated in female.

Color: Shining black; vertex sometimes with reddish-brown markings, legs and ovipositor reddish-brown.

External genitalia: Female, last ventral segment longer than preceding, three times as wide as long, narrowed posteriorly, margins about parallel; pygofers broad and short, much exceeded by the very long ovipositor. Male, last ventral segment longer than preceding, emarginate posteriorly; valve broad, rounded posteriorly; plates broad, diverging from the base, broadly rounded apically, equalling the short pygofers.

Distribution: Taken in Pottawatomie and Cherokee counties.

Hosts: Doctor Ball informs me that *Grindelia* is the host plant of this species.

Driotura gammaroidea var. *fulva* Ball.

Driotura gammaroidea var. fulva Ball, Can. Ent., xxxv, p. 231, 1903.
Driotura gammaroidea var. fulva DeL., Tenn. Bd. Ent., Bul. 17, p. 64, 1916.
Driotura gammaroidea var. fulva Van D., Cat. Hemip. N. A., p. 654, 1917.

Form: In size and shape as in *gammaroidea.*

Color: Nearly uniformly reddish-brown. Last segment of abdomen and ovipositor dark. Eyes and ocelli dark.

Genitalia: As in *gammaroidea.*

Distribution: Reported from Cherokee county only.

Hosts: That of preceding form.

Driotura robusta O. & B.

Driotura robusta O. & B., Proc. Dav. Acad. Sci., vii, p. 87, pl. 4, fig. 4, 1898.
Driotura robusta Metc., Jl. Elisha Mitchell Soc., xxxi, p. 28, 1915.
Driotura robusta DeL., Tenn. St. Bd. Ent., Bul. 17, p. 64, 1916.
Driotura robusta Van D., Cat. Hemip. N. A., p. 654, 1917.
Driotura robusta Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 73, 1919.

Form: Slightly smaller than *gammaroidea.* Length, 2.75 to 3.5 mm. Vertex slightly longer than in *gammaroidea,* otherwise structure much the same.

Color: Vertex varying much in markings, sometimes being light yellow with several small dark spots, often the anterior part with a few black marks and the disc with two large irregular spots. Face light above with dark arcs, then greater part of front black, tip of front light, and clypeus with large black spot. Pronotum anteriorly black, posterior two-thirds white, sometimes partly blackened. Elytra black with the nervures and ramose lines white. Abdomen maculately black and white.

External genitalia: Female, last ventral segment twice as long as preceding, lateral margins broadly rounded with slightly medially emarginate posterior margin; pygofers wedge-shaped, much exceeded by the very long ovipositor. Male, last ventral segment longer than preceding, emarginate posteriorly; valve broad but short, rounded posteriorly;

plates broad, divergent, outer margin concave, inner margin broadly rounding to meet outer margin in obtuse apex; pygofers slightly exceeding plates, covered with short bristles.

Distribution: Taken in Pottawatomie county only.

Hosts: Doctor Ball informs me that *Grindelia* is the host plant of this species.

Genus EUSCELIS Brul.

The members of this genus are generally robust with the head slightly wider than the pronotum. The vertex may be distinctly angulate. The pronotum is rather short. The elytra are long in the forms with a transverse vertex, but usually short in the others. The ovipositor is rather uniformly short, thus distinguishing it from some nearly related genera. The genus is distinctly lacking in positive characters.

Twelve species of this genus have been reported from Kansas and are keyed below.

KEY TO SPECIES.*

A. Vertex transverse, much wider than long, margins nearly or quite parallel, anterior margin obtusely rounding to front.
  B. Size very large, 7 mm. or over. *magnus.*
  BB. Size smaller, 6 mm. or less.
    C. Ground color white, not greenish, margin of vertex with black spots. *exitiosus.*
    CC. Ground color green, vertex with transverse bands.
      D. Vertex slightly longer on middle than against eye, transverse band on vertex narrow and straight. *striolus.*
      DD. Margins of vertex strictly parallel; transverse band on vertex broader, parallel with the margins. *parallelus.*

AA. Vertex not distinctly transverse, usually produced and angulate; anterior margin meeting front at an angle.
  B. Vertex distinctly wider than its middle length.
    C. Markings of vertex in form of transverse lines or absent.
      D. Species stout, elytra shorter than or only slightly exceeding abdomen, central anteapical cell rarely constricted.
        E. Straw-colored species. *extrusus.*
        EE. Black species.
          F. Vertex distinctly angular, nearly twice as long on middle as against eye; a yellow band at base of vertex and usually the nervures yellow. *uhleri.*
          FF. Vertex rounding, but little longer on middle than at eye. *anthracinus.*

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* Adapted from key by Osborn & Ball, Ohio Nat., ii, pp. 231-257, 1902.

AA. Vertex not distinctly transverse—*concluded.*

DD. Species more elongate, elytra longer than abdomen; anterior and middle legs with the black femora orange-tipped. *striatulus.*

CC. Margin of vertex with four black spots; pronotum striped with black and with four stripes on each elytron. *comma.*

BB. Vertex narrow, its basal width rarely equal to its middle length.

C. Face marked with a fuscous "Y"; ovipositor rarely extending beyond elytra. *curtisii.*

CC. Face without fuscous "Y"; ovipositor usually extending beyond elytra.

D. Face with a transverse white band below eyes, pronotum black and yellow. *bicolor.*

DD. Face unicolorous; pronotum with a row of submarginal spots. *obtutus.*

Euscelis magnus (O. & B.).

Athysanus magnus O. & B., Ia. Acad. Sci., iv, p. 225, pl. 26, fig. 2, 1897.
Athysanus magnus O. & B., Ohio Nat., ii, p. 273, 1902.
Euscelis magnus Van D., Cat. Hemip. N. A., p. 655, 1917.

Form: Very large and robust, by far the largest member of the genus. Length, 7 to 8.5 mm. Vertex practically parallel-margined, four times as wide as long, broadly rounding with front. Pronotum transverse, about three times as wide as long, nearly parallel-margined, lateral margins long and parallel, humeral margins broadly rounding with emarginate posterior margin, disc distinctly transversely wrinkled. Elytra broad, but distinctly exceeding the abdomen.

Color: Ashy-gray; vertex yellowish, sparsely irrorate, with brown along anterior and posterior margins, so that there seems to be a light transverse band between. Pronotum brownish, with a transverse yellow band just back of the middle. Elytra with light nervures marked with brown, the center of the cells irrorate with brown and the costal margin yellowish-white. Face yellow, irrorate with brown.

External genitalia: Female, last ventral segment scarcely longer than the preceding, lateral margins produced and broadly rounded, posterior margin deeply and broadly emarginate between the lateral lobes, slightly produced medially and with a distinct notch, so that there seem to be two small median lobes; pygofers robust and long, nearly equalling ovipositor, with a distinct longitudinal depression on the sides along apical third, bearing a few short spines distally. Male, valve triangular, narrow, about half the length of the last ventral segment, apex obtuse; plates nearly three times the last ventral segment, spiny margins rounding basally, then tapering to long acute tips which exceed the short bristly pygofers.

Distribution: Specimens are at hand from Douglas and Neosho counties. Reported also from Pottawatomie county.

Hosts: Osborn and Ball report taking this species from *Spartina cynosuroides* exclusively.

Euscelis exitiosus (Uhl.).

(Pl. 12, figs. 9-10.)

Cicadula exitiosa Uhl., Am. Ent., iii, p. 72, 1880.
Limotettix exitiosa Van D., Psyche, v, p. 306, 1892.
Eutettix exitiosus O. & B., Hemip. Colo., p. 100, 1895.
Athysanus exitiosus O. & B., Ohio Nat., ii, p. 234, pl. 16, fig. 2, 1902.
Athysanus exitiosus Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 86, fig. 21, 1912.
Athysanus exitiosa Will., Kans. Univ. Sci. Bul., viii, p. 226, 1913.
Phrynomorphus exitiosus Barb., Bul. Am. Mus. Nat. Hist., xxxiii, p. 534, 1914.
Athysanus exitiosus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 60, 1916.
Euscelis exitiosus Van D., Cat. Hemip. N. A., p. 655, 1917.
Euscelis exitiosus Fent., Ohio Jl. Sci., xviii, No. 6, p. 185, 1918.
Euscelis exitiosus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 70, 1919.

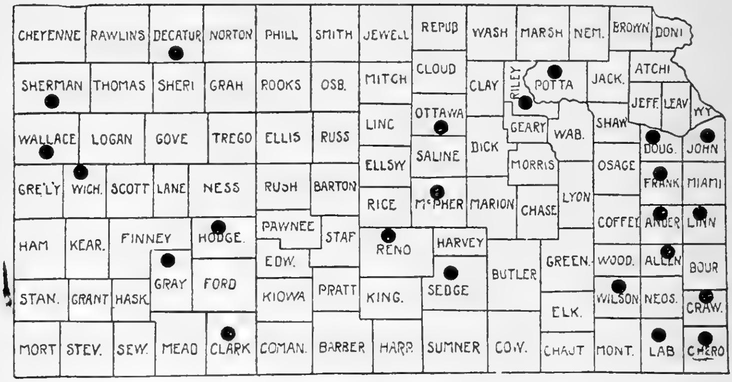
Form: Varying greatly in size. Length, 3.5 to 5.5 mm. Vertex one-third longer on middle than next the eye, over twice as broad as long, broadly rounding with front, obtusely angled at apex. Pronotum one-third longer than vertex, lateral margins short, posterior margin distinctly emarginate. Elytra greatly exceeding the abdomen, somewhat flaring apically, appendix large, extending entirely around the end of the wing.

Color: Varying greatly from quite light to dark forms. Vertex pale, with orange-yellow tinge, especially apically, with two black spots on margin, two black spots, usually fused into a line across the basal angle, and a brown crescent between the eyes, parallel to the anterior margin. Pronotum light brown with four black spots behind anterior margin, disc darker. Scutellum yellowish with black basal angles and a brown divided median line. Elytra milky, hyaline, nervures brown and distinct. Face light, marked with brown arcs.

External genitalia: Female, last ventral segment twice as long as preceding, posterior margin truncate or slightly emarginate; pygofers rather long and narrow, greatly exceeded by the ovipositor, sparsely spined. Male, valve small and triangular, apex obtuse; plates narrow and long, three times as long as the valve, divergent, submarginally spiny, exceeding the pygofers.

Internal male genitalia: Styles with long anterior process and stout process to connective, then narrowing rapidly to about the middle, the margins then about parallel up to the much bent terminal hook; connective slender, Y-shaped, the arms slightly longer than the stem which widens distally; œdagus with basal portion broad and triangular when viewed dorsally, terminal process heavy, widest at middle, ending in a blunt hook.

Distribution: One of the commonest Kansas species and found throughout the state as shown by the following map:



Hosts: Abundant on grasses and weeds and attracted to the lights in great numbers. A distinctly economic species.

Euscelis striolus (Fall.).

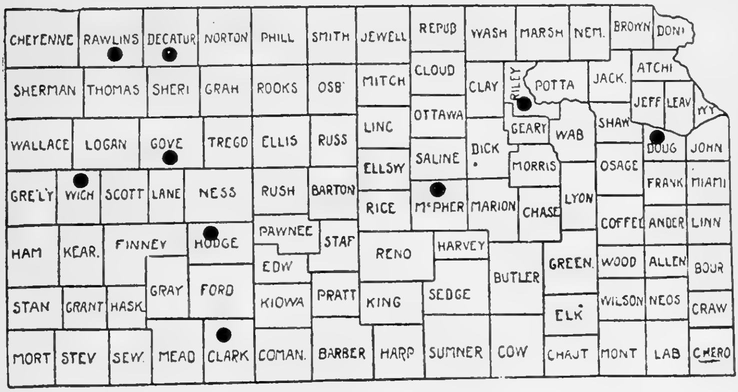
Cicada striola Fall., Acta Holm, xxvii, p. 31, 1806.
Jassus frenatus Germ., Mag. d. Ent., iv, p. 86, 1821.
Jassus striola Flor, Rhyn. Livl., ii, p. 315, 1861.
Limotettix striola Sahlb., Cicad., p. 226, 1871.
Athysanus striolus Fieb., Kat. Eur., Cicad., p. 12, 1872.
Athysanus striola O. & B., Proc. Dav. Acad. Sci., vii, p. 91, pl. 5, fig. 4, 1898.
Athysanus striolus O. & B., Ohio Nat., ii, p. 235, 1902.
Athysanus striolus Osb., 20th Rept. N. Y. St. Ent., p. 527, 1905.
Athysanus striolus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 132, 1915.
Euscelis striolus Van D., Univ. Calif. Publ., Div. Ent., Tech. Bul., i, p. 249, 1916.
Euscelis striolus Van D., Cat. Hemip. N. A., p. 656, 1917.

Form: Long and narrow, resembling an *Idiocerus.* Length, 3.5 to 5 mm. Head wider than pronotum; vertex slightly longer on middle than next the eye, over twice as wide as long, broadly rounding to front. Pronotum not quite twice the length of the vertex, twice as broad as long, lateral margins very short, posterior margin slightly emarginate. Elytra long, greatly exceeding abdomen, appendix large, nervures indistinct.

Color: Greenish; vertex with a rather narrow transverse black stripe just behind the reddish ocelli, not parallel with the margin, having broad green bands before and behind, the margin of vertex showing the topmost of the black facial arcs. Pronotum a little darker than the vertex or the scutellum, the latter with a black transverse impressed line. Elytra pale green, often clouded with fuscous apically. Face greenish, with sutures and arcs of front, black.

External genitalia: Female, last ventral segment twice as long laterally as preceding, lateral margins convex, posterior margin roundingly emarginate to about one-third the distance to the base; pygofers long and narrow, nearly or quite equalling the ovipositor, fairly spiny, especially apically. Male, valve broad, over half longer than last ventral segment, obtusely angled apically; plates together forming a triangle about as long as broad, three times as long as the valve, obtuse apices somewhat divergent. Margins heavily and surface sparsely spined.

Distribution: Occurs throughout the state as shown by the following map:



Hosts: Professor Osborn records sweeping this species from grasses in low, boggy places; Van Duzee from sweeping meadows and pasture lands.

Euscelis parallelus (Van D.).

Athysanus parallelus Van D., Can. Ent., xxiii, p. 169, 1891.
Limotettix parallelus Van D., Psyche, vi, p. 306, 1892.
Athysanus parallelus O. & B., Ohio. Nat., ii, p. 235, 1902.
Euscelis parallelus Van D., Cat. Hemip. N. A., p. 653, 1917.

Form: Resembling *striolus* but larger and broader. Length, 5.25 to 6 mm. Head distinctly wider than pronotum; vertex not produced as in *striolus* but parallel-margined, two and one-half times as wide as long, broadly rounding to face. Pronotum about twice as long as vertex, lateral margins short, posterior margin very slightly emarginate. Elytra long and narrow, appendix large, apically flaring.

Color: Greenish; vertex pale yellow or greenish, with a heavy transverse band between the eyes, leaving only a narrow green band in front and a band about as wide as itself behind. Pronotum pale green, anterior margin narrowly black and sometimes the entire disc is darkened or even quite black, transverse striations distinct on disc. Scutellum pale yellow, unmarked, or with two black dots. Elytra usually pale green with lighter nervures, but often the elytra appear dark brown, due to the darkening of the cells. Face with the sutures, a line on the clypeus and the arcs on the front, black.

External genitalia: Female, last ventral segment nearly twice the length of the preceding, posterior margin slightly rounding, with a wide median incision reaching nearly to the middle; pygofers rather robust, equalling ovipositor, well covered with spines. Male, valve as broad and as long as last ventral segment, obtusely angled apically; plates very broad and stout, about twice as long as the valve, outer margins rounding to the very broad and slightly divergent apices, the whole ventral surface thickly covered with spines; pygofers completely hidden.

Distribution: Seemingly confined to the eastern portion of the state, as shown by its occurrence in Cherokee, Pottawatomie, Riley and Russell counties.

Hosts: Taken sweeping grasses and weeds.

Euscelis extrusus (Van D.).

Athysanus extrusus Van D., Can. Ent., xxv, p. 283, 1893.
Athysanus extrusus O. & B., Proc. Dav. Acad. Sci., vii, p. 92, pl. 6, fig. 1, 1898.
Athysanus extrusus O. & B., Ohio Nat., ii, p. 237, 1902.
Athysanus venosus Osb., 20th Rept. N. Y. St. Ent., p. 526, 1905.
Athysanus extrusus Osb., 20th Rept. N. Y. St. Ent., p. 527, 1905.
Athysanus extrusus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 127, 1915.
Athysanus extrusus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 61, 1916.
Euscelis extrusus Van D., Cat. Hemip. N. A., p. 656, 1917.

Form: Short and very robust. Length, 4.25 to 5.5. mm. Head as wide as pronotum; vertex twice as long on middle as next the eye, over one-third wider than long, obtusely angled apically. Pronotum short, equalled in length by the vertex, nearly three times as wide as long, lateral margins long, humeral margins broadly rounding with emarginate posterior margin, disc transversely wrinkled. Elytra short and broad, broadly rounding apically, just equalling abdomen in the macropterous female, and equalling or slightly exceeding it in the macropterous male, in brachypterous females leaving last abdominal segments and pygofers exposed.

Color: Yellowish, marked with fuscous and black. Vertex pale yellow with five dark triangular spots and with base of inner margin of eye fringed with black. Pronotum and scutellum yellowish marked with light brown. Elytra with nervures light, usually strongly bordered with fuscous. Face pale, the suture, two lines on the clypeus and the arcs on the front, black.

External genitalia: Female, last ventral segment twice the length of the preceding, narrowed posteriorly, lateral angles produced, between which the posterior margin is broadly and deeply excavated; pygofers broad, equalling ovipositor, sparsely spined. Male, valve triangular, as long as last ventral segment, obtusely angled apically; plates broad, three times as long as valve, lateral margins parallel, inner margins roundingly divergent to meet lateral margins in an obtuse apex, sparsely spined along margin and surface, more spiny apically; pygofers very characteristic, compressed beneath the plates, terminating in long style-like processes which extend beyond the plates by the length of the latter.

Distribution: Hitherto taken in Douglas county only.

Hosts: A grass species.

Euscelis uhleri (Ball).

Athysanus uhleri Ball, Can. Ent., xliii, p. 200, 1911.
Athysanus plutonius Prov., Pet. Faune Ent. Can., iii, p. 282, 1889.
Athysanus plutonius O. & B., Ohio Nat., ii, 240, pl. 16, fig. 3, 1902.
Athysanus plutonius Osb., 20th Rept. N. Y. St. Ent., p. 528, 1905.
Athysanus plutonius Osb., Me. Agr. Exp. Sta., Bul. 238, p. 126, 1915.
Euscelis uhleri Van D., Cat. Hemip. N. A., p. 657, 1917.

Form: Robust, widening distally. Length, 4 to 4.5 mm. Vertex nearly twice as long on middle as next the eye, twice as long as broad, obtusely angled apically, margins straight. Pronotum half longer than vertex. lateral margins short, posterior margin slightly emarginate, disc transversely wrinkled. Elytra moderately long, equalling or slightly exceeding abdomen, broad, nearly truncate posteriorly.

Color: Black; vertex with broad line, a spot against either eye, several apical and preapical spots, yellow. Pronotum with a few yellow spots. Scutellum with yellow spots along margin and at apex, two curved basal lines on either side of the middle. Elytra with nervures broadly yellow. All the above yellow markings may be lacking, resulting in a shining black form. On the other hand, the yellow markings may be much stronger and the elytra may be smoky or fuscous with the nervures broadly margined with fuscous. Face black with yellow arcs and sometimes with yellow spots. Front and middle legs yellow from tip of femora on.

External genitalia: Female, last ventral segment a little longer than the preceding, lateral angles produced, subacute, between them the posterior margin is widely emarginate, the middle portion slightly roundingly produced; pygofers broad and short, exceeded by the ovipositor, sparsely spined on distal half. Male, valve about half as long as last ventral segment, rounding posteriorly; plates about two and one-half times as long as valve, tapering to subacute apices which exceed the pygofers.

Distribution: Reported from Riley county.

Hosts: Taken from grasses.

Euscelis anthracinus (Van D.).

Athysanus anthracinus Van D., Can. Ent., xxvi, p. 136, 1894.
Athysanus anthracinus O. & B., Ohio Nat., ii, p. 241, 1902.
Athysanus anthracinus Osb., 20th Rept. N. Y. St. Ent., p. 528, 1905.
Athysanus anthracinus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 126, 1915.
Athysanus anthracinus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 61, 1916.
Euscelis anthracinus Van D., Cat. Hemip. N. A., p. 658, 1917.
Euscelis anthracinus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 71, 1919.
(*Schleroracus anthracinus* Uhl. MS.) in litt.
(*Conogonus gagates* Ashm. MS.) Osb., Proc. Ia. Acad. Sci., l, pt. 2, p. 126, 1892.

Form: Much like preceding species. Length, 3.5 to 4.5 mm. Vertex slightly longer on middle than against eye, two to two and one-half times as wide as long, and obtusely conical and broadly rounding with front, blunter apically than *uhleri*. Pronotum about twice as long as vertex, lateral margins short, posterior margin distinctly concave, disc transversely wrinkled. Elytra broad, exceeding abdomen, broadly rounding and slightly flaring apically.

Color: Shining black; vertex with ocelli, two basal spots and sometimes an apical spot, yellow. Face with a few yellow arcs on front. Front and middle legs yellow from the apex of the femora.

External genitalia: Female, last ventral segment slightly longer than preceding, posterior margin broadly and shallowly emarginate, slightly produced medially, lateral angles obtuse; pygofers broad, nearly or quite equalling ovipositor, sparsely spined on distal half. Male, valve broad, triangular, very obtuse apically, nearly or quite as long as last ventral segment; plates over twice the length of the valve, roundingly triangular to blunt apices, margins and tips spiny, equalling the apically rounding pygofers.

Distribution: Seemingly found only in the eastern portion of the state as shown by its occurrence in Douglas, Pottawatomie, Linn and Chautauqua counties.

Hosts: A grass species.

Euscelis striatulus (Fall.).

Cicada strialuta Fall., Hemip. Suec., Cicad., p. 45, 1826.
Jassus striatulus Flor., Rhyn. Livl., ii, p. 361, 1861.
Limotettix striatula Sahlb., Cicad., 253, 1871.
Jassus plutonius Uhl., Bul. U. S. Geol. Geog. Surv., iii, p. 470, 1877.
Athysanus striatulus Mel., Cicad. Mitt. Eur., p. 264, 1896.
Thamnotettix striatulus Edw., Hemip. Homop. Brit. Isds., p. 172, pl. 19, fig. 9, 1896.
Athysanus striatulus O. & B., Proc. Dav. Acad. Sci., vii, p. 91, pl. 5, fig. 3, 1898.
Athysanus vaccinii O. & B., Ohio Nat., ii, p. 242, 1902.
Athysanus vaccinii Osb., 20th Rept. N. Y. St. Ent.. p. 528, 1905.
Athysanus vaccinii Osb., Me. Agr. Exp. Sta., Bul. 238, p. 130, 1915.
Euscelis striatulus Van D., Cat. Hemip. N. A., p. 658, 1917.

Form: Rather long and slender, especially the males. Length, 3.5 to 4.5 mm. Vertex about one-fourth longer on middle than near the eyes, twice as wide as long, disc sloping and broadly rounded with front, apex obtusely angled. Pronotum nearly or fully twice the length of the vertex, lateral margins short, posterior margin slightly emarginate. Elytra long, much exceeding the abdomen, somewhat flaring.

Color: Vertex, pronotum and scutellum dirty or greenish-yellow. Vertex with two curved marginal lines, a median transverse band and posteriorly a band or a row of two or four spots, brown. Pronotum irregularly marked with brown spots, often a row of them near and parallel to the anterior margin. Scutellum pale or marked with brown spots, basal angles often marked with orange-brown. Elytra greenish-brown, nervures light and narrowly fuscous-margined. Face light, with sutures and arcs black. Basal two-thirds of femora black, apices and tibiæ yellow.

External genitalia: Female, last ventral segment slightly longer than the preceding, posterior margin emarginate between the produced lateral angles and slightly rounding in the middle; pygofers broad, slightly exceeded by the ovipositor, spiny on distal half. Male, valve broad, triangular, obtusely angled apically, three-fourths as long as last ventral segment; plates triangular, over twice as long as the valve, spiny margins convexly narrowing to subacute apices which exceed the pygofers.

Distribution: Taken in Pottawatomie county only.

Hosts: A prairie grass species.

This is the form that Osborn & Ball identify as *Euscelis vaccinii* (Van D.). In his catalog Mr. Van Duzee, while still giving *Euscelis striatulus* (Fall.) and *Euscelis vaccinii* (Van D.) separate numbers, remarks that they are probably not distinct. If this is true then of course Fallen's name stands. Dr. Ball, however, thinks they are separate species and that the form described above is *Euscelis vaccinii* (Van D.). Until some one goes into a careful study of the two above species, *Euscelis instabilis* (Van D.) and probably others, it might be well to follow Van Duzee's synonomy.

Euscelis comma (Van D.).

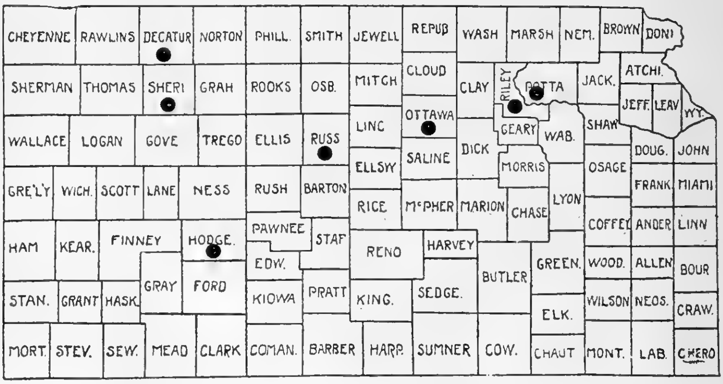
Athysanus comma Van D., Can. Ent., xxiv, p. 114, 1892.
Athysanus comma O. & B., Proc. Ia. Acad. Sci., iv, p. 223, 1897.
Athysanus comma O. & B., Ohio Nat., ii, p. 246, pl. 17, fig. 1, 1902.
Euscelis comma Van D., Cat. Hemip. N. A., p. 660, 1917.

Form: Broad and stout. Length, 4 to 5 mm. Vertex three-fourths longer on middle than next the eye, almost twice as wide as long, disc flat, obtusely rounding with front, obtusely angled apically. Pronotum one-third longer than vertex, two and one-half times as wide as long, lateral margins long, humeral margins fused with slightly emarginate posterior margin. Elytra long, exceeding the abdomen, parallel-margined or short and somewhat flaring, reaching the last abdominal segment, venation indistinct.

Color: Creamy, marked with black and brown. Vertex with four large black marginal spots which extend on to the front, and two large basal ones. Pronotum with four black longitudinal lines, the inner pair extending across the scutellum. Elytra pale with black or dark brown lines on claval suture, around apex, and along inner branch of first sector. Fulvous brown bands are found on the clavus, dividing anteriorly to meet the lines on the pronotum and scutellum, and one parallel with the outer and posterior margin. In the brachypterous forms a large black comma is found on either side of the pygofer. Face and below pale with a black spot below the antennæ, a pair below the lateral margins of the pronotum and a stripe on the lateral margin of the connexivum.

External genitalia: Female, last ventral segment half longer than the preceding, lateral angles obtuse and produced, posterior margin roundingly emarginate with a black-margined median slit; pygofers broad and stout, slightly exceeded by the ovipositor, sparsely spined. Male, valve large, triangular, apex very obtuse or truncated, sides notched; plates twice the length of the valve, margins rounding basally to the middle, then nearly parallel to the truncate apices which nearly or quite equal the robust and short pygofers.

Distribution: Probably occurs throughout the state as shown by the following map:



Hosts: Osborn and Ball give *Elymus canadensis* as the host of this species.

Euscelis curtisii (Fh.).

Amblycephalus curtisii Fh., Homop. N. Y. St. Cab., p. 61, 1851.
Tettigonia curtisii Walk., List Homop., iv, p. 1159, 1852.
Jassus nervatus Prov., Nat. Can., iv, p. 378, 1872.
Deltocephalus curtisii Prov., Pet. Faune Ent. Can., iii, p. 278, 1889.
Athysanus curtisii Van D., Psyche, v, p. 290, 1890.
Athysanus curtisii Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 126, 1892.
Athysanus curtisii O. & B., Proc. Ia. Acad. Sci., iv, p. 221, 1897.
Athysanus curtisii O. & B., Proc. Dav. Acad Sci., vii, p. 91, pl. 5, fig. 1, 1898.
Athysanus curtisii O. & B., Ohio Nat., ii, p. 251, 1902.
Athysanus curtisii Osb., 20th Rept. N. Y. St. Ent., p. 529, 1905.
Athysanus curtisii Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 91, fig. 22, 1912.
Athysanus curtisii Osb., Me. Agr. Exp. Sta., Bul. 238, p. 125, 1915.
Athysanus curtisii DeL., Tenn. St. Bd. Ent., Bul. 17, p. 62, 1916.
Euscelis curtisii Van D., Cat. Hemip. N. A., p. 660, 1917.
Euscelis curtisii Fent., Ohio Jl. Sci., xviii, No. 6, p. 185, 1918.

Form: Short and stout. Length, 3 to 3.5 mm. Vertex one-half longer on middle than against eye, about as wide as long, broadly rounding with front, right-angled apically. Pronotum slightly longer than vertex, lateral margins very short, humeral margins distinct, long, posterior margin very slightly emarginate. Elytra broad and short, usually equalling or exceeding the abdomen, venation simple.

Color: Vertex yellow with two large black spots before the middle and sometimes black marks apically. Pronotum with broad, shining, black anterior band, a wide median yellow band and a narrow, black posterior one. Scutellum yellow, with two brown spots on the disc. Elytra fuscous or nearly black, margins and all nervures but those of the apical cells broadly greenish-yellow. Face pale with dark spot on apex of front, dark stripes on margins of front and on clypeus, forming a black Y.

External genitalia: Female, last ventral segment half longer than preceding, composed of two membranes, the rounding lateral angles only of the inner one showing from under the posteriorly narrowed outer membrane, whose posterior margin is slightly emarginate with sometimes a very small median lobe; pygofers robust, nearly or fully equalling the ovipositor, sparsely spiny. Male, valve broad, as long as last ventral segment, posterior margin rounding; plates together forming a triangle about as broad as long, spiny margins convexly narrowing to acute apices which exceed the spiny pygofers.

Distribution: Taken in Cherokee, Douglas and Riley counties.

Hosts: A very common blue-grass species.

Euscelis bicolor (Van D.).

(Pl. 13, figs. 1-2.)

Athysanus bicolor Van D., Can. Ent., xxiv, p. 114, 1892.
Deltocephalus virgulatus Uhl., Proc. Zoöl. Soc. Lond. for 1895, p. 78.
Athysanus bicolor O. & B., Proc. Ia. Acad. Sci., iv, p. 222, 1897.
Athysanus bicolor O. & B., Proc. Dav. Acad. Sci., vii, p. 91, pl. 5, fig. 2, 1897.
Athysanus bicolor O. & B., Ohio Nat., ii, p. 251, 1902.
Athysanus bicolor Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 92, fig. 23, 1912.
Athysanus bicolor DeL., Tenn. St. Bd. Ent., Bul. 17, p. 62, 1916.
Euscelis bicolor Van D., Cat. Hemip. N. A., p. 661, 1917.
Euscelis bicolor Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 71, 1919.

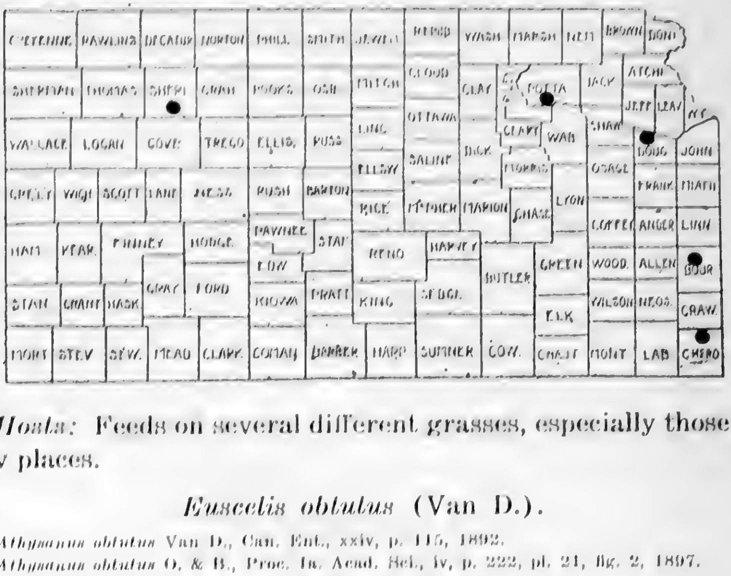
Form: Very much like *curtisii.* Length, 3 to 3.5 mm. Vertex narrower than in *curtisii,* about as wide as long, one-half longer on middle than against eye, conical apically. Pronotum as long as the vertex, lateral margins very short, humeral margins long, posterior margin barely emarginate. Elytra rather short and broad, rounding apically, venation simple.

Color: Vertex yellow, with a pair of large black spots on anterior half in the female which may be confluent and cover the entire anterior half of the vertex as is the case in the male. Pronotum with anterior margin black, the remainder bright yellow. Elytra greenish-yellow with humeral, sutural and apical margins and claval suture fuscous or black, and sometimes with subhyaline and fuscous arcs extending obliquely backward from the costal margins. Face black or fuscous above, pale below, a fuscous lower band sometimes present in the male.

External genitalia: Female, last ventral segment about as long as the preceding, posterior margin angularly emarginate; pygofers moderately robust, widest at the middle, much exceeded by the long ovipositor, very sparsely spined. Male, valve very small, forming an equilateral triangle one-third as wide as the last ventral segment; plates small, short, little longer than the valve, together nearly semicircular, their margins spiny; pygofers exceeding the plates, light apically.

Internal male genitalia: Styles with long, parallel-margined process to connective, a large quadrangular lateral process at about the middle, a distinct notch on the inner margin at the base of the finger-like, granular, terminal process; connective, with sides close together for a short distance at the base, then spreading and running parallel to tip where they fuse and join the long ædagus which narrows to the acute, bifurcated apex, the points close together at the tips, a circular excision between them basally.

Distribution: Common in eastern portion of the state as shown by the following map:



Hosts: Feeds on several different grasses, especially those in low places.

Euscelis obtutus (Van D.).

Athysanus obtutus Van D., Can. Ent., xxiv, p. 115, 1892.
Athysanus obtutus O. & B., Proc. Ia. Acad. Sci., iv, p. 222, pl. 21, fig. 2, 1897.
Athysanus obtutus O. & B., Ohio Nat., ii, p. 252, 1902.
Athysanus obtutus Osb., U. S. Dept. Agr., Div. Ent., Bul. 108, p. 93, fig. 24, 1912.
Phrynomorphus obtutus Barb., Bul. Am. Mus. Nat. Hist., xxxiii, p. 534, 1914.
Athysanus obtutus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 63, 1916.
Euscelis obtutus Van D., Cat. Hemip. N. A., p. 661, 1917.
Euscelis obtutus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 72, 1919.

Form: Much like *bicolor*. Length, 3 to 3.5 mm. Vertex longer and narrower than in *bicolor*, slightly longer than wide, conical apically. Pronotum about as long as vertex, lateral margins very short, humeral margins long, posterior margin very slightly emarginate, disc transversely wrinkled. Elytra rather narrow, apex rounding, not reaching tip of ovipositor and much exceeding abdomen in male.

Color: Vertex brownish, with a pair of large round black spots on disc and usually a smaller pair behind them. Pronotum brownish, with a row of small dark spots near and parallel to anterior margin. Scutellum with four dark spots along base. Elytra fuscous, subhyaline, nervures pale except for the apical ones, which are strongly fuscous. Face brownish, with darker stripes and sometimes the apex of the clypeus fuscous.

External genitalia: Female, last ventral segment about the length of the preceding, posterior margin slightly emarginate; pygofers rather narrow, much exceeded by the long ovipositor, very sparsely spined. Male, valve very small, equilaterally triangular, one-third as wide as last ventral segment; plates but little exceeding the valve, bristly margins broadly rounding, exceeded by the pygofers.

Distribution: Taken in Cherokee, Douglas and Riley counties.

Hosts: Osborn and Ball give *Andropogon scoparius* as a host plant. It likely occurs on other grasses also.

Genus EUTETTIX Van D.

Doctor Ball characterizes this genus as follows:

"Rather stout, head of about the same width as pronotum. Vertex rather short, slightly sloping, distinctly transversely depressed, the apex often slightly concavely upturned. Elytra moderately long, usually slightly flaring, venation simple, only one cross nervure between the sectors. Elytra without supernumerary veinlets or ramose lines, or with these reduced or aggregated into oblique bands."

Mr. Van Duzee adds *E. cinctus* O. & B. to this group. It usually has but one cross nervure between the sectors, but has supernumerary veinlets to the costa.

The six species keyed below have been taken in Kansas.

KEY TO SPECIES.*

A. Elytra without distinct transverse bands.
- B. Large species, over 5 mm. long, elytra black, with large yellow commissural spot. *pictus.*
- BB. Small species, less than 4 mm. long, pale yellowish-green. *tenellus.*

AA. Elytra with oblique bands, obscure in *albidus.*
- B. Elytra with oblique bands distinct.
  - C. Anterior half of elytra white or but faintly reticulated. *seminudus.*
  - CC. Anterior half of elytra distinctly marked.
    - D. Insect reddish, no oblique spot on base of clavus. *strobi.*
    - DD. Insect not reddish, a black oblique spot on base of clavus. *cinctus.*
- BB. Elytra without distinct oblique band, with whole elytra sparsely reticulate. *albidus.*

* Adapted from key by Doctor Ball, Proc. Dav. Acad. Sci., xii, p. 31, 1907.

Eutettix pictus Van D.

Eutettix pictus Van D., Trans. Am. Ent. Soc., xix, p. 301, 1892.
Eutettix magnus Osb., Ent. News, xi, p. 395, 1900.
Eutettix subænea var *picta* Ball, Proc. Dav. Acad. Sci., xii, p. 34, pl. 1, fig. 1, 1907.
Eutettix subænea var *picta* DeL., Tenn. St. Bd. Ent., Bul. 17, p. 65, 1917.
Eutettix pictus Van D., Cat. Hemip. N. A., p. 663, 1917.
Eutettix pictus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 75, 1919.

Form: Large and robust. Length, 5 to 7 mm. Vertex little longer on middle than next the eyes, over twice as wide as long, disc sloping to a preapical transverse depression, then elevated, sloping portion longitudinally striated, raised portion transversely striated. Pronotum over twice as broad as long, lateral margins shorter than the humeral, posterior margin slightly emarginate, disc transversely wrinkled. Scutellum broad, elytra moderately long, exceeding the abdomen, venation simple, only one cross nervure between the sectors.

Color: Vertex, pronotum and scutellum lemon-yellow; anterior half of pronotum dark brown or black, a band of like color across the pronotum just in front of the yellow posterior margin. Elytra dark brown or black, a common oval spot on the suture before the apex of clavus and anterior two-thirds of costal margin, pale yellow, these varying greatly in size, sometimes absent. Sometimes a large hyaline spot before the apex. Face in males dark, in females black above and below but light in the middle.

External genitalia: Female, last ventral segment half longer than preceding, posterior margin shallowly emarginate on either side of a small median lobe; pygofers broad, exceeded by the ovipositor, slightly spined. Male, valve broad, triangular, margins concave just before the subacute apex; plates large, convex, over three times as long as the valve, spiny margins rounding to blunt apices which equal the pygofers.

Distribution: Taken in Cherokee county only.

Hosts: De Long reports this species from oak shrubs.

Eutettix tenellus (Bak.).

Thamnotettix tenellus G. & B., Hemip. Colo., p. 100, 1895 (MS. name).
Thamnotettix tenellus Bak., Psyche, vii, Suppl., p. 24, 1896.
Eutettix tenella Ball, U. S. Dept. Agr., Bur. Ent., Bul. 66, pt. 4, p. 35, pl. 1, fig. 1, 1904.
Eutettix tenella Ball, Proc. Dav. Acad. Sci., xii, p. 41, pl. 1, fig. 11, pl. 4, figs. 4, 5, 1907.
Eutettix tenella Essig, Inj. Benef. Ins. Calif., edn. 2, p. 64, 1915.
Eutettix tenella Smith & Boncq., Phytopathology, v, p. 335, 1915.
Eutettix tenella Boncq. & Hart., Phytopathology, p. 348, 1916.
Eutettix tenellus Van D., Cat. Hemip. N. A., p. 664, 1917.
Eutettix tenella Ball, Utah Agr. Col. Exp. Sta., Bul. 155, 1917.
Eutettix tenella Ser. & Thom., Jl. Ec. Ent., xi, p. 308, 1918.
Eutettix tenella Sev. & Thom., Jl. Ec. Ent., xi, p. 308, 1918.
Eutettix tenella Stahl & Carsn., Jl. Agr. Research, xiv, p. 393, 1918.
Eutettix tenella Sev., Jl. Ec. Ent., xii, pp. 303, 312, 1919.
Eutettix tenella Sev., Facts About Sugar, 8, Nos. 7-13, 1919.

Form: Length, 3 to 3.5 mm. Vertex one-fourth longer on middle than next the eye, about twice as wide as long, transverse depression lacking or obscure, broadly rounding with front, apex rounding. Pronotum twice as long as vertex, lateral margins very short. Elytra long, greatly exceeding the abdomen.

Color: Pale yellowish-green. Vertex yellowish or pale orange-yellow. Pronotum pale green, the disc darker than the margins. Scutellum greenish-yellow. Elytra greenish-yellow, subhyaline, the black abdomen showing through. Face yellowish.

External genitalia: Female, last ventral segment about as long as the preceding, lateral angles broadly rounded and slightly produced, median portion of posterior margin slightly produced, with a semicircular excision reaching about half way to the base; pygofers long, slightly exceeded by ovipositor, sparsely spined on apical third. Male, valve large, semicircular or truncated apically; plates together wider than long, submarginally spined, margins practically parallel to the broad, roundingly truncate apices which are slightly exceeded by the pygofers.

Distribution: The only specimens at hand are from Clark county. This species probably occurs in other southwestern counties.

Hosts: This is the well-known leaf hopper of the sugar beet. Wherever the latter are grown this species is of great economic importance as shown by Ball's work.

Eutettix seminudus (Say).

(Pl. 13, figs. 5-6.)

Jassus seminudus Say, Jl. Acad. Nat. Sci. Phila., vi, p. 307, 1831; Compl. Writ., ii, p. 383.

Bythoscopus seminudus Fh., Homop. N. Y. St. Cab., p. 58, 1851.

Thamnotettix seminudus Uhl., Stand. Nat. Hist., ii, p. 246, 1884.

Athysanus seminudus Van D., Psyche, v, p. 389, 1890.

Eutettix seminudus Van D., Psyche, vi, p. 307, 1892.

Eutettix seminudus Osb., 20th Rept. N. Y. St. Ent., p. 529, 1905.

Eutettix seminuda Ball, Proc. Dav. Acad. Sci., xii, p. 42, pl. 2, fig. 1, 1907.

Eutettix seminuda DeL., Tenn. St. Bd. Ent., Bul. 17, p. 66, 1916.

Eutettix seminudus Van D., Cat. Hemip. N. A., p. 664, 1917.

Eutettix seminudus Weiss, Ent. News, xxix, p. 310, 1918.

Eutettix seminudus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 76, 1919.

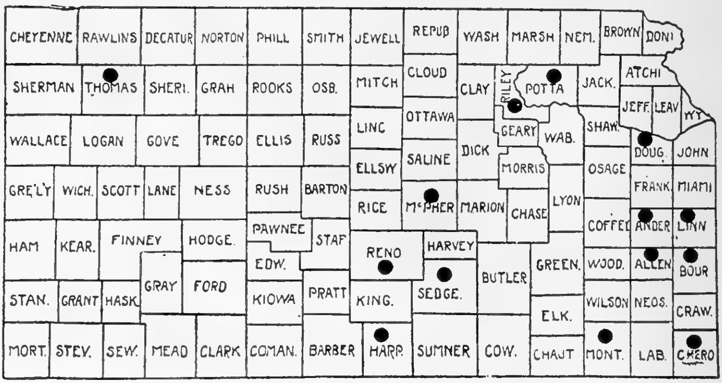
Form: Length, 4 to 5 mm. Vertex one-fourth longer on middle than next the eye, two and one-half times as wide as long, a distinct transverse depression just behind the broadly rounding apex. Pronotum scarcely twice as wide as long, lateral margins very short, humeral margins long. Elytra moderately long, venation indistinct.

Color: Vertex and pronotum creamy white, latter sometimes faintly irrorate with brown. Scutellum white, with basal angles and broad median stripe brown. Elytra milky white, a broad brown saddle across the posterior half of the clavus, a few brown reticulations on the base of the clavus and between the saddle and the brownish apices. Face creamy white.

External genitalia: Female, last ventral segment twice as long as the preceding, notched on either side of a median tooth which itself is slightly notched; pygofers moderately broad, exceeded by ovipositor, sparsely covered with white spines which arise from black dots. Male, valve large, rounded posteriorly; plates together forming a triangle about as long as wide, over twice as long as the valve, spined margins convexly narrowing till near the subacute apices which equal the broad pygofers.

Internal male genitalia: Styles large, triangular in outline, anterior process large, with a deep incision on the outer margin apically, leaving a long, somewhat curved, bluntly pointed, terminal process; connective short, Y-shaped, the stem slightly longer than the branches; œdagus heavy basally and with a large dorsal process to the membrane of the anal tube, divided terminally into a moderately stout median process and two slender lateral processes.

Distribution: Common throughout the state, especially in the eastern part, as shown by the following map:



Hosts: The plant or plants on which the nymphs feed are not yet definitely known, but the adults are taken on a large number of plants such as grape, garden vegetables and many others.

Eutettix strobi (Fh.).

(Pl. 13, figs. 3-4.)

Bythoscopus strobi Fh., Homop. N. Y. St. Cab., p. 58, 1851.
Phlepsius strobi Van D., Psyche, v, p. 390, 1890.
Eutettix strobi Bak., Psyche, vii, Suppl. i, p. 24, 1896.
Eutettix strobi Osb., 20th Rept. N. Y. St. Ent., p. 531, 1905.
Eutettix strobi Ball, Proc. Dav. Acad. Sci., xii, p. 44, pl. 2, fig. 2, pl. 4, fig. 3, 1907
Eutettix strobi Ball, U. S. Dept. Agr., Bur. Ent., Bul. 66, pl. 4, p. 49, 1909.
Eutettix strobi Osb., Me. Agr. Exp. Sta., Bul. 238, p. 138, 1915.
Eutettix strobi DeL., Tenn. St. Bd. Ent., Bul. 17, p. 67, 1916.
Eutettix strobi Van D., Cat. Hemip. N. A., p. 665, 1917.
Eutettix strobi Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 76, 1919.

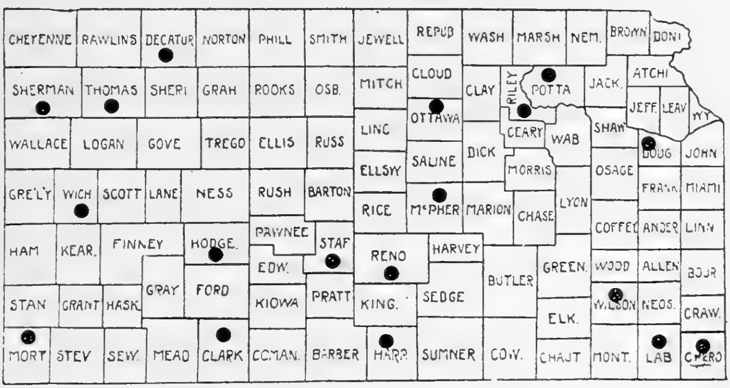
Form: Much like *seminudus.* Length, 4.5 to 5.25 mm. Vertex one-fourth longer on middle than next the eye, two and one-half times as wide as long, with a faint transverse depression, and broadly rounded apically. Pronotum over twice as wide as long, lateral margins rather short. Elytra moderately long.

Color: Vertex, pronotum and scutellum varying from yellowish irrorate with brown, to reddish-brown. Elytra usually milky-white with bands of brown at base, and across apical half of clavus. Frequently these bands are so run together as to give the entire elytra a brownish appearance. Face the color of the vertex.

External genitalia: Female, last ventral segment long, lateral angle broadly rounding, posterior margin notched on either side of a small median notched lobe which gives the appearance of two median teeth; pygofers broad, nearly or quite equalling the ovipositor, sparsely spined. Male, valve broad, rounded posteriorly; plates broad basally then rapidly narrowed, ending in elongate filamentous tips which exceed the pygofers.

Internal male genitalia: Styles large, triangular, broad basally, terminal process slightly convex on mesal margin, posteriorly straight on outer margin; connective very stout, Y-shaped, arms about equalling the basally broadened stem; œdagus with a wide, dorsal process to anal tube membrane, terminal portion composed of a broad median strap-like and terminally bifid process and a pair of lateral narrower and acutely pointed processes.

Distribution: Seemingly our most widely distributed member of the genus, as shown by the following map:



Hosts: This is the species producing the purple spots on *Chenopodium.* De Long reports taking specimens from wild rose.

Eutettix cinctus O. & B.

(Pl. 13, figs. 7-8.)

Eutettix cinctus O. & B., Proc. Dav. Acad. Sci., vii, p. 97, 1898.
Eutettix jucunda Van D., Psyche, vi, p. 307, 1892.
Eutettix cincta Osb., 20th Rept. N. Y. St. Ent., p. 530, 1905.
Eutettix (*Mesamia*) *cincta* Ball, Proc. Dav. Acad. Sci., xii, p. 64, pl. 4, fig. 1, 1907.
Eutettix cincta DeL., Tenn. St. Bd. Ent., Bul. 17, p. 67, 1916.
Eutettix cinctus Van D., Cat. Hemip. N. A., p. 665, 1917.
Eutettix cincta Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 77, 1919.

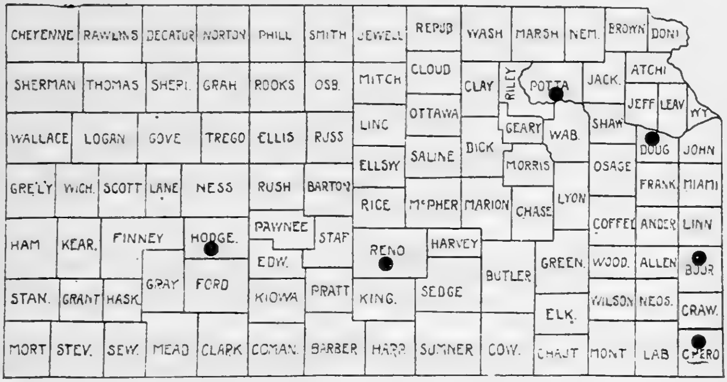
Form: Rather large and robust. Length, 5.25 to 6.25 mm. Vertex one-third longer on middle than next the eye, two and one-half times or over as wide as long, a distinct transverse depression just back of the broadly rounding apex, margin subacute. Pronotum over twice as wide as long, lateral margins short, humeral margins long, posterior margin distinctly concave, disc transversely wrinkled. Elytra moderately long and broad.

Color: Vertex greenish-yellow, apex with reddish tinge. Pronotum yellowish or greenish, irregularly marked with brown. Scutellum dirty-yellow, a small pair of black spots on disc and a larger pair on each lateral margin. Elytra milky, nervures reddish-brown, a large oblique black spot on the base of clavus of each elytron, a broad, brownish band on posterior half of the clavus and sloping back to the costa, costal veinlets broadly black. Face color of vertex above, dark below.

External genitalia: Female, last ventral segment one-half longer than the preceding, lateral margins strongly narrowed posteriorly, posterior margin sinuate on either side of the slightly produced median half; pygofers broad and short, slightly exceeded by the ovipositor, quite spiny on distal half. Male, valve broad but short, triangular, apex very obtuse; plates large, spiny margins concavely narrowing to upturned apices which exceed the pygofers.

Internal male genitalia: Styles large, with an unusually long process to the connective, very strongly hooked distally; connective very long, Y-shaped but with the branches close together, the stem and the branches about equal length; œdagus with an interior process to membrane of anal tube directed cephalad, and two sword-shaped caudal processes, one directly above the other, the dorsal one slightly broader.

Distribution: Fairly common throughout the state as shown by the following map:



Hosts: The definite host is unknown. The adults are commonly taken on weeds and grasses.

Eutettix albidus (Ball).

Phlepsius albidus Ball, Can. Ent., xxxii, p. 203, 1900.
Eutettix albidus Ball, Proc. Dav. Acad. Sci., xii, p. 51, pl. 2, fig. 10, 1907.
Eutettix albidus Van D., Cat. Hemip. N. A., p. 666, 1917.

Form: Rather small but fairly robust. Length, 3.75 to 4 mm. Vertex one-fourth longer on middle than next the eye, about twice as wide as long, disc barely depressed, broadly rounding with front, quite rounding apically. Pronotum over twice as wide as long, lateral margins short, posterior margin distinctly emarginate. Elytra moderately long, vertical and appressed behind.

Color: Vertex creamy-white with six faint brown dots on anterior margin and disc slightly irrorate with brown. Pronotum pale, sometimes with a few brown irrorations. Elytra milky-white, sparsely marked with irregular brown pigment lines which are more distinct in the male, a black spot at tip of clavus and three smaller ones on basal half of clavus at the edge of the markings.

External genitalia: Female, last ventral segment about three times as long as the preceding, keeled, posterior margin slightly rounding and with a small median notch; pygofers stout, nearly equalling ovipositor, sparsely spined. Male, valve broad, margins slightly concave to broadly rounded apex; plates together forming a triangle as broad as long, margins spiny, pilose apices exceeded by the spiny pygofers.

Distribution: Specimens are at hand from Clark county.

Hosts: Doctor Ball gives *Atriplex confertifolia* as the host plant of this species.

Genus Aligia Ball.

Doctor Ball characterizes this genus as follows:

"Vertex short, sloping, rounding to front, without a definitely angled margin except near apex, transverse depression faint or curved posteriorly in the middle and ending at the ocelli; front long, wedge-shaped, margins not constricted between antennal sockets. Elytra subhyaline, the nervures distinct, dark, two cross nervures between the sectors and usually a number of supernumerary veinlets along costa and claval sutures."

None of the members of this genus have yet been reported from Kansas, but the following species should be found:

Aligia modesta (O. & B.).

Eutettix modesta O. & B., Dav. Acad. Sci., vii, p. 98, 1898.
Eutettix (*Aligia*) *modesta* Ball, Proc. Dav. Acad. Sci., xii, p. 58, pl. 3, fig. 4, 1907.
Eutettix modesta Van D., Cat. Hemip. N. A., p. 628, 1917.

Form: A moderately stout species. Length, 4.5 to 5.5 mm. Vertex barely longer on the middle than next the eye, two and one-half times as wide as long, disc sloping, rounding to the front, distinct transverse impression just back of the apex. Pronotum over twice as broad as long, lateral margins very short, humeral margins long, posterior margin very slightly concave. Elytra moderately long, two cross nervures between the sectors.

Color: Pale fulvous or tawny. Vertex whitish with a pair of apical spots, a pair of short lines in each basal angle and often the transverse depression, tawny. Pronotum faintly irrorate with tawny. Elytra reddish-fulvous, subhyaline, with whitish spots and more or less definite bands across the base and before the tip of the clavus. Face pale.

External genitalia: Female, last ventral segment over twice as long as the preceding, lateral angles broadly rounded, posterior margin truncate except for a broad but short rounding lobe on the median third; pygofers stout, widest at the middle, slightly exceeded by the ovipositor, sparsely spined apically. Male, valve broad and triangular, rounded apically; plates large, convex, nearly four times the length of the valve, apices acute, margins spiny.

Distribution: This species has not yet been reported from Kansas, but very likely occurs in the eastern part of the state.

Hosts: Doctor Ball records this as an oak-feeding species.

Genus Mesamia Ball.

Doctor Ball describes this genus as follows:

"Vertex with the disc depressed, anterior margin usually elevated and acutely angled with the front, margin often slightly produced, front narrow, slightly constricted at antennal socket, then angularly widened to the ocelli; surface smooth polished, nearly flat above. Elytra subhyaline, the second cross nervure present (sometimes obscure) and the central anteapical cell slightly constricted. Usually with a number of supernumerary veinlets along the clavus and costa."

Three of the four species keyed below have been collected in Kansas.

KEY TO SPECIES.*

A. Species with fuscous markings or at least with fuscous nervures.
- B. A dark saddle on elytra between the cross nervures. *nigridorsum.*
- BB. Without a definite dark band.
  - C. Size of *nigridorsum*, vertex depressed, with four spots on anterior margin, connected by a line posteriorly, with a broad band below vertex. *straminea.*
  - CC. Smaller than *nigridorsum*, vertex flat, sometimes with a narrow line above and below margin. *coloradensis.*

AA. Species fulvous-yellow with light spots. *vitellina.*

Mesamia nigridorsum Ball.

Mesamia nigridorsum Ball, Proc. Dav. Acad. Sci., xii, p. 60, pl. 3, fig. 6; pl. 4, fig. 6. 1907.

Paramesus twiningi Van D., Trans. Am. Ent. Soc., xxi, p. 290, 1894.

Paramesus jucundus G. & B., Hemip. Colo., p. 84, 1895.

Eutettix nigridorsum DeL., Tenn. St. Bd. Ent., Bul. 17, p. 68, 1916.

Mesamia nigridorsum Van D., Cat. Hemip. N. A., p. 628, 1917.

Form: Length, 3.75 to 5 mm. Vertex one-third longer on middle than next the eye, not quite twice as broad as long, disc depressed, anterior margin elevated and acutely angled with front. Pronotum scarcely twice as broad as long, lateral margins somewhat shorter than the humeral. Elytra long, flaring, with characteristic venation, two cross nervures between the sectors, several cross veins along clavus and claval suture and with six or seven reflexed costal veins.

Color: Vertex white apically, back of which is an irregular black line connected anteriorly with two large quadrangular spots, disc brown. Pronotum brown anteriorly back of which is a light line containing two dark spots on either side, rest of pronotum brownish, irrorate with fuscous. Scutellum brown with one white spot on each margin and one apically. Elytra milky-white, nervures brown, a dark brown saddle across posterior two-thirds of clavus, apex and costal veinlets black. Face brownish, black above, arcs pale.

External genitalia: Female, last ventral segment long, posterior margin broadly and deeply emarginate and with a median lobe which is slightly notched apically; pygofers stout, exceeded by ovipositor, sparsely spined apically. Male, valve very small, posteriorly broadly rounded;

* Adapted from key by Doctor Ball, Proc. Dav. Acad. Sci., xii, p. 60, 1907.

plates a little longer than basal width, margins spiny, acute apices equalling or exceeding pygofers.

Distribution: Taken in Douglas, Pottawatomie, Riley and Clark counties.

Hosts: Doctor Ball gives *Helianthus* as the host of this species.

Mesamia straminea (Osb.).

Paramesus stramineus Osb., Proc. Ia. Acad. Sci., v, p. 241, 1898.

Eutettix (Mesamia) straminea Ball, Proc. Dav. Acad. Sci., xii, p. 62, pl. 3, fig. 7, pl. 4, fig. 7, 1907.

Mesamia straminea Van D., Cat. Hemip. N. A., p. 628, 1917.

Form: That of *nigridorsum.* Length, 4.5 to 5.5 mm. Vertex slightly longer and more angled than in *nigridorsum,* about twice as wide as long, disc depressed, margin acute. Pronotum about twice as wide as long, lateral margins short. Elytra long and narrow, often flaring, two cross nervures between the sectors, central anteapical cell sometimes divided, with six or seven costal veinlets.

Color: Straw-colored with a greenish tinge. Vertex with white anterior and posterior margins, former with an interrupted black line often reduced to four spots, disc yellowish-green. Pronotum anteriorly yellowish-green, posteriorly darker, irrorate with brown, the two parts separated by a darker line which is produced medially. Scutellum olive-brown, basal angles with orange spot, and with seven light spots around the edge. Elytra milky-white, subhyaline, disc brownish, nervures brown, costal nervures and apex fuscous, three pairs of white spots along the suture. Face pale, darkening with dark bands above to a black line under the margin of the vertex.

External genitalia: Female, last ventral segment long, posterior margin broadly and deeply emarginate, with a median lobe which is slightly emarginate apically; pygofers broad, exceeded by ovipositor, sparsely spined. Male, valve very small, rounded posteriorly; plates together forming a triangle a little longer than broad, margins spiny, apices acute, exceeding the pygofers.

Distribution: Taken in Pottawatomie and Riley counties.

Hosts: Doctor Ball reports this on the rough-leaved species of *Helianthus.*

Mesamia coloradensis (G. & B.).

Allygus coloradensis G. & B., Hemip. Colo., p. 91, 1895.

Paramesus immaculatus Ball, Can. Ent., xxxvii, p. 211, 1905.

Eutettix (Mesamia) coloradensis Ball, Proc. Dav. Acad. Sci., xii, p. 63, 1907.

Paramesus coloradensis Tuck., Kans. Univ. Sci. Bul., iv, p. 66, 1907.

Mesamia coloradensis Van D., Cat. Hemip. N. A., p. 628, 1917.

Form: Like *straminea,* but smaller. Length, 3.75 to 4.5 mm. Vertex one-half longer on middle than next the eye, about twice as wide as long, depression slight, acutely angled with front, apex a trifle more pointed than in *straminea.* Pronotum about twice as wide as long, lateral margins short, broadly rounding with humeral margins. Elytra rather short with the two cross nervures characteristic of the group.

Color: Whitish, sometimes tinged with green or brown. Vertex unmarked or usually with thin interrupted marginal line and a pair of basal spots, brown or black. Pronotum usually unmarked or with disc irrorate with brown and a few dark spots behind the eyes. Elytra milky-white with nervures brown, sparsely reticulated with brown. Face pale, unmarked, or with dark bands darkening above.

External genitalia: Female, last ventral segment twice as long as the preceding, narrowed strongly on posterior half, posterior margin broadly and deeply emarginate, with a median lobe which has brown margins and is very slightly notched apically; pygofers broad, exceeded by ovipositor, sparsely spined on distal half. Male, valve small, rounded posteriorly; plates about equal in length to their combined basal width, margins spiny, acute apices exceeding pygofers.

Distribution: Taken in Ottawa county only.

Hosts: Doctor Ball gives *Artemesia dracunculoides* as the host plant of this species.

Mesamia vitellina (Fh.).

Acocephalus vitellinus Fh., Homop. N. Y. St. Cab., p. 57, 1851.
Jassus twiningi Uhl., Bul. U. S. Geol. Geog. Surv., iv, p. 511, 1878.
Selenocephalus vitellinus Van D., Psyche, v, p. 390, 1890.
Paremesus furcatus Osb., Can. Ent., xxxii, p. 285, 1900.
Paramesus vitellina Osb., 20th Rept. N. Y. St. Ent., p. 516, 1905.
Eutettix (*Mesamia*) *vitellina* Ball, Proc. Dav. Acad. Sci., xii, p. 67, pl. 4, fig. 2, 1907.
Eutettix vitellina Osb., Me. Agr. Exp. Sta., Bul. 238, p. 139, 1915.
Mesamia vitellina Van D., Cat. Hemip. N. A., p. 628, 1917.

Form: Our largest member of the genus. Length, 5.5 to 6.5 mm. Vertex long, almost as long as the pronotum, one-half longer on the middle than next the eye, less than twice as broad as long in the female, very slightly depressed, margin acute. Pronotum over twice as broad as long, lateral margins not greatly shorter than the humeral, posterior margin emarginate. Elytra long, venation indistinct, but with the two cross nervures between the sectors and several costal veinlets.

Color: Fulvous-yellow. Vertex yellow, unmarked. Pronotum fulvous with anterior margin yellow, with a fairly distinct median line and lateral ones, light. Scutellum pale, basal angles fulvous. Elytra golden or fulvous-yellow with darker oblique basal band and a parallel band ending on tip of clavus, darker, whole surface with white spots. Face yellow.

External genitalia: Female, last ventral segment nearly twice as long as preceding, narrowed posteriorly to broadly rounding lateral lobes, between which the posterior margin is emarginate with a strap-like median lobe; pygofers broad, exceeded by ovipositor, sparsely spined. Male, valve triangular, two-thirds as long as last ventral segment, obtuse apically; plates nearly four times the length of the valve, apices attenuate, acute, exceeding pygofers, margins spined.

Distribution: Not yet reported for Kansas, but should be found.

Hosts: Doctor Ball gives wild rose as the host plant of this species.

Genus PHLEPSIUS Fieb.

The members of this genus are generally robust species with vertex broad, usually distinctly longer on middle than next the eye and obtusely angled. Their chief characteristic is the marking of the elytra with brown ramose pigment lines which are not confined, as in *Eutettix,* to any particular part of the elytra. Due to these lines the species are, with few exceptions, brownish, but even in these exceptions, the ramose lines are found.

All of the twenty-one species keyed below have been found in Kansas.

KEY TO SPECIES.*

A. Head narrower than the pronotum.
- B. Species large, 7 mm. or over; head much narrower than pronotum; elytra long and narrow.
  - C. Reddish-brown, length, 9 to 10 mm. *majestus.*
  - CC. Paler, grayish or cinereous, length 9 mm. or less. *spatulatus.*
- BB. Species smaller, 7 mm. or less; head slightly narrower than pronotum; stouter species with shorter elytra.
  - C. Sutural margin of elytra not definitely marked with ivory lobate markings.
    - D. Elytra marked with numerous ivory areoles. *areolatus.*
    - DD. Elytra without ivory areoles. *superbus.*
  - CC. Sutural margin of elytra definitely marked with ivory lobate markings.
    - D. Species longer, length 6 mm. or over.
      - E. Rather slender species, female segment excavated to base or nearly so. *excultus.*
      - EE. More robust species; female segment excavated half way to base. *decorus.*
    - DD. Species smaller, length less than 6 mm. *ovatus.*

AA. Head as wide or wider than pronotum.
- B. Vertex short, but little longer on the middle than next the eye, edge obtuse.
  - C. General color yellowish or brownish, closely inscribed.
    - D. Uniformly colored species.
      - E. Distinctly robust species, narrowed apically.
        - F. Margin of vertex black on either side of a light tip. *lascivious.*

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* Adapted from keys by Van Duzee, Trans. Am. Ent. Soc., xix, p. 65, 1892, and De Long, Tenn. St. Bd. Ent., Bul. 17, p. 68, 1916.

AA. Head as wide or wider than pronotum—*concluded.*

FF. Margin of vertex not black.

G. Species dark or dirty brown.

H. Species not over 5.5 mm. long. *altus.*

HH. Species longer, 6 mm. or over. *incisus.*

GG. Species fulvous-brown; length, 6 to 7 mm. *turpiculus.*

EE. More slender species, elytra narrowed apically.

F. Species about 6 mm. long; female segment not produced at sides into distinct lobes.

G. Female segment excavated, with median tooth; male valve long, apex rounded. *irroratus*

GG. Female segment truncate, without median tooth; male valve short and truncated. *truncatus.*

FF. Species smaller, less than 6 mm. long; female segment produced at sides into distinct lobes. *lobatus*

DD. Vertex, pronotum and scutellum yellow, elytra dark brown. *collitus.*

CC. General color cinereous, sparsely inscribed. *cinereus.*

BB. Vertex longer, distinctly longer on middle than next the eye; disc depressed, edge acute or subacute.

C. Elytra closely dotted, not reticulated, with some of the dots in irregular lines. *punctiscriptus.*

CC. Elytra reticulated.

D. Size medium, 6 to 7 mm. long.

E. Head, pronotum and scutellum not distinctly yellow, elytra with two clearer transverse bands indicated. *apertus.*

EE. Head, pronotum and scutellum pale yellow, elytra evenly inscribed. *fulvidorsum.*

DD. Size large, 7 mm. or over.

E. Length, 8 to 8.5 mm.; elytra distinctly narrowed apically, female segment not produced medially. *nebulosus*

EE. Length, 7 to 7.5 mm.; elytra scarcely narrowed apically, female segment produced medially. *solidaginis.*

Phlepsius majestus O. & B.

Phlepsius majestus O. & B., Proc. Ia. Acad. Sci., iv, p. 229, pl. 26, fig. 6, 1897.
Phlepsius majestus Osb., 20th Rept. N. Y. St. Ent., p. 533, 1905.
Phlepsius majestus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 76, 1916.
Phlepsius majestus Van D., Cat. Hemip. N. A., p. 667, 1917.
Phlepsius majestus Ball, Ann. Ent. Soc. Am., xi, p. 382, 1918.
Phlepsius majestus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 101, 1919.

Form: Our largest Phlepsid, elongate. Length, 9 to 10 mm. Head much narrower than pronotum; vertex distinctly produced, twice as broad as long, front long and narrow. Pronotum over twice as broad as long, broadest at lateral angles, anterior margin strongly convex, lateral margins longer than humeral, posterior margin slightly emarginate. Elytra long and narrow, greatly exceeding abdomen.

Color: Reddish-brown; vertex yellowish, two apical and two basal spots black, disc with a large black transverse band on each side, median longitudinal line brown. Pronotum yellowish marked with brown or black. Scutellum yellowish marked with brown on basal angles and apically. Elytra pale yellow to milky-white marked with reddish-brown irrorations.

External genitalia: Female, last ventral segment one-third longer than preceding, posterior margin emarginate, with two distinct median points between which is an incision extending fully half way to base; pygofers broad and short, equalling ovipositor, spiny medially on distal half. Male, last ventral segment truncate; valve scarcely twice as broad as long, roundingly produced to very broad apex; plates long, spiny margins convexly rounding to blunt tips which exceed the short spiny pygofers.

Distribution: Taken in Douglas and Pottawatomie counties.

Hosts: De Long reports sweeping this species from weeds in open woods.

Phlepsius spatulatus Van D.

Phlepsius spatulatus Van D., Trans. Am. Ent. Soc., xix, p. 78, 1892.
Phlepsius personatus Bak., Can. Ent., xxx, p. 30, 1898.
Phlepsius spatulatus Snow, Kans. Univ. Sci. Bul., ii, p. 349, 1904.
Phlepsius spatulatus Van D., Cat. Hemip. N. A., p. 667, 1917.
Phlepsius spatulatus Ball, Ann. Ent. Soc. Am., xi, p. 384, 1918.

Form: Smaller than *majestus*. Length, 7 to 9 mm. Head much narrower than the pronotum; vertex one-fourth longer on middle than next the eye, not quite twice as wide as long. Pronotum about twice as wide as long, lateral and humeral margins about equal, posterior margin slightly emarginate, transversely wrinkled.

Color: Pale grayish or cinereous, sometimes fulvous-brown. Vertex whitish, with broad transverse brown band between eyes and usually with brown spots before and behind this. Pronotum irrorate with brown and yellow. Scutellum yellowish. Elytra cinereous, regularly inscribed with brown, darker apically. Face pale or yellowish, marked with brown arcs.

External genitalia: Female, last ventral segment half longer than the preceding, longest at the rounding lateral lobes between which it is emarginate, with a pair of stout acute teeth in this emargination and between them an acute median notch; pygofers broad and short, slightly exceeded by ovipositor, sparsely spined. Male, last ventral segment as long as preceding, valve narrow, two to two and one-half times as wide as long, obtusely angulated, or rounded apically; plates long, spiny margins at first convex and then suddenly narrowed at proximal third, then tapering regularly to long attenuate and acute tips which exceed the spiny pygofers, with a brown line, parallel to margin, on the proximal third.

Distribution: Found in western Kansas, specimens having been taken in Reno, Stafford, Thomas and Sherman counties.

Hosts: Unknown.

Phlepsius areolatus Bak.

Phlepsius areolatus Bak., Can. Ent., xxx, p. 30, 1898.
Phlepsius areolatus Van D., Cat. Hemip. N. A., p. 668, 1917.

Form: A stout robust species. Length, 5.5 to 6.75 mm. Head narrower than pronotum; vertex not quite twice as broad as long, rounded apically, disc strongly depressed, the margin thin. Pronotum about twice as long as the vertex, twice as broad as long, widest at lateral angles, humeral margins a little longer than the lateral, posterior margin about truncate, transversely wrinkled. Elytra moderately long, flaring at tips.

Color: Cinereous, marked with dark brown; vertex yellowish with four black spots along margin, the median pair larger and triangular, with two small apical spots, and disc with two large brown patches. Pronotum irrorate with yellowish and brown. Scutellum yellowish or whitish, marked with brown. Elytra milky-white, irrorate with dark brown, with a strong areolate appearance. Face yellowish irrorate with brown.

External genitalia: Female, last ventral segment half longer than the preceding, lateral margins strongly narrowed on their distal half, hind margin broadly emarginate and with a small median notch; pygofers broad and short, exceeded by ovipositor, sparsely bristly. Male, last ventral segment longer than preceding; valve very small, rounded posteriorly; plates broad, together forming a triangle broader than long, spiny margins narrowed evenly to the obtuse tips which exceed the very short, bristly pygofers.

Distribution: Sherman, Pottawatomie and Douglas counties.

Hosts: Unknown.

Phlepsius superbus Van D.

Phlepsius superbus Van D., Trans. Am. Ent. Soc., xix, p. 81, 1892.
Phlepsius superbus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 77, 1916.
Phlepsius superbus Van D., Cat. Hemip. N. A., p. 668, 1917.
Phlepsius superbus Ball, Ann. Ent. Soc. Am., xi, p. 383, 1918.
Phlepsius superbus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 98, 1919.

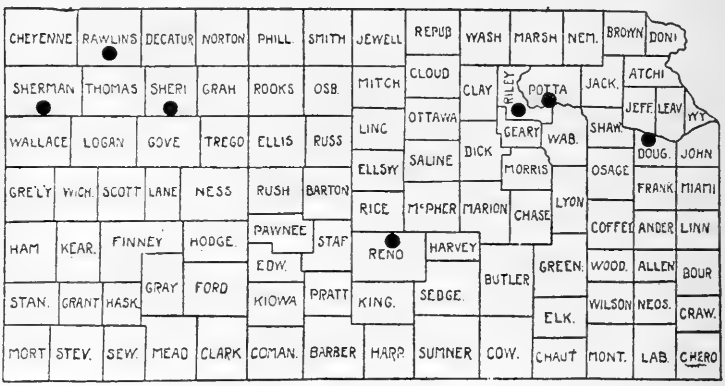
Form: A medium-sized, semirobust species. Length, 6.25 to 7 mm. Head slightly narrower than pronotum. Vertex half longer on middle than next the eye, twice as broad as long, obtusely but distinctly angulate. Pronotum twice as long as vertex, twice as wide as long, anterior margin strongly convex, humeral margins longer than the lateral, posterior margin clearly concave, transversely wrinkled. Scutellum large.

Elytra long, distinctly narrowed apically, slightly flaring, appendix present.

Color: Yellowish or yellow-fulvous; vertex and pronotum yellowish, irrorate with brown, scutellum lighter, with traces of two yellow lines. Elytra yellowish, nearly evenly inscribed with brown, white lobate sutural line not distinct. Face yellowish, irrorate with brown and marked with darker arcs.

External genitalia: Female, last ventral segment very characteristic, over twice longer than preceding, strongly narrowed posteriorly and with a very large median incision reaching nearly to base, making the segment appear almost like two widely-separated lateral lobes; pygofers very broad, slightly exceeded by ovipositor, distal half bristly. Male, last ventral segment slightly longer than preceding; valve small, narrow, posteriorly rounded; plates very broad, short, inner margins contiguous, outer margins broadly rounding, together describing a semicircle, slightly exceeded by the bristly pygofers, and with a row of spines, well in, but parallel to outer margin.

Distribution: Found throughout the state as shown by the following map:



Hosts: De Long records sweeping this species from pasture and grass land.

Phlepsius excultus (Uhl.).

Jassus excultus Uhl., Bul. U. S. Geol. Geog. Surv., iii, p. 467, 1877.
Phlepsius excultus Van D., Trans. Am. Ent. Soc., xix, p. 80, 1892.
Phlepsius excultus Osb., 20th Rept. N. Y. St. Ent., p. 534, 1905.
Phlepsius excultus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 77, 1916.
Phlepsius excultus Van D., Cat. Hemip. N. A., p. 667, 1917.
Phlepsius excultus Ball, Ann. Ent. Soc. Am., xi, p. 387, 1918.
Phlepsius excultus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 97, 1919.
(*Jassus infumatus* and *scalaris* Uhl., MS.) in collections.

Form: Semi-slender species. Length, 6 to 7 mm. Head slightly narrower than pronotum; vertex less than twice as wide as long, half longer on middle than next the eye, disc sloping, broadly rounded with front, obtusely angled apically. Pronotum twice as wide as long, slightly emarginate posteriorly, lateral margins as long as humeral, posterior half of disc strongly wrinkled, pits distinct. Elytra long, not strongly narrowed apically, appendix distinct.

Color: Vertex, pronotum and scutellum pale to orange-yellow, irrorate with light brown; vertex with two brown spots on posterior margin near the eyes, pronotum usually with four spots along anterior margin and scutellum with two spots on anterior margin. Elytra light cinereous, closely and evenly inscribed with dark brown and with the trilobate sutural line ivory-white. Face fulvous-yellow, heavily irrorate with dark brown.

External genitalia: Female, last ventral segment with lateral angles triangularly or truncately produced, broadly incised medially nearly or quite to base, exposing base of ovipositor with its overlapping plates; pygofers broadest at the middle, exceeded by the ovipositor, spined distally. Male, last ventral segment longer than the preceding; valve broad but short, rounded posteriorly; plates broad basally, triangular, submarginally spined margins somewhat concavely narrowed to acute apices which exceed the spiny pygofers.

Distribution: Reported by Van Duzee from Kansas.

Hosts: Unknown.

Phlepsius decorus O. & B.

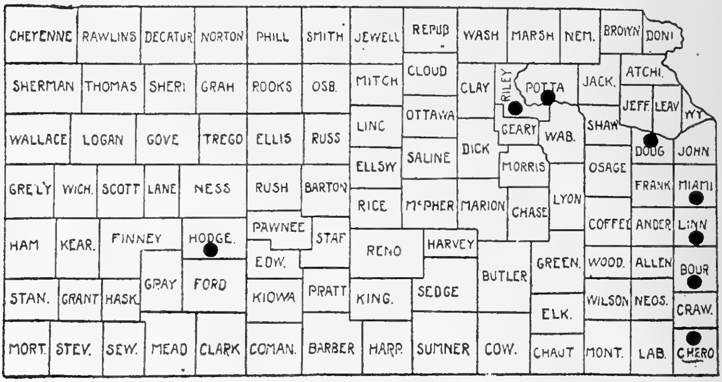
Phlepsius decorus O. & B., Proc. Ia. Acad. Sci., iv, p. 230, pl. 26, fig. 7, 1897.
Phlepsius decorus Osb., 20th Rept. N. Y. St. Ent., p. 533, 1905.
Phlepsius decorus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 141, 1915.
Phlepsius decorus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 76, 1916.
Phlepsius decorus Van D., Cat. Hemip. N. A., p. 668, 1917.
Phlepsius decorus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 99, 1919.

Form: Broader and shorter than *excultus.* Length, 5.5 to 6.25 mm. Head slightly narrower than pronotum; vertex one-third longer on middle than next the eye, nearly or quite twice as wide as long, disc flat, rather acutely angled with the front, obtusely angled apically. Pronotum short, about half longer than the vertex, usually more than twice as wide as long, humeral margins distinctly longer than the lateral, posterior two-thirds transversely wrinkled. Elytra short and wide, broadly flaring.

Color: Usually dark brown. Vertex white, with a few broad marginal markings and with brown irrorations forming a broad transverse band between the eyes, and a pair of more or less definite dark spots near posterior margin. Pronotum yellowish marked with brown, with two crescentiform dashes near posterior margin and a black spot behind each eye. Scutellum yellowish with two spots on disc and two on anterior margin, fuscous. Elytra milky-white to nearly smoky, marked with dark brown nervures and irrorations, scutellum and sutural margins usually white, the latter with the three ivory-white lobate markings, usually distinct. Face yellowish, strongly irrorate with brown.

External genitalia: Female, last ventral segment little longer than preceding, lateral margins quite short, posterior margin truncate and with a broad median notch reaching half or two-thirds the distance to the base; pygofers broad, exceeded by ovipositor, very sparsely spined on distal half. Male, last ventral segment longer than preceding; valve small, triangular, obtusely angled apically; plates broad and short, inner margins contiguous, submarginally spined, lateral margins convexly rounding to obtuse apices which are distinctly exceeded by the preapically spiny pygofers.

Distribution: Fairly common in eastern Kansas as shown by its distribution on the following map:



Hosts: Found on pasture grasses.

Phlepsius ovatus Van D.

Phlepsius ovatus Van D., Trans. Am. Ent. Soc., xix, p. 79, 1892.
Phlepsius ovatus G. & B., Hemip. Colo., p. 94, 1895.
Phlepsius ovatus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 75, 1916.
Phlepsius ovatus Van D., Cat. Hemip. N. A., p. 668, 1917.
Phlepsius ovatus Ball, Ann. Ent. Soc. Am., xi, p. 387, 1918.

Form: A small robust species, smaller than two preceding. Length, 5 to 6 mm. Head slightly narrower than pronotum; vertex one-half longer on middle than next the eye, nearly or quite as wide as long, obtusely rounding with front, obtusely angled apically. Pronotum a little over half longer than the vertex, twice as broad as long, lateral margins nearly or quite as long as the humeral, posterior margins slightly emarginate, posterior two-thirds transversely wrinkled. Elytra short and broad, moderately exceeding the abdomen.

Color: Usually lighter than *decorus*, yellowish-white inscribed with dark brown. Vertex yellow, irrorate with light brown, the latter forming two spots on either side of the apex and two broad transverse bands on the disc, connected by a short curved line with the posterior margin. Pronotum with brown marks which are less prominent on the posterior portion of the disc. Scutellum with large brown triangles in basal angles.

Elytra whitish, heavily inscribed with brown nervures and ramose markings, lighter on costa, and suture with distinct ivory trilobate markings. Face yellow, marked with brown irrorations and arcs.

External genitalia: Female, last ventral segment broad and short, roundingly narrowed posteriorly, posterior margin broadly excavated to nearly one-half the distance to the base and with a median notch extending nearly to the base; pygofers broad, slightly exceeded by ovipositor, apical half bristly. Male, last ventral segment longer than preceding; valve narrow, triangular, about one-half wider than long, apex acute; plates broad and short, submarginally spined, margins convexly rounding to obtuse apices which extend beyond the valve less than the length of the latter and nearly or quite equalling the short bristly pygofers.

Distribution: Taken in Pottawatomie and Morton counties.

Hosts: The only host plant record is that given by De Long who swept a single female from pasture grasses.

Phlepsius lascivius Ball.

Phlepsius lascivius Ball, Can. Ent., xxxii, p. 200, 1900.
Phlepsius lascivius Van D., Cat. Hemip. N. A., p. 670, 1917.

Form: Medium sized, semi-robust species. Length, 6 to 6.5 mm. Head as wide as the pronotum; vertex one-third longer on middle than next the eye, two and one-half to three times as wide as long, broadly rounded apically. Pronotum twice as wide as long, humeral and lateral margins about equal in length, rounding into each other, posterior margins somewhat emarginate. Elytra broad and moderately long, flaring behind, claval nervures parallel, not united by a transverse nervure.

Color: Faintly light brown. Vertex, pronotum and scutellum yellowish, irrorate with brown; elytra whiter. Vertex with irregular black markings on either side of the white apex, back of this a lighter area and then irrorate with fulvous brown to the base. Scutellum with two light spots on margin and at apex, and a dark spot on each margin. Elytra finely and evenly inscribed with fuscous dots which fuse into lines costally and apically. Face heavily irrorate with fuscous, black above.

External genitalia: Female, last ventral segment very long, slightly narrowed posteriorly, posterior margin truncate, with a small median notch between which and the lateral angles the margin is slightly concave; pygofers not as broad as in preceding species, slightly exceeded by ovipositor and sparsely spined. Male, valve very broad, triangular, with obtuse or subacute apex; plates large, broad at base, narrowing rapidly on basal third and then produced as parallel-margined, bluntly pointed, divergent lobes which completely hide and exceed the pygofers.

Distribution: Taken in Gove county only.

Hosts: Unknown.

Phlepsius altus O. & B.

Phlepsius altus O. & B., Ia. Acad. Sci., iv, p. 228, pl. 26, fig. 5, 1897.
Phlepsius altus O. & B., Proc. Dav. Acad. Sci., vii, p. 99, pl. 6, fig. 3, 1898.
Phlepsius mimus Bak., Ent. News, ix, p. 67, 1898.
Phlepsius mimus Van D., Bul. Buf. Soc. Nat. Sci., ix, p. 225, 1909.
Phlepsius altus Van D., Cat. Hemip. N. A., p. 670, 1917.

Form: Small and stout. Length, 5.5 mm. Head slightly wider than pronotum; vertex one-third longer on middle than next the eye, three times as wide as long, obtusely angled apically. Pronotum twice as wide as long, basal half transversely wrinkled, lateral margins short, humeral margins longer, posterior margin slightly emarginate. Elytra short, flaring, claval veins slightly approaching each other near the middle.

Color: Dark fulvous; vertex, pronotum and scutellum soiled yellowish-white, usually nearly uniformly irrorate with dark brown, posterior two-thirds of pronotum often darker. Elytra whitish, heavily inscribed with dark brown, leaving spots here and there. Face yellowish-white, nearly uniformly irrorate with dark brown.

External genitalia: Female, last ventral segment over twice longer than preceding, narrowed posteriorly, posterior margin broadly emarginate nearly one-third of distance to the base, emargination with a deep median slit, lateral angles lobular and appressed to the pygofers; pygofers semirobust, exceeded by the ovipositor, very sparsely spined. Male, last ventral segment as long as preceding; valve broad, triangular, slightly longer than ultimate segment, margins indented just before the acutely pointed apex; plates broad, ventrally convex, submarginally spined margins narrowing to obtuse tips which exceed the pygofers.

Distribution: Taken in Pottawatomie, Riley, Gray and Sheridan counties.

Hosts: Osborn and Ball report this species as abundant on *Bouteloua hirsuta.*

Phlepsius incisus Van D.

Phlepsius incisus Van D., Trans. Am. Ent. Soc., xix, p. 73, 1892.
Phlepsius incisus Osb., 20th Rept. N. Y. St. Ent., p. 533, 1905.
Phlepsius incisus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 143, 1915.
Phlepsius incisus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 71, 1916.
Phelpsius incisus Van D., Cat. Hemip. N. A., p. 570, 1917.

Form: Rather robust, larger than *altus.* Length, 6 to 6.5 mm. Head slightly wider than pronotum; vertex slightly longer on middle than next the eye, over three times as wide as long, disc depressed, margin acute, apex obtusely rounded. Pronotum about three times as long as vertex, twice as broad as long, lateral margins short, posterior margin emarginate, not transversely wrinkled. Elytra broad, not narrowed apically, appendix distinct.

Color: Yellowish, irrorate with testaceous-brown. Vertex yellowish, irrorate with light brown. Pronotum yellowish with posterior two-thirds heavily irrorate with light brown. Scutellum pale, somewhat maculate with brown. Elytra cinereous, heavily irrorate with dark brown, tips of claval veins often white. Face yellowish, heavily irrorate with brown.

External genitalia: Female, last ventral segment twice the length of the preceding, keeled, posterior margin obtusely produced with a broad and deep median notch. Male, last ventral segment widened posteriorly; valve large, very broad, triangular, obtusely pointed; plates large, broad basally, spiny margins sinuately narrowing to broad rounded apices which exceed the pygofers.

Distribution: Taken in Pottawatomie county.

Hosts: Unknown.

Phlepsius turpiculus Ball.

Phlepsius turpiculus Ball, Can. Ent., xxxii, p. 200, 1900.
Phlepsius turpiculus Van D., Cat. Hemip. N. A., p. 671, 1917.

Form: Rather large and robust. Length, 6 to 7 mm. Head as wide as the pronotum; vertex slightly longer on middle than next the eye, over three times as broad as long, obtusely rounding with front, obtusely angled at apex. Pronotum with lateral margins shorter than the humeral, posterior margin slightly emarginate, disc transversely wrinkled. Elytra long, narrowing apically.

Color: Dirty-yellow, irrorate with fulvous. Vertex, pronotum, and scutellum yellowish, marked with dirty fulvous, margins of latter sometimes with two dark spots. Elytra whitish, heavily irrorate with light or dark brown. Face yellowish, quite evenly irrorate with brown.

External genitalia: Female, last ventral segment twice as long as the preceding, posterior margin slightly notched medially, either side of which it is sinuate to the prominent lateral angles, pygofers semi-robust, long, usually equalling or slightly exceeding the ovipositor, rather spiny except on basal third. Male, last ventral segment wider than preceding; valve large and broad, triangular, margins indented midway to the obtuse apex; plates four times the length of the valve, slightly constricted basally, then broadening before narrowing again to long finger-like processes whose acute tips exceed the pygofers. A brown line, parallel to the margin and ending in a brown basal spot, on the proximal half of the plates.

Distribution: This species occurs in western Kansas, specimens having been taken in Thomas and Morton counties.

Hosts: Unknown.

Phlepsius irroratus (Say).

(Pl. 14, figs. 1-2.)

Jassus irroratus Say, Jl. Acad. Nat. Sci. Phila., vi, p. 308, 1831; Compl. Writ., ii, p. 384.
Jassus testudinarius Burm., Genera Ins., i, pl. 14, 1838.
Jassus inornatus Pack., U. S. Ent. Comm., Bul. 7, p. 80, 1881.
Allygus irroratus Uhl., Stand. Nat. Hist., ii, p. 245, 1884.
Phlepsius irroratus Van D., Ent. Am., vi, p. 93, 1890.
Phlepsius irroratus Van D., Trans. Am. Ent. Soc., xix, p. 71, 1892.

Phlepsius irroratus Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 126, 1892.
Phlepsius irroratus Osb., 20th Rept. N. Y. St. Ent., p. 533, 1906.
Phlepsius irroratus Osb., U. S. Dept. Agr., Bur. Ent., Bul. 108, p. 94, fig. 25, 1912.
Phlepsius irroratus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 139, 1915.
Phlepsius irroratus Gibs., Can. Ent., xlviii, p. 178, 1916.
Phlepsius irroratus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 72, 1916.
Phlepsius irroratus Van D., Cat. Hemip. N. A., p. 671, 1917.
Phlepsius irroratus Fent., Ohio Jl. Sci., xviii, p. 185, 1918.
Phlepsius irroratus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 90, 1919.

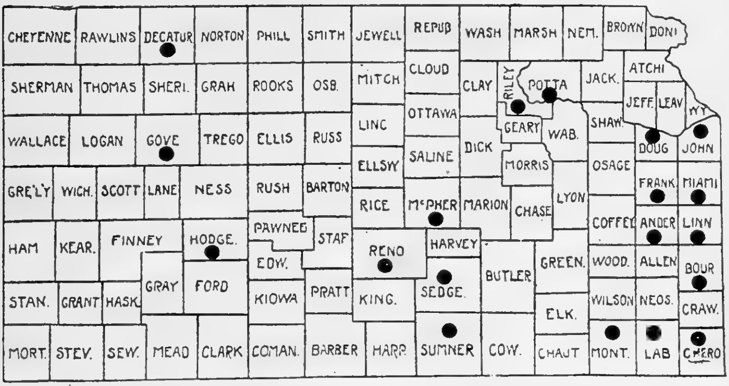
Form: A rather slender and elongate species. Length, 5.5 to 7 mm. Head as wide as pronotum; vertex one-third longer at middle than next the eye, over twice as wide as long, obtusely angled apically. Pronotum long, barely twice as wide as long, anterior margin strongly convex, lateral margins short, posterior margin slightly emarginate. Elytra long, narrowed apically.

Color: Grayish to yellowish, strongly and evenly inscribed. Vertex yellowish with an apical median line and spots on posterior margin whitish. Disc of pronotum more heavily irrorate than margins. Scutellum irrorate, with two or three marginal dark spots, an apical and two preapical marginal spots, white. Elytra whitish with fuscous nervures and closely inscribed with fuscous. Face yellowish, closely irrorate with fuscous.

External genitalia: Female, last ventral segment twice as long as preceding, rounded laterally, rounded lateral angles exceeded in length by three median teeth, the wider middle one separated by deep excavations from the outer two; pygofers rather slender, widest at the middle, exceeded by ovipositor, spined on apical half. Male, valve as broad as last ventral segment, triangular, apex rounded; plates broad basally, then narrowing to constriction near middle, and then broadening to obtusely pointed apices, each with a row of submarginal spines and bearing soft silky hairs, greatly exceeding the very short apically bristled pygofers.

Internal male genitalia: Styles triangular, very large basally, with a long finger-like terminal process which is strongly roughened, especially on the lateral margin; connective Y-shaped, with the cleft deep and more strongly chitinized on outer part, stem ending in a broad base; œdagus broad basally, gradually widening to an enlarged tip which is serrate, and with a small dorsal process for attachment to anal tube.

Distribution: This is our commonest Phlepsid. It is found throughout the state as shown by the following map:



Hosts: One of our most destructive leaf hoppers. Common on grasses, grains, alfalfa, and clover.

Phlepsius truncatus Van D.

Phlepsius truncatus Van D., Trans. Am. Ent. Soc., xix, p. 72, 1892.
Phlepsius truncatus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 72, 1916.
Phlepsius truncatus Van D., Cat. Hemip. N. A., p. 672, 1917.
Phlepsius truncatus Fent., Ohio Jl. Sci., xviii, p. 185, 1918.

Form: Similar to *irroratus*, narrow and elongate. Length, 5.5 to 6.25 mm. Head slightly wider than pronotum; vertex one-fourth longer on middle than next the eye, over twice as broad as long, disc slightly transversely depressed, obtusely angulate apically. Pronotum slightly over twice the length of the vertex, lateral margins shorter than the humeral, posterior margin slightly emarginate, without transverse wrinkles. Elytra broader than in *irroratus*, narrowed apically.

Color: A trifle darker than *irroratus*. Vertex yellowish, irrorate with brown, sometimes with whitish spots on posterior margin. Pronotum with disc darker than margins. Scutellum pale with two black spots on each margin. Elytra whitish, very closely inscribed with brown. Face yellowish, closely and evenly inscribed with brown.

External genitalia: Female, last ventral segment twice as long as the preceding, lateral margins sinuate, posterior margin truncate, lateral angles rounded; pygofers rather long and narrow, slightly exceeded by the ovipositor, sparsely spined distally. Male, valve as broad as last ventral segment, triangular, obtusely rounded apically; plates wide, not quite four times as long as the valve, submarginally spined margins sinuately tapering to obtuse apices which greatly exceed the very short, apically bristled pygofers.

Distribution: Taken in Riley and Pottawatomie counties.

Hosts: Found on grasses with *irroratus*.

Phlepsius lobatus Osb.

Phlepsius lobatus Osb., Proc. Ia. Acad. Sci., v, p. 247, 1898.
Phlepsius lobatus Van D., Cat. Hemip. N. A., p. 673, 1917.

Form: Much like preceding species, but smaller. Length, 5.5 to 5.75 mm. Head as wide as pronotum; vertex one-third longer at middle than next the eye, over twice as wide as long, obtusely angled apically. Pronotum over twice as wide as long, lateral margins short, posterior margin slightly emarginate, transverse wrinkles on basal half indistinct. Elytra long, narrowed apically.

Color: Light brown. Vertex, pronotum, and scutellum dirty-yellow, evenly inscribed with light brown, disc of pronotum sometimes darker. Elytra whitish, evenly irrorate with dark brown except on costal area where irrorations tend to form spots. Face yellowish, quite evenly irrorate with brown.

External genitalia: Female, last ventral segment very long, strongly narrowed posteriorly, with two distinct lateral lobes, between which the margin is deeply and truncately incised, the median portion slightly produced, carinate, and with a very small incision; pygofers long and narrow, barely exceeded by the ovipositor, spiny on distal half. Male, valve triangular, obtusely angled; plates broad, spined margins tapering slightly sinuately to obtuse apices which greatly exceed the short pygofers.

Distribution: Taken in Riley and Pottawatomie counties.

Hosts: Unknown.

Phlepsius collitus Ball.

Phlepsius collitus Ball, Can. Ent., xxxv, p. 227, 1903.
Phlepsius collitus Osb., Ohio Nat., v, p. 275, 1905.
Phlepsius collitus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 142, 1915.
Phlepsius collitus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 73, 1916.
Phlepsius collitus Van D., Cat. Hemip. N. A., p. 672, 1917.
Phlepsius collitus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 95, 1919.

Form: Rather slender and elongate. Length, 5.5 to 6 mm. Head as wide as pronotum; vertex scarcely longer on middle than next the eye, three times as wide as long, disc convex, obtusely rounded apically. Pronotum two and one-half times as long as vertex, strongly convex anteriorly, lateral margins shorter than humeral, posterior margin angularly concave. Elytra long and narrow.

Color: Vertex, pronotum, and scutellum fulvous. Vertex mottled with brown, often with two darker spots basally. Pronotum often with disc darker than margins which are marked with brown. Scutellum with two dark spots on each lateral margin. Elytra whitish hyaline, heavily inscribed with brown, with suggestions of two whitish bands starting from the first and the third of the three white spots on the clavus. Face yellowish or fulvous, heavily irrorate with brown.

External genitalia: Female, last ventral segment half longer than the preceding, narrowed posteriorly, emarginate between the lateral lobes, the median third roundingly produced and medially notched; spiny pygofers long and narrow, very slightly exceeded by the ovipositor. Male, valve broad and triangular, obtuse apically; plates broad and convex, submarginally spined margins narrowing to obtuse tips which greatly exceed the short pygofers.

Distribution: Taken in Cherokee county.

Hosts: De Long reports this species as abundant on grasses and weeds.

Phlepsius cinereus Van D.

Phlepsius cinereus Van D., Trans. Am. Ent. Soc., xix, p. 68, 1892.
Phlepsius cinereus Van D., Bul. Buf. Soc. Nat. Sci., viii, No. 5, p. 69, 1907.
Phlepsius cinereus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 70, 1916.
Phlepsius cinereus Van D., Cat. Hemip. N. A., p. 672, 1917.
Phlepsius cinereus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 88, 1919.

Form: Moderately large and elongate. Length, 5.5 to 7 mm. Head as wide as pronotum; vertex short, very slightly longer at middle than next the eye, three times as wide as long, nearly rounded apically. Pronotum nearly three times as long as vertex, lateral margins shorter than humeral, posterior margin slightly emarginate. Elytra moderately long and broad, apically flaring.

Color: The lightest of the Kansas species, light cinereous with pale irrorations. Vertex evenly inscribed though often with two darker basal spots. Disc of pronotum often darker. Scutellum with two black spots on each margin and often a pair on disc. Elytra sparsely inscribed. Face yellowish-white, faintly inscribed.

External genitalia: Female, last ventral segment twice as long as preceding, slightly narrowed posteriorly, lateral angles broadly rounding, posterior margin concave between lateral angles and the median notched tooth; pygofers rather stout, constricted basally, exceeded by ovipositor, sparsely spined on distal half. Male, valve broad, longer than ventral segment, triangular, apex obtuse; plates broad, over twice the length of the valve, submarginally spined margins slightly constricted basally, then tapering to obtuse apices which exceed the pygofers.

Distribution: Taken in Logan county.

Hosts: Van Duzee reports taking this species on low tangled vines.

Phlepsius punctiscriptus Van D.

Phlepsius punctiscriptus Van D., Trans. Am. Ent. Soc., xix, p. 75, 1892.
Phlepsius punctiscriptus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 74, 1916.
Phlepsius punctiscriptus Van D., Cat. Hemip. N. A., p. 673, 1917.

Form: Medium-sized, rather wedge-shaped. Length, 5.75 to 7 mm. Head slightly wider than pronotum; vertex at least half longer at middle than next the eye, two and one-half times as wide as long, disc depressed, margin subacute. Pronotum twice as long as vertex, lateral margins shorter than humeral, posterior margin slightly emarginate, disc transversely wrinkled. Elytra rather long and broad, usually vertical apically, appearing to narrow the insect posteriorly.

Color: Somewhat darker than *cinereus.* Vertex yellowish-white, not inscribed along most of anterior margin, but brown back of this. Pronotum and scutellum also yellowish-white, quite evenly inscribed with fulvous brown, disc of pronotum often darker, tip of scutellum white. Elytra milky-white, dotted with fine brown points, apically darker. Face yellowish-white, marked with light brown.

External genitalia: Female, last ventral segment twice as long as the preceding, lateral margins strongly narrowed near apex to the obtuse lateral lobes between which the posterior margin is slightly emarginate, with the median portion produced and broadly and shallowly notched; pygofers broad, widest at the middle, slightly exceeded by the ovipositor, sparsely bristled on the distal half. Male, valve about half as long as wide, obtusely angled apically; plates broad basally, nearly four times the length of the valve, the submarginally spined margins narrowing to the long acute tips which greatly exceed the short pygofers.

Distribution: This species has been taken in Riley, Pottawatomie, and Gove counties.

Hosts: Unknown.

Phlepsius apertus Van D.

Phlepsius apertus Van D., Trans. Am. Ent. Soc., xix, p. 76, 1892.

Phlepsius apertus Osb., 20th Rept. N. Y. St. Ent., p. 532, 1905.

Phlepsius apertus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 140, 1915; Bul. 248, p. 79. 1916.

Phlepsius apertus Van D., Cat. Hemip. N. A., p. 673, 1917.

Phlepsius apertus Fent., Ohio Jl. Sci., xviii, p. 185, 1918.

Form: Medium-sized, fairly robust, posteriorly narrowed. Length, 5 to 6.5 mm. Head as wide as pronotum; vertex distinctly produced medially, nearly one-half longer on middle than next the eye, disc depressed posteriorly, apex distinctly obtusely angular, margin subacute. Pronotum twice as long as vertex, anterior margin strongly convex, posterior margin slightly emarginate, humeral margins slightly longer than the lateral, disc distinctly wrinkled. Elytra moderately long, strongly overlapping and flaring apically.

Color: Vertex, pronotum, and scutellum dirty-yellowish, elytra milky-white. Vertex irrorate with light brown, apex light with a black spot either side, and usually two dark spots on posterior margin. Pronotum irrorate with light brown, disc darker. Scutellum irrorate with light brown, two dark spots on each margin, between which and apically there is a light spot. Elytra with an indistinct oblique light band before the middle where the dark brown irrorations are not as heavy as on the other portions which are tinged with fulvous. Face yellowish, irrorate with brown, darker above.

External genitalia: Female, last ventral segment twice as long as preceding, lateral angles rounded, with a broad median incision, widening basally, nearly or quite reaching the base, leaving two large lateral lobes, with prominent inner angles; pygofers moderately broad, exceeded by ovipositor, spiny apically. Male, valve broad, triangular, slightly longer than last ventral segment, obtuse apically; plates large and very broad basally, margins convex to about the apical third, tips parallel-margined and divergent, submarginal spines and marginal hairs not reaching the apex; pygofers completely hidden by the plates.

Distribution: Our only specimen of this species is from Lincoln county.

Hosts: Taken on grasses.

Phlepsius fulvidorsum (Fh.).

Jassus fulvidorsum Fh., Homop. N. Y. St. Cab., p. 62, 1851.
Phlepsius fulvidorsum Van D., Psyche, v, p. 390, 1890.
Phlepsius fulvidorsum Van D., Trans. Am. Ent. Soc., xix, p. 74, 1892.
Phlepsius fulvidorsum Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 126, 1892.
Phlepsius fulvidorsum Osb., 20th Rept. N. Y. St. Ent., p. 532, 1905.
Phlepsius fulvidorsum Osb., Me. Agr. Exp. Sta., Bul. 238, p. 142, 1915.
Phlepsius fulvidorsum DeL., Tenn. St. Bd. Ent., Bul. 17, p. 72, 1916.
Phlepsius fulvidorsum Van D., Cat. Hemip. N. A., p. 673, 1917.

Form: Females robust, males more slender. Length, 6 to 7 mm. Head as wide as pronotum; vertex two and one-half times as broad as long, one-half longer on middle than next the eye, with basal and preapical transverse depressions, the margin acute. Pronotum over twice as wide as long, lateral margins short, posterior margin emarginate. Elytra moderately long and fairly broad.

Color: Vertex, pronotum, and scutellum yellow, elytra darker. Vertex irrorate with light brown, frequently with five or six darker marginal spots. Pronotum irrorate with brown, disc darker. Scutellum pale, with two dark marginal spots. Elytra ivory-white to fulvous, coarsely and darkly irrorate. Face yellowish, heavily irrorate with dark brown.

External genitalia: Female, last ventral segment half longer than preceding, narrowed posteriorly, lateral angles not prominent, posterior margin sinuate on either side of the produced median half which is medially notched; pygofers semi-robust, barely exceeded by ovipositor, distal half somewhat spiny. Male, valve large, broad and triangular, obtusely angled apically; plates large and broad, completely hiding the pygofers, over twice as long as valve, margins strongly spined and convexly narrowed to the blunt apices.

Distribution: Taken in Pottawatomie county only.

Hosts: Recorded by Van Duzee on hemlock, spruce and pine. Professor Osborn gives birch, strawberry and blueberry as hosts. De Long records it from grasses.

Phlepsius nebulosus Van D.

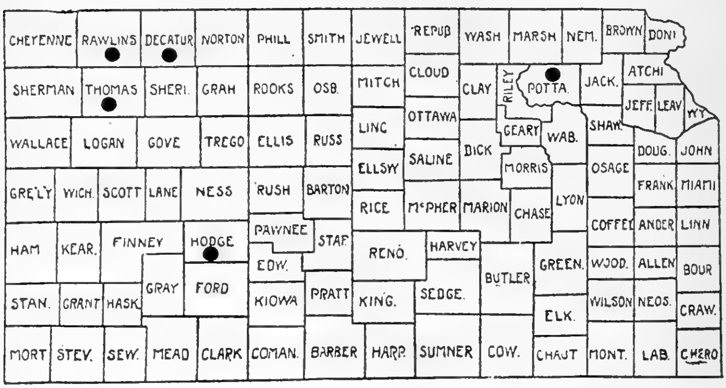
Phlepsius nebulosus Van D., Trans. Am. Ent. Soc., xix, p. 77, 1892.
Phlepsius nebulosus O. & B., Proc. Dav. Acad. Sci., vii, p. 100, pl. 6, fig. 4, 1898.
Phlepsius nebulosus Osb., 20th Rept. N. Y. St. Ent., p. 532, 1905.
***Phlepsius nebulosus* Van D., Cat. Hemip. N. A., p. 674, 1917.**

Form: Large, somewhat elongate. Length, 8 to 9 mm. Head slightly wider than pronotum; vertex one-fourth to one-half longer on middle than next the eye, two and one-half times as wide as long, disc depressed, margin acute, apex rounded to obtusely angulate. Pronotum transverse, over twice as wide as long, anterior margin broadly rounding, humeral margins a little longer than the lateral, posterior margin emarginate, disc distinctly wrinkled. Elytra moderately long, broad, slightly overlapping apically and slightly flaring.

Color: Vertex, pronotum, and scutellum yellowish, elytra whitish fulvous. Vertex and pronotum irrorate with light brown, latter darker on the disc. Scutellum pale with two dark marginal spots. Elytra rather evenly and closely inscribed with light to dark brown. Face yellowish, irrorate with brown.

External genitalia: Female, last ventral segment about three times as long as preceding, narrowed posteriorly to rounded, moderately produced, lateral angles, between which the posterior margin is emarginate and with a small median notch; pygofers moderately robust, exceeded by ovipositor, sparsely spined on distal half. Male, valve broad and triangular, nearly as long as last ventral segment, obtusely angulated apically; plates large, broad basally, three times as long as valve, margins with submarginal spines nearly to the obtuse diverging tips which greatly exceed the short and broad pygofers.

Distribution: Found chiefly in western Kansas as shown by the following map:



Hosts: Osborn & Ball record this species from *Panicum virgatum.*

Phlepsius solidaginis (Walk.).

Acocephalus solidaginis Walk., List Homop., iii, p. 847, 1851.
Phlepsius humidus Van D., Trans. Am. Ent. Soc., xix, p. 76, 1892.
Phlepsius humidus Osb., 20th Rept. N. Y. St. Ent., p. 532, 1905.
Phlepsius solidaginis Van D., Can. Ent., xli, p. 384, 1909.
Phlepsius humidus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 143, 1915.
Phlepsius humidus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 74, 1916.
Phlepsius solidaginis Van D., Cat. Hemip. N. A., p. 674, 1917.

Form: Smaller than preceding species. Length, 7 to 8 mm. Head slightly wider than pronotum; vertex one-half longer on middle than next the eye, two and one-half times as wide as long, disc depressed, margin acute, obtusely angled apically. Pronotum transverse, twice as broad as long, humeral margins a little longer than the lateral, posterior margin emarginate, disc transversely wrinkled. Elytra moderately long and broad, slightly flaring apically.

Color: Vertex, pronotum, and scutellum yellowish, elytra fulvous. Vertex sparsely inscribed with light brown, pronotum with disc darker, scutellum with two dark marginal spots and light spots between. Elytra irrorate with dark brown, with whitish areas on base and at tip of claval area, there appearing to be two dark transverse bands behind these, and with a few dark spots on costal area. Face yellowish, irrorate with brown.

External genitalia: Female, last ventral segment twice as long as preceding, lateral angles large and obtuse, posterior margin deeply emarginate and sinuate on either side of a large median lobe which is notched and slightly exceeds the lateral angles; pygofers rather long and narrow, exceeded by ovipositor, distal half spiny. Male, valve broad and triangular, longer than last ventral segment, apex obtuse; plates together forming a triangle almost as wide as long, submarginally spined margins tapering regularly to subacute apices which greatly exceed the short pygofers, margins pilose, especially basally.

Distribution: Specimens of this species have been taken in Pottawatomie, Riley and Clark counties.

Hosts: Van Duzee gives *Sagittaria* and *Polygonum* as host plants. It is found on low ground.

Genus ACINOPTERUS Van D.

In the members of this genus the head is narrower than the pronotum and the vertex is nearly twice as long on the middle as next the eye. The pronotum is rather short, the lateral margins nearly as long as the humeral, and with the disc transversely wrinkled. The scutellum is finely but very distinctly granular. The moderately long elytra are very characteristically narrowed apically, the nervures strong.

The one species of the genus and one of its varieties have been found in the state.

Acinopterus acuminatus Van D.

(Pl. 14, figs. 3-4.)

Acinopterus acuminatus Van D., Psyche, vi, p. 308, 1892.

Acinopterus acuminatus G. & B., Hemip. Colo., p. 94, 1895.

Acinopterus acuminatus Van D., Bul. Buf. Soc. Nat. Sci., viii, No. 5, p. 69, 1907; ix, p. 225, 1909.

Acinopterus acuminatus Osb., Ohio Nat., ix, p. 466, 1909.

Acinopterus acuminatus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 89, 1916.
Acinopterus acuminatus Van D., Cat. Hemip. N. A., p. 675, 1917.
Acinopterus acuminatus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 102, 1919.

Form: Rather robust, slightly tapering posteriorly. Length, 5 to 6.5 mm. Head distinctly narrower than pronotum, vertex nearly twice as long on middle as next the eye, about twice as wide as long. Pronotum over twice as wide as long, lateral margins long, posterior margin concave, disc transversely wrinkled. Scutellum large, entire surface granular. Elytra moderately long, tapering to acute apices, venation distinct.

Color: Vertex, pronotum, and scutellum greenish or olive-green, scutellum with two light longitudinal lines. Elytra shining dark brown, the nervures lighter, some of the cells, especially along the costa and on the clavus, subhyaline or greenish. Face olive-green, unmarked.

External genitalia: Female, last ventral segment twice as long as preceding, broadest basally, lateral margins broadly rounding to slightly produced posterior margin, which has an indistinct median notch; pygofers rather narrow, slightly exceeded by ovipositor, bearing a few scattered large spines. Male, valve covered by the large ventral segment; plates long and narrow, parallel-margined, obtuse apices somewhat divergent; spiny pygofers greatly exceeding plates.

Internal male genitalia: Styles fastened to a large round lobe at the base of the plates, margins of anterior half sinuately tapering, distal half stout and strongly curved, the large club-shaped and coarsely granular apices strongly diverging; connective small, heart-shaped, with the incision wide and the apex broadly rounding; œdagus very characteristic of the genus, broad basally, narrowing to the middle, distal half with two small ventral sword-like processes and a larger dorsal one, the latter fimbriate apically on the ventral margin.

Distribution: Specimens have been taken in Cherokee, Bourbon, and Miami counties. It is likely well distributed over the southeastern part of the state.

Hosts: De Long reports this species as abundant on grasses. Dr. Ball believes wild geranium to be the host plant.

Acinopterus acuminatus var. *viridis* Ball.

Acinopterus acuminatus var. viridis Ball, Can. Ent., xxxv, p. 231, 1903.

Form: That of typical *acuminatus.*

Color: Entire insect greenish, vertex with a yellowish tinge, ocelli reddish-brown. Nervures of elytra usually dark green, apical nervures sometimes bordered with fuscous.

Distribution: Our only specimens of this variety have come from Morton county.

Hosts: Probably the same as those of typical *acuminatus.*

Genus THAMNOTETTIX Zett.

The members of this genus are slender bodied, with long and narrow elytra, giving them a distinctly elongate appearance. The vertex is always wider than long, sometimes about parallel-margined, usually distinctly produced. The pronotum is rounded anteriorly with rather short and sharp lateral margins.

Nine of the eleven species keyed below have been taken in the state.

KEY TO SPECIES.

A. Vertex short, nearly parallel-margined, apex with two large black spots.
- B. Elytra without large yellow spot on clavus.
  - C. Reddish-brown large species, usually 6 mm. or over. *kennicotti.*
  - CC. Lighter and smaller species, less than 6 mm. in length. *brittoni.*
- BB. Elytra with large yellow spot on clavus. *clitellarius.*

AA. Vertex distinctly produced medially, without two large black apical spots.
- B. Margin of vertex without definite dark markings.
  - C. Brownish species. *longulus.*
  - CC. Greenish species. *inornatus.*
- BB. Margin of vertex with definite dark markings.
  - C. Disc of vertex marked with fulvous lines. *perspicillatus.*
  - CC. Disc of vertex unmarked (spots behind ocelli in *ciliatus*).
    - D. Margin of vertex with four black spots.
      - E. Size larger, over 4.5 mm. in length.
        - F. Vertex produced, about one-third wider than long, no spots on disc. *melanogaster.*
        - FF. Vertex shorter, nearly twice as broad as long, two black spots behind ocelli. *ciliatus.*
      - EE. Size smaller, less than 4.5 mm. in length.
        - F. Face not black.
          - G. Color dull yellow; female segment with distinct median tooth, male plates with long attenuate tips. *fitchii.*
          - GG. Brighter yellow in color; female segment without distinct median tooth, male plates not at all attenuate. *pallidula.*
        - FF. Face black, due to coalescing arcs. *nigrifrons.*

Thamnotettix kennicotti (Uhl.).

Jassus kennicotti Uhl., Proc. Am. Ent. Soc., ii, p. 161, 1863.
Thamnotettix kennicotti Uhl., Stand. Nat. Hist., p. 246, 1884.
Thamnotettix kennicotti Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 126, 1892.
Thamnotettix kennicotti Osb., 20th Rept. N. Y. St. Ent., p. 534, 1905.
Thamnotettix kennicotti Osb., Me. Agr. Exp. Sta., Bul. 238, p. 134, 1915.
Thamnotettix kennicotti DeL., Tenn. St. Bd. Ent., Bul. 17, p. 79, 1916.
Thamnotettix kennicotti Van D., Cat. Hemip. N. A., p. 676, 1917.

Form: Large and elongate. Length, 5.75 to 7 mm. Vertex short, over twice as broad as long, margins nearly parallel, sloping, and broadly rounding to front. Pronotum twice as long as vertex, lateral margins convex, widening posteriorly, humeral margins straight, distinctly angled with slightly emarginate posterior margin. Scutellum large. Elytra very long and narrow, greatly exceeding the abdomen.

Color: Rich reddish-brown; vertex yellowish, two large black apical spots between red ocelli, a fulvous transverse band on basal portion. Pronotum fulvous with a broad median band and sometimes a narrow yellow band on posterior margin. Elytra fulvous with lighter nervures and a distinct yellow stripe along costal suture. Yellow beneath.

External genitalia: Female, last ventral segment over twice as long as preceding, lateral margins rounding into rounded posterior margin, sometimes with a broad median keel; pygofers rather narrow, slightly exceeded by ovipositor, sparsely bristled. Male, last ventral segment as long as preceding; valve small, triangular, apex obtuse; plates broad on proximal half, then tapering to long attenuate tips; pygofers short, equalling or slightly exceeding plates, sparsely bristled.

Distribution: Taken in Cherokee and Pottawatomie counties.

Hosts: Doctor Ball gives this as a *Cratægus* species. De Long records sweeping specimens from oak.

Thamnotettix brittoni Osb.

Thamnotettix brittoni Osb., Proc. Dav. Acad. Sci., x, p. 166, 1907.
Thamnotettix brittoni Metc., Jl. Elisha Mitchell Sci. Soc., xxxi, p. 26, 1915.
Thamnotettix brittoni DeL., Tenn. St. Bd. Ent., Bul. 17, p. 79, 1916.
Thamnotettix brittoni Van D., Cat. Hemip. N. A., p. 677, 1917.

Form: Smaller and narrower than preceding species. Length, 5 to 6 mm. Vertex even less produced than in *kennicotti;* twice as broad as long, sloping, broadly rounding with front. Pronotum, scutellum and elytra as in *kennicotti.*

Color: Lighter, otherwise as in *kennicotti.*

External genitalia: Female, last ventral segment nearly as long as broad, lateral margins broadly rounding with somewhat produced posterior margin, keeled medially; pygofers rather narrow, slightly exceeded by ovipositor, slightly bristled. Male, valve broad and short, obtuse apically; plates broad basally, spiny margins concavely narrowing to long attenuate tips which nearly equal the bristly pygofers.

Distribution: Labette and Cherokee counties are the only ones in which this species has yet been taken.

Hosts: De Long reports taking this species from oak shrubs.

Thamnotettix clitellarius (Say).

(Pl. 14, figs. 5-6.)

Jassus clitellarius Say, Jl. Acad. Nat. Sci. Phila., vi, p. 309, 1831; Compl. Writ., ii. p. 384.

Bythoscopus clitellarius Fh., Homop. N. Y. St. Cab., p. 58, 1851.

Thamnotettix clitellarius Uhl., Stand. Nat. Hist., ii, p. 246, 1884.

Bythoscopus clitellarius Saund., Ins. Inj. Fruits, p. 188, 1886.

Thamnotettix clitellarius Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 126, 1892.

Thamnotettix clitellarius Osb., 20th Rept. N. Y. St. Ent., p. 534, 1905.

Thamnotettix clitellarius Osb., Me. Agr. Exp. Sta., Bul. 238, p. 134, 1915.

Thamnotettix clitellarius Van D., Cat. Hemip. N. A., p. 678, 1917.

Thamnotettix clitellarius Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 79, 1919.

Form: Length, 4.5 to 5.5 mm. Vertex short, over twice as broad as long, sloping, rounding to front. Pronotum twice as broad as long, strongly convex anteriorly, humeral margins longer than the lateral, posterior margin slightly emarginate. Scutellum large. Elytra characteristic of the genus.

Color: Vertex bright yellow except for two large black spots apically and the somewhat brown posterior margin. Pronotum brown on anterior third and along posterior margin, with a broad yellow band between. Scutellum brown. Elytra brown with costal area hyaline and a very characteristic oval yellow spot covering the greater part of the clavus. Yellow on face and beneath.

External genitalia: Female, last ventral segment long, lateral margins rounded with posterior margin which is deeply excavated on either side of a median tooth, which exceeds the rest of the margin and has its truncate apex slightly notched; pygofers long and narrow, basally constricted, slightly exceeded by ovipositor, sparsely spiny. Male, last ventral segment shorter than preceding; valve broad, triangular, margins slightly concave, apex obtuse; plates very long, exceeding bristly pygofers, margins slightly concave past middle, tips divergent preapically and apices curved. Pygofers with a large spine on apical margin.

Internal male genitalia: Styles large, with very large laterally rounded anterior process, a strong process to connective, after which the mesal margin is weakly chitinized for a short distance, then tapering sinuately to the obtuse apex which has a short but distinct lateral tooth, the entire apical portion quite roughened, so as to give the lateral margins the appearance of being serrate; connective stout, cleft at both ends, the arms at the anterior end rounded, those at the caudal end straight; œdagus with a weak dorsal basal projection which widens dorsally, the terminal portion long and deeply bicleft apically, forming two strap-like, curling, and acute appendages.

Distribution: This species has been taken in Douglas, Pottawatomie, and Riley counties.

Hosts: Found on many different plants.

Thamnotettix longulus G. & B.

(Pl. 14, fig. 7.)

Thamnotettix longula G. & B., Hemip. Colo., p. 97, 1895.
Thamnotettix longula O. & B., Proc. Ia. Acad. Sci., iv, p. 226, 1897.
Thamnotettix longula DeL., Tenn. St. Bd. Ent., Bul. 17, p. 82, 1916.
Thamnotettix longulus Van D., Cat. Hemip. N. A., p. 6880, 1917.

Form: Quite elongate. Length, 5 to 6 mm. Vertex more produced than in preceding species, being distinctly longer on middle than next the eye, twice as wide as long, sloping, and rounding obtusely with front. Pronotum long, scarcely twice as broad as long, strongly convex anteriorly, slightly emarginate posteriorly, lateral margins nearly as long as the humeral. Elytra very long and narrow.

Color: Nearly unicolorously fulvous, marked with brown. Vertex fulvous, white ocelli connected by light band, with median longitudinal line and two basal spots, darker. Pronotum irregularly mottled with darker spots anteriorly. Scutellum with basal angles and two spots on disc darker than the fulvous background. Elytra light fulvous, nervures lighter, some of them tending to be darker margined. Face marked with brown arcs.

External genitalia: Female, last ventral segment twice as long as the preceding, narrowed posteriorly, the posterior margin angularly emarginate one-third the length of the segment, slightly elevated; pygofers long and narrow, slightly exceeded by ovipositor, bearing many long bristles on posterior half. Male, last ventral segment two-thirds the length of the preceding, valve broad, triangular, obtuse at apex; plates broad basally and long, spiny margins tapering somewhat concavely to the acute tips which nearly equal the long-bristled pygofers.

Internal male genitalia: Styles very broad anteriorly due to large anterior processes and large processes to the connective, with a very definite lateral incision apically, leaving a large outwardly curving apical tooth which has its outer margin quite rough with small teeth; connective large, deeply bifid anteriorly, slightly so apically; œdagus broad basally, with a small basal and dorsal process, then gradually tapering till it divides into two long, apical, acutely-pointed processes.

Distribution: This species has been taken only in Cherokee and Douglas counties.

Hosts: DeLong reports this species as abundant on grasses.

Thamnotettix inornatus Van D.

Thamnotettix inornatus Van D., Trans. Am. Ent. Soc., xix, p. 303, 1892.
Thamnotettix inornatus Osb., 20th Rept. N. Y. St. Ent., p. 536, 1905.
Thamnotettix inornatus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 137, 1915.
Thamnotettix inornatus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 81, 1916.
Thamnotettix inornatus Van D., Cat. Hemip. N. A., p. 684, 1917.

Form: Long and narrow. Length, 4.75 to 5.5 mm. Vertex distinctly produced, half longer on middle than next the eye, flattened, subacute apically. Pronotum long, not twice as broad as long, humeral margins a little longer than lateral, posterior margin slightly emarginate. Elytra very long and narrow.

Color: Nearly uniformly yellowish-green. Ocelli brown or black, a brown curved line from each to the apex. Elytra subhyaline, tips smoky, nervures bright yellow to brown. Face yellow, with brown arcs and with sutures of front black.

External genitalia: Female, last ventral segment half longer than preceding, broadly but not deeply emarginate medially, having distinct lateral angles; pygofers long and narrow, exceeded by ovipositor, bristly on posterior half. Male, valve broad, triangular, very obtuse apically; plates large and broad, margins armed with very long, white spines, convexly tapering to subacute apices; pygofers very characteristic, viewed laterally they are long and triangular, tapering to long and slender apex which terminates in a chitinous point, just exceeding plates, and bearing a tuft of white bristles just before the middle.

Distribution: This species has not yet been collected in Kansas, but undoubtedly occurs in the eastern part of the state.

Hosts: DeLong collected this species from *Elymus virginicus* and from other tall grasses.

Thamnotettix perspicillatus O. & B.

Thamnotettix perspicillatus O. & B., Proc. Ia. Acad. Sci., iv, p. 227, 1897.
Thamnotettix perspicillatus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 81, 1916.
Thamnotettix perspicillatus Van D., Cat. Hemip. N. A., p. 680, 1917.

Form: Smaller than the preceding species. Length, 3.5 to 4 mm. Vertex about half wider than long, broadly rounding apically, disc sloping, rounding obtusely with front. Pronotum twice as broad as long, anterior margin strongly convex, lateral margins very short, humeral margins distinct, posterior margin slightly emarginate. Elytra typical of the genus though not as long as in the two preceding species.

Color: Grayish or brownish; vertex whitish, tinged with orange, with a wavy black line on each side from apex to ocelli, two brown median lines bending at right angles just before the middle, and two brown circles on the disc. Pronotum gray, with six white spots along the anterior margin, two small black spots back of each eye, and five faint longitudinal lines. Elytra subhyaline, marked with brown and black spots, nervures darkened apically. Front gray, with light median line and arcs.

External genitalia: Female, last ventral segment one-half longer laterally than preceding, posterior margin strongly and angularly produced; pygofers long and narrow, exceeded by ovipositor, bristly medially and apically. Male, last ventral segment as long as preceding; valve broad and short; plates broad basally, the spiny margins concavely narrowed to long attenuate tips which are slightly exceeded by the bristly pygofers.

Distribution: This species has not yet been reported from the state, but probably occurs here.

Hosts: Various grasses.

Thamnotettix melanogaster (Prov.).

Jassus melanogaster Prov., Nat. Can., iv, p. 378, 1872.
Thamnotettix melanogaster Prov., Pet. Faune Ent. Can., iii, p. 284, 1890.
Thamnotettix melanogaster Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 126, 1892.
Thamnotettix melanogaster Osb., 20th Rept. N. Y. St. Ent., p. 537, 1905.
Thamnotettix melanogaster Osb., Me. Agr. Exp. Sta., Bul. 238, p. 136, 1915.
Thamnotettix melanogaster DeL., Tenn. St. Bd. Ent., Bul. 17, p. 80, 1916.
Thamnotettix melanogaster Van D., Cat. Hemip. N. A., p. 682, 1917.

Form: Long and narrow. Length, 4.75 to 5.25 mm. Vertex distinctly produced, nearly half longer on middle than next the eye, one-third wider than long, disc flat or slightly concave. Pronotum nearly twice as wide as long, lateral margins distinct. Elytra very long.

Color: Brownish or yellowish-green, sometimes washed with orange. Vertex with four large black spots on margin, the two middle ones larger than the outer, disc unmarked. Scutellum with dark transverse impressed line. Face yellow. Abdomen black beneath.

External genitalia: Female, last ventral segment as long as preceding, narrowed posteriorly, posterior margin slightly emarginate; pygofers long, widest at the middle, exceeded by ovipositor, quite bristly on distal half. Male, valve large, broad and triangular, obtusely angled apically; plates very characteristic, broad basally, outer margin sinuately convex to acute, dark, chitinous apex, inner margin concave, so that apices are turned toward each other, a row of bristles running diagonally across before the middle, while on the outer margin and apically are long silky hairs; pygofers taper to long acute tips that exceed the plates.

Distribution: Reported from Riley county.

Hosts: Professor Osborn records this species as being common on coarse grasses and sedges on low ground.

Thamnotettix ciliatus Osb.

Thamnotettix ciliatus Osb., Proc. Ia. Acad. Sci., v, p. 244, 1898.
Thamnotettix ciliatus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 138, 1915.
Thamnotettix ciliatus Van D., Cat. Hemip. N. A., p. 683, 1917.

Form: Elongate like preceding species. Length, 4.5 to 5.5 mm. Vertex nearly twice as wide as long, about one-third longer on middle than next the eye, broadly rounded apically and obtusely rounding with front. Pronotum less than twice as wide as long, lateral margins short, humeral margins long. Elytra characteristic of the genus.

Color: Green or yellowish-green. Vertex yellow with four large black spots on margin, a spot, varying greatly in size, back of the ocelli and often two small parallel lines on the disc about half way between the base and the apex. Pronotum with disc greenish, margins frequently more yellow. Scutellum yellow. Elytra greenish, hyaline, apex sometimes smoky, nervures yellow or whitish. Face yellowish-green with antennal pits and sutures of front black, sometimes with black arcs. Nearly entirely black beneath.

External genitalia: Female, last ventral segment slightly longer than preceding, narrowed posteriorly, posterior margin slightly concave; pygofers long and narrow, slightly exceeded by ovipositor, spined on distal half. Male, valve large and broad, rounded posteriorly; plates broad and short, outer margin sinuately and convexly rounding to meet the divergent inner margins, the truncate apex with an acute inner angle, a few spines on the disc, margins and apices with long white silky hairs; pygofers long, exceeding plates, obtuse apically.

Distribution: Taken in Cherokee county.

Hosts: Grasses or sedges in low places.

Thamnotettix fitchii Van D.

Thamnotettix fitchii Van D., Ent. Am., vi, p. 133, 1890.
Thamnotettix fitchii Smith, N. J. Agr. Exp. Sta., Bul. K, p. 42, fig. 62, 1890.
Thamnotettix fitchii Osb., 20th Rept. N. Y. St. Ent., p. 535, 1905.
Thamnotettix fitchii Osb., Me. Agr. Exp. Sta., Bul. 238, p. 137, 1915.
Thamnotettix fitchii DeL., Tenn. St. Bd. Ent., Bul. 17, p. 79, 1916.
Thamnotettix fitchii Van D., Cat. Hemip. N. A., p. 683, 1917.
(*Cicadula 4-punctata* Fh. MS) in collections.

Form: Small but fairly robust for this genus. Length, 3.75 to 4.25 mm. Vertex distinctly wider than long, produced, obtusely angled. Pronotum with very short lateral margins, humeral margins long. Elytra long.

Color: Pale or dirty-yellow. Vertex with four black spots near margin, median longitudinal line and faint spots on either side, brown. Pronotum with five pale longitudinal lines. Scutellum yellow. Elytra smoky yellow with paler nervures. Face brownish, with pale median line and arcs, antennal pit and small spot below each ocellus, black.

External genitalia: Female, last ventral segment as long on lateral margins as preceding but with posterior margin broadly emarginate; valve broad and short, not at all angulate; plates broad basally, spiny margins concavely narrowed to long attenuate tips which exceed the short bristly pygofers.

Distribution: Specimens of this species have been taken in Douglas, Riley, and McPherson counties.

Hosts: This species occurs on grasses in low and moist places.

Thamnotettix pallidulus Osb.

Thamnotettix pallidulus Osb., Proc. Ia. Acad. Sci., v, p. 245, 1898.
Thamnotettix pallidulus Van D., Cat. Hemip. N. A., p. 684, 1917.

Form: Very much like *fitchii.* Length, 3.75 to 4.25 mm. Vertex nearly one-third wider than long, one-third longer on middle than next the eye, roundingly angulate apically. Pronotum strongly convex anteriorly, lateral margins very short, humeral margins long, posterior margin practically straight. Elytra characteristic of the genus.

Color: More yellow than *fitchii.* Vertex, pronotum, and scutellum bright yellow. Vertex with four black marginal spots, ocelli black. Elytra a dirty-yellow, nervures yellowish or whitish, more distinct basally. Face with brownish arcs and sometimes a black spot below ocelli.

External genitalia: Female, last ventral segment about length of the preceding, composed of two membranes, the outer strongly narrowed posteriorly, exposing the sides and lateral angles of the inner, posterior margin of the outer nearly truncate, sometimes slightly emarginate; pygofers short and stout, nearly equalling ovipositor, distal half quite bristly. Male, valve broad and short, broadly rounded posteriorly; plates broad basally, spiny margins slightly convex, tips acute, exceeded by the strongly bristled pygofers which, viewed laterally, are triangular, drawn out into long, attenuate, and acute apices.

Distribution: Taken in Cherokee and Douglas counties.

Hosts: Probably a grass feeder.

Thamnotettix nigrifrons (Forbes).

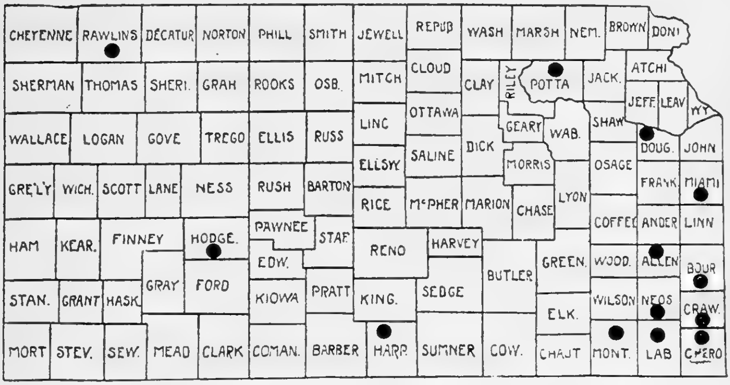
Cicadula nigrifrons Forbes, 14th Rept. Ill. St. Ent., p. 67, pl. 5, fig. 3, 1864.
Thamnotettix perpunctata Van D., Bul. Buf. Soc. Nat. Sci., v, pp. 200, 212, 1894.
Deltocephalus nigrifrons O. & B., Proc. Ia. Acad. Sci., iv, p. 218, 1897 (part).
Thamnotettix perpunctata Bak., Psyche, viii, p. 116, 1897.
Deltocephalus nigrifrons Osb., U. S. Dept. Agr., Bur. Ent., Bul. 108, p. 77, fig. 14, 1912 (part).
Thamnotettix nigrifrons Van D., Cat. Hemip. N. A., p. 684, 1917.
Thamnotettix nigrifrons Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 81, 1919.

Form: Smaller than preceding species. Length, 3.25 to 4 mm. Vertex wider than long, one-third longer at middle than next the eye, roundingly obtuse apically. Pronotum nearly one-half longer than the vertex, not twice as wide as long, anterior margin strongly convex, lateral margins very short, humeral margins long, posterior margin very slightly emarginate. Scutellum broad. Elytra long and narrow, strongly overlapping apically, only one cross nervure between the sectors.

Color: Yellowish-green; vertex yellowish, with four large black marginal spots, ocelli black, median longitudinal line brown. Pronotum with whitish or yellowish spots along anterior margins sometimes with black showing through the disc. Scutellum yellowish or whitish, with basal angles and apex rather more strongly yellow, and with black transverse impressed line. Elytra subhyaline, rather smoky apically, nervures whitish or yellowish. Face yellow, strongly marked with black coalescing arcs. Beneath black marked with yellow.

External genitalia: Female, last ventral segment as long as preceding, composed of two membranes, the outer strongly narrowed posteriorly, exposing lateral angles of the shorter inner membrane, posterior margin of outer membrane truncate or elevated and seemingly broadly emarginate; pygofers long, slightly exceeded by ovipositor, bristly, especially on distal half. Male, last ventral segment as long as preceding; valve broad and short, posteriorly broadly rounded; plates broad and triangular, spiny margins rather slightly concave to acute apices which are slightly exceeded by the bristly and acute pygofers.

Distribution: Very common in the eastern part of the state as shown by the following map:



Hosts: Doctor Forbes when describing this species reported it as injurious to oats, wheat, and corn. Professor Osborn says it shows a distinct preference for annual grasses such as foxtail and the panic grasses from which it migrates into the cultivated crops on the withering of the former. He also says it is very common on bluegrass and timothy.

Genus CHLOROTETTIX Van D.

The members of this genus are mostly rather large species of a uniform green color, often fading to a yellowish-green in preserved specimens. A few species, however, are small and some are marked with spots or bands on the head, pronotum, or scutellum. The vertex is broad, either rounded or distinctly bluntly angled apically. The sides of the pronotum are moderately long. The elytra are long and thin, subhyaline, with a distinct appendix, the nervures indistinct.

All the members of the genus are grass feeders and so no mention will be made of the specific hosts of each species.

The seven species keyed below have all been recorded from Kansas.

KEY TO SPECIES.*

A. Vertex with anterior margin rounded, not distinctly angulate.
   B. General color brownish, elytra appearing striped. *necopinus.*

* Adapted from key by DeLong, Ohio St. Univ. Bul., xxiii, No. 15, p. 4, 1919.

BB. General color greenish.

C. Female ventral segment with broad spatulate process; male plates long, gradually tapering. *spatulatus.*

CC. Female ventral segment notched but without spatulate process.

D. Size large, 7.5 mm. long; female segment uniformly, concavely and deeply notched, male plates narrowed at half their length then produced. *unicolor.*

DD. Size smaller, not over 7 mm. long; female segment with sides of notch each bearing a lateral tooth, male plates very short, broadly rounded. *viridius.*

AA. Vertex with anterior margin distinctly but bluntly angulate.

B. Size smaller, not exceeding 6.5 mm. in length.

C. Vertex distinctly angled, almost twice as long at middle as next the eyes; female segment broadly and triangularly notched half way to base. *vividus.*

CC. Vertex more bluntly angled, not over one-half longer at middle than next the eyes; female segment narrowly incised nearly to base. *galbanatus.*

BB. Size larger, 7 mm. or longer; female segment broadly but shallowly emarginate, a minute notch and brown spot at center. *tunicatus.*

Chlorotettix necopinus Van D.

Chlorotettix necopinus Van D., Can. Ent., xxv, p. 282, 1893.
Chlorotettix necopinus Van D., Bul. Buf. Soc. Nat. Sci., ix, p. 228, 1909.
Chlorotettix necopinus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 84, 1916.
Chlorotettix necopinus Van D., Cat. Hemip. N. A., p. 688, 1917.
Chlorotettix necopinus Fent., Ohio Jl. Sci., xviii, p. 185, 1918.
Chlorotettix necopinus DeL., Ohio St. Univ. Bul., xxiii, p. 8, 1919.
Chlorotettix necopinus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 83, 1919.

Form: Length, 7 mm. Vertex slightly longer on middle than next the eye, over twice as wide as long. Pronotum twice as wide as long, anterior margin strongly convex, posterior margin distinctly concave, short lateral margins rounding into the humeral margins, disc transversely wrinkled. Elytra long, greatly exceeding abdomen.

Color: General color brownish. Vertex, pronotum, and scutellum with a greenish tinge. Vertex with a broad transverse black band on the disc. Pronotum marked with brown, the median line and anterior margin paler. Scutellum with triangular spots in basal angles, a median line with a small spot on either side, brown. Elytra brown with the nervures lighter, giving them a striped appearance. Face with ten pale arcs and two brown spots at base of clypeus.

External genitalia: Female, last ventral segment over twice as long as the preceding, strongly narrowed posteriorly, lateral angles acute, between them the posterior margin being broadly and deeply cleft, the cleft with a small blunt tooth; pygofers rather broad, nearly equalling ovipositor, spined on distal half. Male, valve about twice as long as preceding segment, broad, margins concave on either side of the rounded apex;

plates broad basally, suddenly constricted beyond middle and then produced to the slightly divergent tips, exceeded by the blunt and spiny pygofers.

Distribution: Specimens of this species have been taken only from Cherokee county.

Chlorotettix spatulatus O. & B.

(Pl. 14, fig. 8.)

Chlorotettix spatulatus O. & B., Proc. Ia. Acad. Sci., iv, p. 225, pl. 26, fig. 4, 1897.
Chlorotettix spatulatus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 86, 1916.
Chlorotettix spatulatus Van D., Cat. Hemip. N. A., p. 686, 1917.
Chlorotettix spatulatus DeL., Ohio St. Univ. Bul., xxiii, p. 12, 1919.
Chlorotettix spatulatus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 86, 1919.

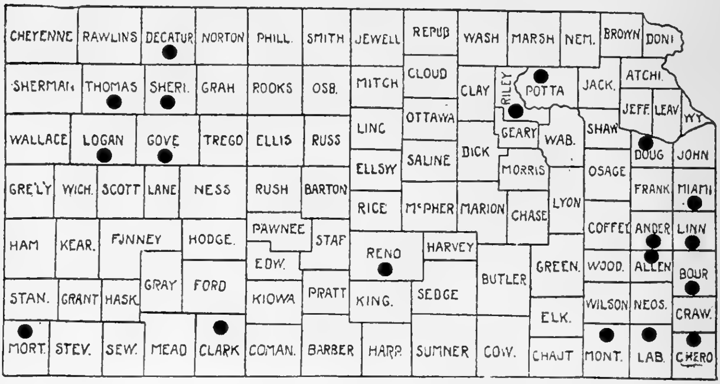
Form: Length, 6 to 7 mm. Vertex slightly longer on the middle than next the eye, over twice as wide as long, broadly rounding with front. Pronotum twice as wide as long, posterior margin distinctly emarginate, short lateral margins rounding with humeral margins, disc transversely wrinkled. Elytra rather broad, greatly exceeding abdomen, venation weak.

Color: Uniformly greenish or yellowish-green.

External genitalia: Female, last ventral segment one-half longer than the preceding, posterior margin broadly notched nearly three-fourths of the distance to the base, the notch with a median spatulate process over one-half the length of the notch; pygofers long and narrow, exceeding the ovipositor, sparsely spined. Male, valve broad, longer than last ventral segment, obtusely rounded apically; plates about three times as long as the valve, broad basally, convex, spiny margins tapering to the subacute apices, which are exceeded by the bristly pygofers.

Internal male genitalia: Styles with large anterior curving process and very broad at point of attachment to connective, then tapering rather gradually till terminal fourth, when they are suddenly narrowed to long and slender apical portion; connective Y-shaped, the stem also somewhat divided apically; œdagus long and curving, dividing into two branches apically, which in turn divide again, there being thus four slender curving and acutely-tipped terminal processes, the inner pair of which are longer than the outer.

Distribution: This is our commonest member of the genus. It is found all over the state, as shown by the following map:



Chlorotettix unicolor (Fh.).

Bythoscopus unicolor Fh., Homop. N. Y. St. Cab., p. 58, 1851.
Jassus unicolor Uhl., Bul. U. S. Geol. Geog. Surv., iv, p. 511, 1878.
Grypotes unicolor Uhl., Stand. Nat. Hist., ii, p. 246, 1884.
Thamnotettix unicolor Harr., Ottawa Nat., vi, p. 32, 1892.
Athysanus unicolor Southw., Science, xix, p. 288, 1892.
Chlorotettix unicolor Van D., Psyche, vi, pp. 306, 308, 1892.
Chlorotettix vanduzei Bak., Can. Ent., xxx, p. 219, 1898.
Chlorotettix unicolor Osb., 20th Rept. N. Y. St. Ent., p. 538, 1905.
Chlorotettix unicolor Osb., Me. Agr. Exp. Sta., Bul. 238, p. 144, 1915; Bul. 248, p. 76, 1916.
Chlorotettix unicolor Van D., Cat. Hemip. N. A., p. 685, 1917.
Chlorotettix unicolor Fent., Ohio Jl. Sci., xviii, p. 185, 1918.
Chlorotettix unicolor DeL., Ohio Jl. Sci., xviii, p. 227, 1918.
Chlorotettix unicolor DeL., Ohio St. Univ. Bul., xxiii, p. 13, 1919.

Form: One of our largest species. Length, 6.75 to 8 mm. Vertex slightly longer at middle than next the eye, two and one-half times as broad as long, broadly rounding with front. Pronotum short, over twice as broad as long, anterior margin broadly but not strongly convex, short lateral margins rounding with the humeral margins, posterior margin distinctly emarginate. Elytra long, greatly exceeding the abdomen.

Color: Almost uniformly pale green or yellowish-green. Elytra hyaline, the nervures often dark green in color.

External genitalia: Female, last ventral segment nearly twice as long as the preceding, with a fairly broad median notch the apex of which is surrounded by a brown spot, the posterior margin sinuate on either side of the notch; pygofers rather long, spiny, slightly exceeding the ovipositor. Male, valve broad, posterior margin somewhat sinuate on either side of the obtuse, nearly truncate apex; plates broad basally, submarginally spined margins concave on apical half, tips produced, subacute, slightly diverging, greatly exceeded by the pygofers.

Distribution: Van Duzee reports this species from Kansas. The specimens in the Snow collection are from Colorado, Nebraska, and Maine.

Chlorotettix viridius Van D.

Chlorotettix viridius Van D., Psyche, vi, p. 309, 1892.
Athysanus viridius Southw., Science, xix, p. 288, 1892.
Chlorotettix viridius Weed, Can. Ent., xxiv, p. 278, 1892.
Chlorotettix viridius Osb., 20th Rept. N. Y. St. Ent., p. 538, 1905.
Chlorotettix viridius DeL., Tenn. St. Bd. Ent., Bul. 17, p. 86, 1916.
Chlorotettix viridius Van D., Cat. Hemip. N. A., p. 687, 1917.
Chlorotettix viridius DeL., Ohio St. Univ. Bul., xxiii, p. 15, 1919.
Chlorotettix viridius Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 84, 1919.

Form: Like *unicolor* but smaller. Length, 6 to 7 mm. Vertex slightly longer at middle than next the eye, over twice as wide as long, broadly rounding with front. Pronotum scarcely twice as wide as long, anterior margin broadly convex, posterior margin slightly concave. Elytra greatly exceeding abdomen.

Color: Bright or apple-green. Vertex and anterior portion of pronotum yellowish. Elytra hyaline, nervures greenish.

External genitalia: Female, last ventral segment with acute lateral angles between which is a broad incision reaching nearly to the base, the margins of the incision each with an obtuse blackish tooth near the middle; the long sparsely spined pygofers slightly exceeding the ovipositor. Male, valve broad, slightly shorter than last ventral segment, broadly rounded posteriorly; plates short, produced beyond the valve about the length of the latter, together nearly semicircular, margins spiny, apices somewhat divergent; thin pygofers greatly exceeding the plates.

Distribution: Specimens of this species have thus far been found in Labette, Bourbon, and Cherokee counties. Thus it seems to be confined to the southeastern part of the state.

Chlorotettix vividus Crmb.

Chlorotettix vividus Crmb., Ann. Ent. Soc. Am., viii, p. 197, 1915.
Chlorotettix vividus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 88, 1916.
Chlorotettix vividus Van D., Cat. Hemip. N. A., p. 687, 1917.
Chlorotettix vividus DeL., Ohio St. Univ. Bul., xxiii, p. 19, 1919.
Chlorotettix vividus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 84, 1919.

Form: The smallest species of the genus in Kansas. Length, 5.5 to 6 mm. Vertex nearly twice as long at middle as next the eye, one and one-half times as wide as long, convex. Pronotum scarcely twice as wide as long, anterior margin strongly convex, lateral margins short, posterior margin slightly emarginate. Elytra strongly exceeding abdomen.

Color: Brownish-green; elytra more distinctly green than vertex, pronotum, and scutellum.

External genitalia: Female, last ventral segment twice the length of the preceding, lateral angles obtuse, posterior margin broadly and triangularly notched nearly half way to the base; pygofers narrow, very slightly exceeded by the ovipositor, spiny on distal half. Male, valve broad, longer than last ventral segment, margins sinuate on either side of the slightly notched apex; plates long, spiny margins narrowing to the attenuately produced apices which are equalled by the bristly pygofers.

Distribution: The only Kansas records for this species are from Douglas and Cherokee counties.

Chlorotettix galbanatus Van D.

Chlorotettix galbanatus Van D., Psyche, vi, p. 310, 1892.
Athysanus galbanatus Southw., Science, xix, p. 288, 1892.
Chlorotettix unicolor Bak., Can. Ent., xxx, p. 219, 1898.
Chlorotettix galbanatus Osb., 20th Rept. N. Y. St. Ent., p. 538, 1905.
Chlorotettix galbanatus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 143, 1915.
Chlorotettix galbanatus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 88, 1916.
Chlorotettix galbanatus Van D., Cat. Hemip. N. A., p. 687, 1917.
Chlorotettix galbanatus Fent., Ohio Jl. Sci., xviii, p. 185, 1918.
Chlorotettix galbanatus DeL., Ohio St. Univ. Bul., xxiii, p. 22, 1919.
Chlorotettix galbanatus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 83, 1919.

Form: A little larger than *vividus.* Length, 6 to 6.5 mm. Vertex quite obtusely angled, one-half longer on middle than next the eye, over twice as wide as long. Pronotum long, less than twice as wide as long, anterior margin strongly convex, lateral margins short, posterior margin slightly emarginate. Elytra greatly exceeding the abdomen.

Color: Uniformly pale yellowish-green. Elytra hyaline, slightly iridescent.

External genitalia: Female, last ventral segment long, divided into two large lateral lobes by a rather broad incision reaching nearly to the base; pygofers slightly exceeded by ovipositor, sparsely bristly, especially apically. Male, valve large, broad, longer than last ventral segment, very obtusely angled apically; plates large, broad, hairy margins rounding to the obtuse apices which are slightly exceeded by the pygofers.

Distribution: So far this species has been taken only in Douglas and Wyandotte counties.

Chlorotettix tunicatus Ball.

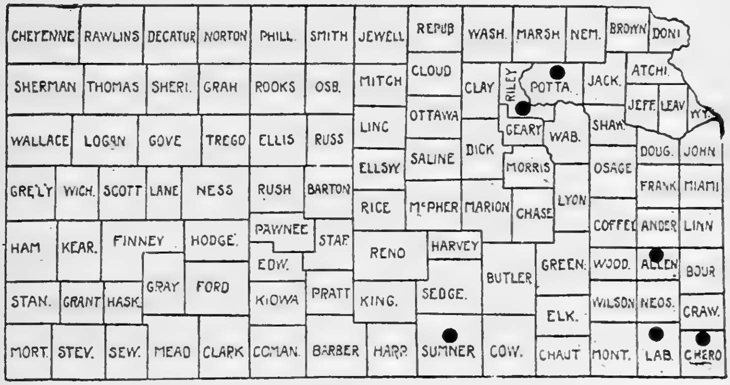
Chlorotettix tunicatus Ball, Can. Ent., xxxii, p. 340, 1900.
Chlorotettix tunicatus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 87, 1916.
Chlorotettix tunicatus Van D., Cat. Hemip. N. A., p. 688, 1917.
Chlorotettix tunicatus DeL., Ohio St. Univ. Bul., xxiii, p. 25, 1919.
Chlorotettix tunicatus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 83, 1919.

Form: Larger than *galbanatus.* Length, 7 mm. Vertex one-half longer at middle than next the eye, twice as wide as long, broadly rounding with front. Pronotum long, less than twice as wide as long, anterior margin broadly convex, posterior margin slightly concave. Elytra greatly exceeding the abdomen.

Color: Uniformly pale yellowish-green. Elytra subhyaline.

External genitalia: Female, last ventral segment one-half longer than the preceding, lateral angles broadly rounding, posterior margin roundingly emarginate nearly one-half the distance to the base, brownish medially; pygofers slightly exceeded by the ovipositor, distal half spiny. Male, valve broad, slightly longer than the last ventral segment, margins concave on either side of the obtusely angled apex; plates broad basally, convex, spiny margins rounding to the obtuse apices.

Distribution: Fairly common in eastern Kansas as shown by the following map:



Genus Jassus Fabr.

In the members of this genus the head is distinctly narrower than the pronotum, and seems to be set back on the latter. The vertex is quadrate, not at all produced in front. The front has distinct transverse striæ. The pronotum is very short, about the length of the vertex, the lateral portions well covered by the head, with short lateral margins, long humeral margins, and the posterior margin slightly concave. The scutellum is very large, wider than long. The elytra are rather short and broad, broadly rounded apically, the nervures strong.

A single species of the genus occurs in Kansas.

Jassus olitorius Say.

(Pl. 15, figs. 1-2.)

Jassus olitorius Say, Jl. Acad. Nat. Sci. Phila., vi, p. 310, 1831; Compl. Writ., ii, p. 385.
Jassus subbifasciatus Say, Jl. Acad. Nat. Sci. Phila., vi, p. 310, 1831.
Cœlidia olitorius Fh., Homop. N. Y. St. Cab., p. 58, 1851.
Jassus fuscipennis Spangb., Of. Vet. Akad. Forh., xxxv, No. 8, p. 26, 1878.
Cœlidia semifasciata Uhl., Stand. Nat. Hist., ii, p. 245, fig. 311, 1884.
Jassus olitorius Van D., Psyche, v, p. 389, 1890.
Idiocerus subbifasciatus Prov., Pet. Faune Ent. Can., iii, p. 292, 1890.
Pediopsis subbifasciatus Harr., Ottawa Nat., vi, p. 31, 1892.
Jassus olitorius Osb., 20th Rept. N. Y. St. Ent., p. 539, 1905.
Jassus olitorius Osb., Me. Agr. Exp. Sta., Bul. 238, p. 145, 1915.
Jassus olitorius DeL., Tenn. St. Bd. Ent., Bul. 17, p. 91, 1916.
Jassus olitorius Van D., Cat. Hemip. N. A., p. 689, 1917.
Jassus olitorius Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 104, 1919.

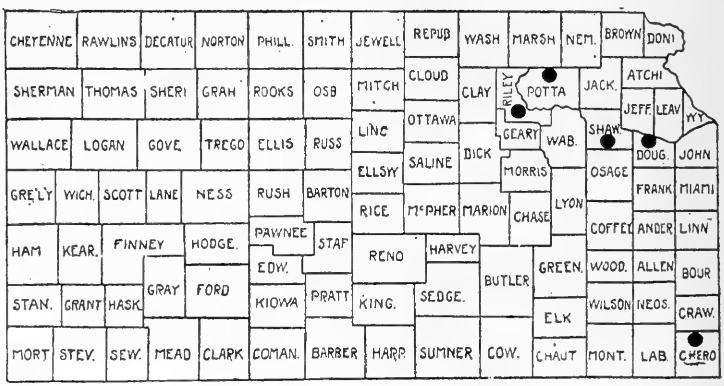
Form: Length, 6 to 8 mm. Head much narrower than the pronotum. Vertex about as wide as long, rounded anteriorly. Pronotum about as long as the vertex, three times as wide as long, widest at lateral angles, lateral margins short, humeral margins long, posterior margin slightly emarginate. Scutellum very large. Elytra rather short and broad, rounded apically, venation distinct.

Color: Varying from light to dark brown. Vertex dirty-yellow, ocelli, a median longitudinal line, and often a pair of spots on disc, brownish. Pronotum brown, darker posteriorly in the male. Scutellum brown, sometimes with basal angles and two spots on disc black. Elytra brown, nervures usually darker, females with two light transverse bands. Face the color of the vertex, the front usually darker. Males lack the light bands on the elytra and are uniformly darker.

External genitalia: Female, last ventral segment laterally twice as long as the preceding, keeled, and with posterior margin strongly produced medially; pygofers short, broad basally but strongly narrowed apically, much exceeded by the long stout ovipositor. Male, valve hidden by the short last ventral segment; plates very long and narrow, becoming vertical and spiny on their apical half, their apices exceeding the ventrally shortened but dorsally produced pygofers.

Internal male genitalia: Styles long and slender, curving, enlarged distally, apices obtuse, proximal end with two chitinous processes, the ventral one the larger, the whole end spreading out into a thin chitinous fan-shaped base; connective of two pieces, the first is V-shaped and connects the styles, the second is columnar, deeply cleft at the upper end for the reception of the apex of the V-shaped portion and connecting with the œdagus at the lower end, and the whole connective projecting ventrad, instead of dorsad, as is usually the case; œdagus widened a short distance from its base for the attachment of a long dorsal process which runs up for the attachment of the membrane from the anal tube, then continuing as a long narrow curving process which is suddenly bent and narrowed preapically, and finally ending in a delicate spine-like tip.

Distribution: This species occurs in eastern Kansas as shown by the following map:



Hosts: This seems to be a very general feeder. The adults are especially common in Douglas county on *Ambrosia trifida.* The nymphs have frequently been taken on oak.

Genus NEOCŒLIDIA G. & B.

The members of this genus are generally short and robust though some are distinctly elongate. The head is narrower than the pronotum and is obtusely conical. The pronotum is very short and broad, the anterior and posterior margins being nearly parallel. The elytra are short and broad, with usually four apical cells, though sometimes there are but three. The valve of the male is very characteristic being very large and produced posteriorly so as to completely cover the rest of the genitalia.

One of the two species keyed below has been taken in the state. The other one probably occurs here too.

KEY TO SPECIES.

A. Color yellowish-green, apex of vertex without black spot. *tumidifrons.*
AA. Color whitish, apex of vertex with black spot. *candida*

Neocœlidia tumidifrons G. & B.

Neocœlidia tumidifrons G. & B., Hemip. Colo., p. 104, 1895.
Neocœlidia tumidifrons O. & B., Proc. Ia. Acad. Sci., iv, p. 183, 1897.
Neocœlidia tumidifrons Osb., Me. Agr. Exp. Sta., Bul. 238, p. 145, 1915.
Neocœlidia tumidifrons DeL., Tenn. St. Bd. Ent., Bul. 17, p. 91, 1916.
Neocœlidia tumidifrons Van D., Cat. Hemip. N. A., p. 690, 1917.
Neocœlidia tumidifrons Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 103, 1919.

Form: Short and very robust. Length, 4 to 5 mm. Head narrower than the pronotum. Vertex one-half longer at the middle than next the eye, a little broader than long, tumid and obtusely conical. Pronotum shorter than the vertex, over three times as wide as long, lateral margins convex, humeral margins long, anterior and posterior margins about parallel, transversely rugose. Elytra short and broad, barely reaching to tip of abdomen.

Color: Uniformly yellowish or yellowish-green, the vertex and face sometimes washed with orange. Elytra subhyaline, the nervures indistinct.

External genitalia: Female, last ventral segment large, posterior margin slightly sinuate on either side of a small median notch, lateral angles slightly produced and rounded; pygofers large, slightly exceeded by ovipositor and sparsely spined. Male with the large triangular valve characteristic of the genus.

Distribution: Specimens of this species have been taken in Cherokee and Douglas counties.

Neocœlidia candida Ball.

Neocœlidia candida Ball, Ent. News, xx, p. 166, 1909.
Neocœlidia candida Van D., Trans. San Diego Soc. Nat. Hist., ii, p. 55, 1914.
Neocœlidia candida Van D., Cat. Hemip. N. A., p. 690, 1917.

Form: Stout and robust. Length, 4.25 to 4.5 mm. Vertex a little wider than long, bluntly oval apically, disc convex, rounding to the tumid front. Pronotum shorter than the vertex, over three times as wide as long, anterior and posterior margins about parallel, humeral margins long and rounding with the shorter lateral margins. Elytra short but exceeding abdomen, venation distinct.

Color: Whitish, sometimes tinged with pale green. Vertex with black apical spot, ocelli and sometimes a pair of spots on disc, brown. Pronotum and scutellum unmarked except for brownish impressed line of the latter. Elytra milky-white, nervures pale brown, apical cells sometimes brownish. Face pale, unmarked.

External genitalia: Female, last ventral segment three times as long as the preceding, curved around the pygofers, posterior margin slightly medially produced; pygofers broad, nearly equalling the ovipositor, sparsely spined. Male, valve as broad basally as last ventral segment, longer than broad, apex acute, nearly equalling pygofers, with two round black spots on disc.

Distribution: Not yet reported from Kansas but should occur in the western portion of the state.

Hosts: Doctor Ball informs me that *Atriplex canescens* is the host plant of this species.

Genus CICADULA Zett.

In general the members of this genus are rather small and elongate. The vertex is longer on the middle than next the eye, but not strongly produced. The pronotum is short, the anterior margin more or less convex, the posterior margin slightly concave. The elytra are long, exceeding the abdomen, overlapping apically, with a distinct appendix, and with the inner sector not forked, there being only two anteapical cells. The wings have three apical cells, thus differing from the wings of the two following genera where there are but two apical cells.

Four species and a variety of this genus have been taken in Kansas.

KEY TO SPECIES.

A. Species large and robust, 4.5 mm. or more in length. *punctifrons.*

AA. Species smaller, elongate, 4 mm. or less in length.

B. Vertex with four black spots. *variata.*

AA. Species smaller—*concluded.*

BB. Vertex with six black spots.

C. Four of the black spots in a row on the margin of vertex; basal angles of scutellum black. *lepida.*

CC. Black spots of vertex in two rows of three each, the two anterior pairs usually forming lines; basal angles of scutellum unmarked. *sexnotata.*

Cicadula punctifrons (Fall.).

Cicada punctifrons Fall., Hemip. Suec., Cicad., p. 42, 1826.
Thamnotettix punctifrons Boh., Kong. Vet. Akad. Handl. for 1847, p. 33.
Jassus punctifrons Flor., Rhyn. Livl., p. 328, 1861.
Limotettix punctifrons Sahlb., Cicad., p. 244, 1871.
Cicadula punctifrons Fieb., Revue d'Ent., iv, pp. 50, 58, 1885.
Cicadula punctifrons Van D., Psyche, vi, p. 305, 1892.
Cicadula punctifrons Mel., Cicad. Mitt. Eur., p. 34, pl. 11, figs. 1-4, 1896.
Cicadula punctifrons Edw., Hemip. Homop. Brit. Isds., p. 185, pl. 21, fig. 3, 1896.
Cicadula punctifrons Osb., 20th Rept. N. Y. St. Ent., p. 540, 1905.
Cicadula punctifrons Van D., Cat. Hemip. N. A., p. 692, 1917.

Form: A robust species. Length, 4 to 5 mm. Vertex nearly parallel-margined, very slightly longer on the middle than next the eye, broadly rounding with front. Pronotum twice as wide as long, anterior margin broadly convex, posterior margin very slightly emarginate, lateral margins very short, humeral margins long. Elytra long and narrow, greatly exceeding the abdomen, strongly overlapping apically, appendix distinct.

Color: Vertex, pronotum, and scutellum dirty-yellow. Vertex with two large round black spots anteriorly. Elytra milky-white, washed with yellow.

External genitalia: Female, last ventral segment about as long as preceding, posterior margin slightly produced medially; pygofers large, widest at the middle, equalling or slightly exceeding the ovipositor. Male, valve broad, rounded posteriorly, about three-fourths as long as last ventral segment; plates broad basally, about twice as long as valve, spineless margins narrowing somewhat concavely to the subacute somewhat divergent apices; pygofers broad, bristly, slightly exceeding plates.

Distribution: Hamilton county has furnished the only specimens of this species yet taken in the state.

Hosts: Willow.

Cicadula punctifrons var. *repleta* Fieb.

(Pl. 15, figs. 3-4.)

Cicadula punctifrons var. *repleta* Fieb., Revue d'Ent., iv, p. 49, 1885.
Macrosteles punctifrons var. *repleta* Horv., Ann. Mus. Natl. Hung., vi, p. 566, 1908.
Cicadula punctifrons var. *americana* Van D., Can. Ent., xxiii, p. 169, 1891.
Cicadula punctifrons var. *americana* Osb., 20th Rept. N. Y. St. Ent., p. 540, 1905.
Cicadula punctifrons var. *americana* DeL., Tenn. St. Bd. Ent., Bul. 17, p. 93, 1916.
Cicadula punctifrons var. *repleta* Van D., Cat. Hemip. N. A., p. 693, 1917.

Form: Like the preceding but usually larger. Length, 5 to 6 mm. The lateral margins of pronotum relatively longer than in typical *punctifrons.*

Color: Ground color like the preceding, variously marked with brown or black. In lightly marked specimens there are faint brown stripes on the elytra and two brownish spots on the margin of the apex between the two usual large black spots. Moderately colored specimens show five dark stripes on the elytra, two on the clavus and three on the corium, with sometimes black triangles in the basal angles of the scutellum. In dark forms the black stripes of the elytra may fuse and make the whole elytron, except the costal margin, almost black.

External genitalia: As in typical *punctifrons.*

Internal male genitalia: Styles very characteristic, broadest at point of attachment to connective, then narrowing to middle and again widening, the preapical incision on lateral margin deep and extending cephalomesad, forming a distinct shoulder on lateral margin which bears several hairs, the terminal process long, directed caudo-laterad, obliquely truncate apically, forming a produced and acute lateral angle, the inner margin with a few preapical small teeth; connective Y-shaped, the arms bending distally around the styles, the stem about as long as the arms, divided and slightly emarginate basally; œdagus with a large wide dorsal plate-like process at the base which extends dorsad to the membrane from the anal tube, the distal portion wide at base, then narrowing, widening again, and then gradually tapering to the blunt, slightly concavely-tipped apex just before which there are two small sword-shaped, acutely-tipped lateral processes.

Distribution: Most of our specimens are from Hamilton county. It has also been taken at Kansas City, Mo.

Hosts: Willow.

Cicadula variata (Fall.).

Cicada variata Fall., Acta Holm, xxvii, p. 34, 1806.
Jassus variata H. S., Nomen. Ent., i, p. 70, 1835.
Jassus fumatus H. S., Fauna Germ., fasc. 153, 5, 1838.
Thamnotettix variata Kirschb., Cicad. v. Wiesbd., p. 99, 1868.
Limotettix variata Sahlb., Cicad., p. 250, 1871.
Cicadula variata Fieb., Revue d'Ent., iv, p. 51, 1885.
Cicadula variata Van D., Psyche, vi, p. 305, 1892.
Cicadula variata Edw., Hemip. Homop. Brit. Isds., p. 185, pl. 21, fig. 6, 1896.
Cicadula variata Osb., 20th Rept. N. Y. St. Ent., p. 540, 1905.
Cicadula variata Osb., Me. Agr. Exp. Sta., Bul. 238, p. 145, 1915.
Cicadula variata DeL., Tenn. St. Bd. Ent., Bul. 17, p. 94, 1916.
Cicadula variata Van D., Cat. Hemip. N. A., p. 693, 1917.
Cicadula variata Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 106, 1919.

Form: Fairly elongate. Length, 3.75 to 4.25 mm. Vertex about one-half longer on middle than next the eye, nearly or fully twice as wide as long, apex obtusely angled. Pronotum twice as wide as long, lateral margins very short, posterior margin very slightly emarginate. Elytra moderately broad, greatly exceeding abdomen.

Color: Yellowish or yellowish-green. Vertex with two large black spots near posterior margin and a pair on the anterior margin between the vertex and the front. Scutellum with two large black spots in basal angles, the anterior portions showing through the pronotum. Elytra whitish hyaline, often smoky, especially on basal two-thirds, and with a light spot on the claval suture. Nervures light. Face unmarked, or with sutures of front black.

External genitalia: Female, last ventral segment short, about as long as the preceding, posterior margin truncated; pygofers nearly or fully equalling the black ovipositor, the apices with a few white spines. Male, valve long, triangular, apex obtusely rounded, nearly covering the narrow plates.

Distribution: Specimens are at hand from Douglas, Pottawatomie, and Riley counties. It probably occurs throughout the eastern part of the state.

Hosts: This species is reported from grasses and weeds. Our specimens were taken at lights.

Cicadula lepida Van D.

Cicadula lepida Van D., Can. Ent., xxvi, p. 139, 1894.
Cicadula lepida Osb., 20th Rept. N. Y. St. Ent., p. 540, 1905.
Cicadula lepida DeL., Tenn. St. Bd. Ent., Bul. 17, p. 94, 1916.
Cicadula lepida Van D., Cat. Hemip. N. A., p. 694, 1917.
Cicadula lepida Fent., Ohio Jl. Sci., xviii, p. 185, 1918.
Cicadula lepida Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 106, 1919.

Having no specimens of this species at hand, we copy the following description from De Long:

"Resembling *variata*, but distinguished from it by the vertex more produced on the middle, and with a black spot next each eye. Length, 3.5 to 4 mm.

"Vertex bluntly angulate, slightly more than half longer on the middle than next the eye, more angulately produced than *variata*

"*Color:* Yellow, often tinged with green; vertex with two spots near the base, two large spots on apex, a vertical mark either side, between ocellus and eye, and often short, frontal arcs, black. Elytra whitish, often tinged with yellow, smoky at apex, nervures pale.

"*Genitalia:* Female, last ventral segment rather short, slightly emarginate at middle; pygofers as long as black ovipositor, clothed with white spines. Male, valve large and rounded, plates short, convexly rounding to rather blunt apices, outer margins with long white spines."

Distribution: Specimens of this species have been taken in Douglas and Pottawatomie counties.

Hosts: De Long reports sweeping specimens from small grass in low, swampy ground.

Cicadula sexnotata (Fall.).

(Pl. 15, figs. 5-6.)

Cicada sexnotata Fall., Acta Holm, xxvii, p. 34, 1806.
Jassus sexnotata Burm., Genera Ins., pl. 14, 1838.
Cicadula sexnotata Zett., Ins. Lapp., column 297, 1840.
Thamnotettix sexnotata Stal, Stet. Ent. Zeit., xix, p. 194, 1858.
Macrosteles sexnotata Fieb., Verh. Zoöl.-Bot. Ges. Wien., xvi, p. 504, 1866.

Limotettix sexnotata Sahlb., Cicad., p. 247, 1871.
Cicadula sexnotata Fieb., Revue d'Ent., iv, p. 47, 1885.
Cicadula 4-lineata Forbes, Rept. Ill. St. Ent., xiv, p. 68, pl. 5, fig. 4, 1884.
Cicadula sexnotata Woodw., Psyche, v, p. 75, 1888.
Cicadula sexnotata Osb., 20th Rept. N. Y. St. Ent., p. 539, 1905.
Cicadula sexnotata Osb., U. S. Dept. Agr., Bur. Ent., Bul. 108, p. 97, fig. 27, 1912.
Cicadula sexnotata Osb., Me. Agr. Exp. Sta., Bul. 238, p. 147, 1915.
Cicadula sexnotata Osb., Me. Agr. Exp. Sta., Bul. 248, p. 59, 1916.
Cicadula sexnotata DeL., Tenn. St. Bd. Ent., Bul. 17, p. 95, 1916.
Cicadula sexnotata Van D., Cat. Hemip. N. A., p. 694, 1917.
Cicadula sexnotata Ell., Vort. Landburg, xxxvii, No. 40, p. 453, 1918.
Cicadula sexnotata Fent., Ohio Jl. Sci., xviii, p. 185, 1918.
Cicadula sexnotata Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 107, 1919.

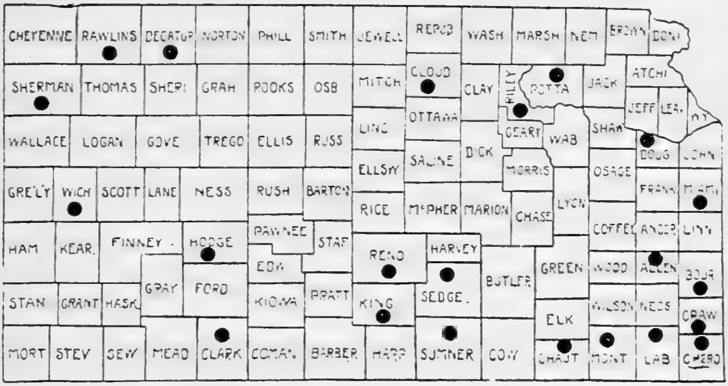
Form: Distinctly elongate. Length, 3.5 to 4 mm. Vertex slightly longer at middle than next the eye, nearly or fully twice as wide as long, broadly rounding with front. Pronotum broadly convex anteriorly, very slightly concave posteriorly, lateral margins very short. Elytra greatly exceeding abdomen.

Color: Yellowish or yellowish-green. Vertex with a pair of black spots posteriorly, and two pairs of black transverse lines, one pair on the anterior margin, the other pair between these and the posterior spots, also a black line between the reddish ocelli and the eyes. Pronotum frequently darker or with black showing through, especially on posterior portion. Elytra yellowish-gray, often smoky apically. Face with sutures, arcs on front, and median longitudinal line, black.

External genitalia: Female, last ventral segment rather short, posterior margin truncated; pygofers equalling the black ovipositor, with a few white spines apically. Male, valve large, triangular, apex obtusely rounded; plates small, projecting beyond the valve about the length of the latter and then produced into two attenuated apices which nearly or quite equal the bristly pygofers.

Internal male genitalia: Styles with large anterior process, a fair-sized process to connective, concave laterally just before the middle and then mesally concave just after the middle, strongly notched laterally to form a somewhat curved bluntly pointed terminal process; connective in the shape of a broad Y, the arms rounding, the stem widening distally; œdagus curved at base, long and slender, deeply cleft at apex to form two strap-like subacutely pointed processes, the dorsally extending basal process quite large.

Distribution: This is one of our most abundant species. It is found in every part of the state as shown by the following map:



Hosts: Feeds on a great variety of plants. Often is a pest to crops because of its large numbers. Doctor Osborn records it as feeding upon oats, timothy, corn, potatoes, and pasture grasses.

Genus Balclutha Kirk.

The members of this genus are rather elongate slender species. The head is narrower than the pronotum and the vertex is short, the margins nearly parallel. The elytra are very long, greatly exceeding the abdomen, overlapping apically, with a distinct appendix, and with only two anteapical cells. The hind wings have only two apical cells.

Only two members of this genus have been taken in Kansas.

KEY TO SPECIES.

A. Elytra with black or brown spots. *punctata.*
AA. Elytra unicolorous. *impicta.*

Balclutha punctata (Thunb.).

(Pl. 16, figs. 1-2.)

Cicada punctata Thunb., Acta Upsala, iv, p. 21, 1782.
Eupteryx clypeata Curt., Brit. Ent., xiv, p. 640, 1837.
Cicadula spreta Zett., Ins. Lapp., column 298, 1840.
Jassus punctatus Walk., List Homop., iii, p. 877, 1851.
Typhlocyba vernalis Fh. MS., in collections.
Gnathodus punctatus Fieb., Verh. Zoöl.-Bot. Ges. Wien., xvi, p. 505, 1866.
Thamnotettix punctatus Kirschb., Cicad. v. Wiesbd., p. 90, 1868.
Typhlocyba rosea Prov., Nat. Can., iv, p. 378, 1872.
Typhlocyba punctata Prov., Pet. Faune Ent. Can., iii, p. 301, 1890.
Typhlocyba jacosa Prov., Pet. Faune Ent. Can., iii, p. 300, 1890.

Gnathodus punctatus Mel., Cicad. Mitt. Eur., p. 314, pl. 12, figs. 5-8, 1896.
Gnathodus punctatus Edw., Hemip. Homop. Brit. Isds., p. 191, pl. 21, fig. 10, 1896.
Balclutha punctata Mats., Termes. Fuzet., xxv, p. 358, 1902.
Balclutha punctata Osb., Me. Agr. Exp. Sta., Bul. 238, p. 149, 1915; Bul. 248, p. 79, 1916.
Balclutha punctata DeL., Tenn. St. Bd. Ent., Bul. 17, p. 96, 1916.
Balclutha punctata Van D., Cat. Hemip. N. A., p. 696, 1917.

Form: Distinctly elongate, narrowing posteriorly. Length, 3.5 to 4 mm. Head much narrower than pronotum, vertex slightly longer on middle than next the eye, over three times as wide as long, sloping, and broadly rounding with front. Pronotum long, anterior margin strongly convex, posterior margin slightly concave, broadest at lateral angles. Elytra very long, overlapping at apex.

Color: Greenish or yellowish-green. Vertex yellowish-green, unmarked, or with three faint brownish longitudinal stripes. Pronotum yellowish-green, darker on the disc, unmarked, or with five brownish longitudinal stripes. Scutellum pale, often with basal angles and two spots on disc fuscous. Elytra greenish with hyaline smoked tips or milky-white with green nervures, always marked with black or brown spots. Face yellowish-green, often washed with fuscous.

External genitalia: Female, last ventral segment long, posterior margin truncate; pygofers long and narrow, spiny, equalling ovipositor. Male, valve very small, just visible from under last ventral segment, rounded posteriorly; plates broad, triangular, spiny margins convexly narrowing to the produced and filamentous apices which nearly equal the pygofers.

Internal male genitalia: Styles truncate anteriorly, lacking the usual anterior process, then narrowing on both sides, especially the inner, to the middle, then widening to a subacute angle on the lateral margin formed by a deep and fairly wide lateral incision which bears a few hairs, the apical process long and narrow and curving strongly to the acute tip; connective Y-shaped, the arms widest at point of attachment to styles, then narrowed and bent mesad anteriorly, the stem longer than the rounding arms, and widened and slightly concave basally; œdagus with a large swollen base, then suddenly narrowing to a long delicate terminal lash.

Distribution: Douglas county seems to be the only one in which this species has yet been taken. The Snow collection also contains specimens from Kansas City, Mo. It probably occurs throughout the eastern portion of the state.

Hosts: Professor Osborn counts this species as of probable economic importance due to its occurring in grasses and cereal crops. He mentions Canadian bluegrass as a definite host. The writer has taken this species on *Elymus* in Douglas county.

Balclutha impicta (Van D.).

(Pl. 16, figs. 3-4.)

Gnathodus impictus Van D., Can. Ent., xxiv, p. 113, 1892.
Balclutha impictus Van D., Bul. Buf. Soc. Nat. Sci., ix, p. 229, 1909.
Balclutha impictus Osb., Me. Agr. Exp. Sta., Bul. 238, p. 149, 1915.
Balclutha impictus DeL., Tenn. St. Bd. Ent., Bul. 17, p. 96, 1916.
Balclutha impicta Van D., Cat. Hemip. N. A., p. 697, 1917.

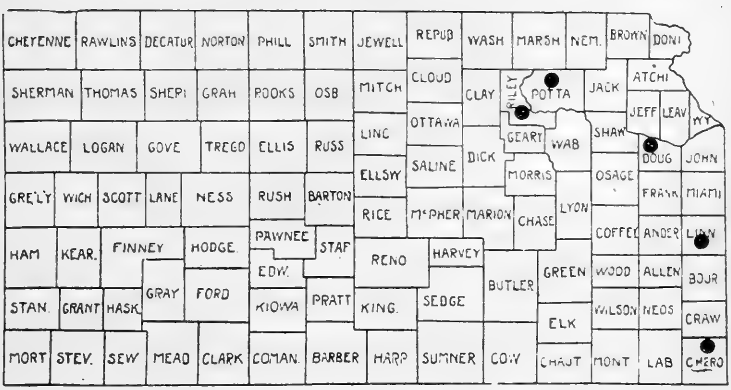
Form: Slightly smaller than *punctata*. Length, 3.5 to 3.75 mm. Head narrower than pronotum, vertex very slightly longer on middle than next the eye, over three times as wide as long. Pronotum long, anterior margin strongly convex, posterior margin very slightly emarginate. Elytra very long, greatly exceeding abdomen, narrow, overlapping apically.

Color: Greenish, sometimes tinged with yellow, Elytra greenish basally, becoming whitish apically.

External genitalia: Female, last ventral segment rather long, posterior margin truncate; pygofers long and narrow, widest at middle, spiny, equalling ovipositor. Male, valve distinct, nearly semicircular; plates small, margins convexly narrowing to the attenuate tips which are strongly exceeded by the pygofers.

Internal male genitalia: Styles produced anteriorly into a wide process, widest at point of attachment to connective by a rounded inner lobe, preapical lateral incision nearly semicircular, the terminal process rather short, curved, the apex more heavily chitinized and roughened; connective Y-shaped, the arms stout and triangular, separated by a rather narrow incision, the stem longer than the arms, widened to the truncate apex; œdagus with a broad rectangular dorsally-directed attachment process at the base, the main portion swollen basally and gradually tapering to the broad but rather deeply bifid apex, so that it seems to end in two delicate processes.

Distribution: This species seemingly is found throughout the eastern part of the state as shown by the following map:



Hosts: No definite host plant seems yet to have been found for this species. It is undoubtedly a grass feeder.

Genus EUGNATHODUS Bak.

The members of this genus are very much like those of *Balclutha,* being long and slender, the elytra long and greatly exceeding the abdomen, with only two anteapical cells, and a distinct appendix. The wings also possess but two apical cells. Here, however, the head is distinctly wider than the pronotum and thus these forms are readily separable from those of the preceding genus.

One member of the genus occurs in Kansas.

Eugnathodus abdominalis (Van D.).

(Pl. 16, figs. 5-6.)

Gnathodus abdominalis Van. D., Can. Ent., xxiv, p. 113, 1892.
Eugnathodus abdominalis Bak., Invert. Pacifica, i, p. 2, 1903.
Balclutha abdominalis DeL., Tenn. St. Bd. Ent., Bul. 17, p. 95, 1916.
Eugnathodus abdominalis Van D., Cat. Hemip. N. A., p. 697, 1917.
Eugnathodus abdominalis Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 107, 1919.

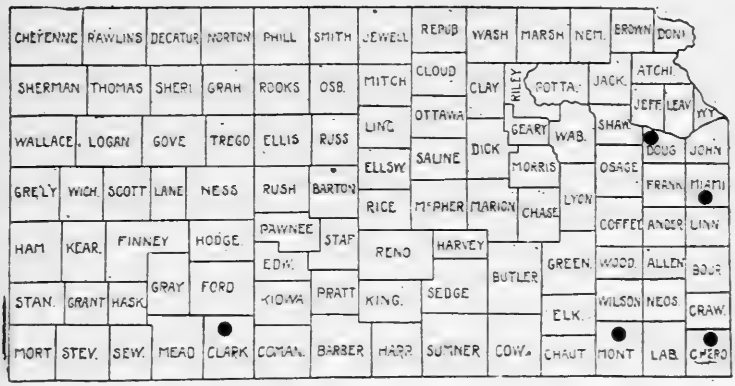
Form: Distinctly elongate, tapering posteriorly. Length, 3 to 3.5 mm. Head as wide or slightly wider than the pronotum. Vertex short, slightly longer at middle than next the eye, about three times as wide as long. Pronotum broadly rounded anteriorly, not as much produced as in *Balclutha,* lateral angles sharp, posterior margin very slightly emarginate. Elytra very long, greatly exceeding abdomen, strongly overlapping apically, appendix distinct, only two anteapical cells. Wings with two apical cells.

Color: Greenish, tinged with whitish on elytra and fuscous on vertex, pronotum, and scutellum. Pronotum sometimes with three dark longitudinal lines.

External genitalia: Female, last ventral segment short, slightly sinuate on either side of a very slight median prominence; pygofers long and narrow, widest at the middle, slightly exceeded by the ovipositor. Male, valve broad, rounded posteriorly; plates broad basally, short, spiny lateral margins convexly narrowing to the divergent apices, which are exceeded by the pygofers.

Internal male genitalia: Styles with an anterior process, a large rounded lobe to connective, then suddenly narrowed, the terminal process curved outward, rather short and stout; connective Y-shaped, the arms widely separated and curved apically around styles, the stem longer than the arms, widened basally; œdagus enlarged basally, with a small dorsally directed plate, then rapidly narrowed to long terminal process, which curves dorsad and ends rather obtusely.

Distribution: Most abundant in the eastern counties of the state, as shown by the following map:



Hosts: Probably a grass feeder.

Tribe TYPHLOCYBINI (Kirschb.).

The members of this tribe are rather uniformly small species, elongate and fragile. They differ from the other tribes of the *Jassinæ* and from other *Cicadellidæ* in two particulars chiefly, namely, that the four sectors of the elytra run to the cross nervures without branching so that there are no anteapical cells, and in the fact that the ocelli are often wanting.

The tribe is divided into a number of genera, six of which are represented in our fauna. The genus *Eupteryx,* though not represented in the state, is included in the key.

The following key to the genera is adapted from Gillette, Proc. U. S. Natl. Mus., xx, p. 710, 1898. I have followed the nomenclature given by McAtee, Proc. Biol. Soc. Wash., xxxi, p. 109, 1918.

KEY TO GENERA.

A. Sectors of posterior wings ending in a marginal vein.
  B. Elytra with an appendix. *Alebra.*
  BB. Elytra without an appendix.
    C. Two apical cells in posterior wing. *Dikraneura.*
    CC. One apical cell in posterior wing. *Empoasca.*
AA. Sectors of posterior wings ending in wing margin, no marginal vein.
  B. All four sectors extending to the wing margin. *Eupteryx.*
  BB. Sectors one and two uniting so that only three veins extend to the wing margin.
    C. First and third apical cells of elytra contiguous at base, second apical cell triangular. *Typhlocyba.*

AA. Sectors of posterior wings—*concluded.*

CC. First and third apical cells of elytra completely separated by the second oblong apical cell.

D. Scutellum thickened and distinctly elevated apically. *Hymetta.*

DD. Scutellum not thickened and elevated apically. *Erythroneura.*

Genus ALEBRA Fieb.

The members of this genus are slender forms with a bluntly rounded head which is narrower than the pronotum. Ocelli are present. The elytra greatly exceed the abdomen, overlap at the apex, and have a distinct appendix. The sectors of the under wings end in a marginal vein and there are three apical cells.

One species and a variety have been taken in the state.

Alebra albostriella (Fall.).

Cicada albostriella Fall., Hemip. Suec. Cicad., p. 54, 1826.
Cicada elegantula Zett., Fauna Lapp., i, p. 536, 1828.
Cicadula elegantula Zett., Ins. Lapp., column 298, 1840.
Typhlocyba albostriella Flor, Rhyn. Livl., ii, p. 382, 1861.
Typhlocyba pallidula Walsh, Proc. Bost. Soc. Nat. Hist., ix, p. 315, 1864.
Compsus albostriella Sahlb., Cicad., p. 156, 1871.
Alebra albostriella Fieb., Revue d'Ent., iii, p. 40, 1884.
Alebra pallida Woodw., Psyche, v, p. 213, 1889.
Alebra albostriella Mel., Cicad. Mitt. Europ., p. 316, pl. 12, figs. 9, 10, 1896.
Alebra albostriella Edw., Hemip. Homop. Brit. Isds., p. 193, pl. 22, fig. 1, 1896.
Alebra albostriella Gill., Proc. U. S. Natl. Mus., xx, p. 713, 1898.
Alebra albostriella DeL., Tenn. St. Bd. Ent., Bul. 17, p. 97, 1916.
Alebra albostriella Van D., Cat. Hemip. N. A., p. 699, 1917.
Alebra albostriella Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 109, 1919.

The following description of this species is given by De Long:

"Rather robust, long, yellow or white in color. Length, 3.5 to 4 mm.

"Head blunt, parallel-margined, slightly curved anteriorly. Pronotum wider than head including eyes, elytra long, rather narrow.

"*Color:* Male, usually bright yellow, apices of elytra fumose. Female, varying, usually white, pronotum with two stripes, a broad one on suture and one along costa of elytra, yellow, head and pronotum often brown."

Distribution: The only record of this species for the state is from Pottawatomie county.

Hosts: De Long records taking specimens from willows, grapevines and weeds. Crevecoeur took specimens from burr oak.

Alebra albostriella var. *fulveola* (H. S.).

Typhlocyba fulveola H. S., Fauna Germ., cxiv, No. 16, 1839.
Typhlocyba aurea Walsh, Proc. Bost. Soc. Nat. Hist., ix, p. 315, 1864.
Compsus fulveola Sahlb., Cicad., p. 158, 1871.
Alebra albostriella var. *fulveola* Fieb., Revue d'Ent., iii, p. 41, 1884.
Alebra albostriella var. *fulveola* Edw., Hemip. Homop. Brit. Isds., p. 193, pl. 22, fig. 2, 1896.
Alebra albostriella var. *fulveola* Van D., Cat. Hemip. N. A., p. 699, 1917.

Form: That of the preceding. Length, 3.5 to 4 mm. Head narrower than the pronotum, blunt anteriorly, the vertex one-half wider than long. Pronotum twice as wide as long, broadly rounded anteriorly, lateral margins fairly long, posterior margin somewhat emarginate. Elytra very long, greatly exceeding the abdomen.

Color: The specimens at hand are almost uniformly orange-yellow, the elytra pale apically, and often with a pruinose spot along costal margin. Beneath and legs the same color except for the black tarsal claws.

External genitalia: Male, last ventral segment half longer than the preceding, strongly narrowed posteriorly, keeled posterior margin truncate or slightly emarginate; valve present, but hidden under last ventral segment unless the latter be raised up, small and rounded posteriorly; plates very large, suddenly narrowed preapically and then parallel-margined to the blunt bristly apices which far exceed the pygofers.

Distribution: Specimens are at hand from Douglas county and also from Kansas City, Mo., indicating its occurrence in the eastern portion of the state.

Hosts: Unknown.

Genus DIKRANEURA Hardy.

The members of this genus are small and quite slender. The vertex is usually obtusely produced anteriorly. The elytra greatly exceed the abdomen but lack an appendix, thus differing from *Alebra*. The sectors of the hind wings all end in a marginal vein and there are two apical cells, differing in the latter respect from *Empoasca* where only one apical cell is found.

Two species of this genus have been collected in Kansas. These may be separated by the following key:

KEY TO SPECIES.

A. Vertex strongly produced, two reddish longitudinal lines on vertex and pronotum. *abnormis.*

AA. Vertex shorter, usually reddish apically, without longitudinal lines. *fieberi.*

Dikraneura abnormis (Walsh).

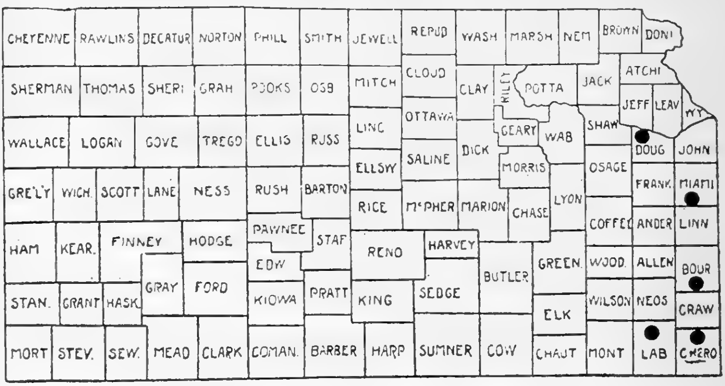
Chloroneura abnormis Walsh, Proc. Bost. Soc. Nat. Hist., ix, p. 316, 1864.
Dicraneura abnormis Woodw., Psyche, v, p. 213, 1889.
Dicraneura abnormis Gill., Proc. U. S. Natl. Mus., xx, p. 719, 1898.
Dicraneura abnormis DeL., Tenn. St. Bd. Ent., Bul. 17, p. 98, 1916.
Dikraneura abnormis Van D., Cat. Hemip. N. A., p. 700, 1917.
Dikraneura abnormis Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 110, 1919.

Form: Very slender. Vertex over twice as long at middle as next the eye, one-third wider than long, acutely angled apically. Pronotum long and narrow, one-half longer than vertex, lateral margins long, slightly widening posteriorly, humeral margins short, posterior margin distinctly concave. Elytra very long and narrow.

Color: Vertex and pronotum yellowish, with two broad reddish longitudinal stripes. Scutellum yellowish. Elytra greenish, nervures yellowish especially apically where the elytra become hyaline. Face pale. Abdomen black.

External genitalia: Female, last ventral segment rather short, narrow, posterior margin broadly but slightly convex; pygofers long and narrow, exceeded by ovipositor, somewhat hairy along mesal margins and apically. Male, valve large, broad, lateral margins roundingly narrowed posteriorly, posterior margin truncate; plates broad, narrowing rather concavely to the attenuate and divergent tips which are upturned and exceed the pygofers.

Distribution: This species seemingly is found only in the eastern portion of the state as shown by the following map:



Hosts: Occurs on a large number of grasses.

Dikraneura fieberi (Loew).

Notus fieberi Loew in Then, Kat. Ostr. Cicad., p. 39, 1886.
Notus forcipatus Fieb., Revue d'Ent., iii, p. 53, 1884.
Dicraneura fieberi Mel., Cicad. Mitt. Eur., p. 325, 1896.
Dicraneura fieberi Gill., Proc. U. S. Natl. Mus., xx, p. 722, 1898.
Dicraneura fieberi Osb., Me. Agr. Exp. Sta., Bul. 238, p. 151, 1915.
Dicraneura fieberi DeL., Tenn. St. Bd. Ent., Bul. 17, p. 98, 1916.
Dikraneura fieberi Van D., Cat. Hemip. N. A., p. 701, 1917.
Dikraneura fieberi Fent., Ohio Jl. Sci., xviii, p. 186, 1918.
Dikraneura fieberi Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 110, 1919.

Form: Length about 3.5 mm. Vertex not as produced as in *abnormis*, more rounded apically, over one-half longer at middle than next the eye, nearly twice as wide as long. Pronotum long, only about one-third wider than long, lateral margins straight, humeral margins short. Elytra long and narrow.

Color: Light yellow. Vertex yellowish, often with the apical portion distinctly reddish. Pronotum yellowish, the disc sometimes reddish or orange colored. Elytra yellowish, nervures yellow, often quite hyaline, especially at the tips.

External genitalia: Female, last ventral segment very short laterally, posterior margin incised on either side of a large produced median lobe whose margins taper slightly from the broad base to the rounded apex; last abdominal tergite large and inflated, appearing as two broad lobes at the base of the pygofers, which are broad, mesally spiny, and nearly or fully equal the ovipositor. Male, valve very large and inflated, a little wider than long, lateral margins rounded, posterior margin truncate or slightly concave, with a longitudinal median line; plates projecting from under the valve as two large style-like processes, spiny, curved dorsally, with a distinct black tooth on inner margin before the black-tipped apices, which exceed the pygofers.

Distribution: Taken hitherto only in Cherokee and Douglas counties. Probably occurs throughout the eastern part of the state.

Hosts: This is a grass-feeding species which, according to Osborn, may be of economic importance because of occurring in large numbers on cultivated grasses, such as timothy.

Genus EMPOASCA Walsh.

The forms belonging to this genus are slender, greenish species, very largely unicolorous. The elytra are long and lack an appendix. The sectors of the hind wings end in a marginal vein, thus agreeing with the two preceding genera, but in this genus there is only one apical cell. Ocelli are present.

The six species keyed below have been collected in the state. Other species have been taken, but I am not quite certain as to their specific identity.

KEY TO SPECIES.

A. Vertex rounded, at most but slightly produced medially.
- B. Elytra with two transverse dark stripes. *trifasciata.*
- BB. Elytra without transverse stripes.
  - C. Size large, robust, length usually about 4 mm., elytra unicolorous. *obtusa.*
  - CC. Size smaller, more slender, seldom exceeding 3.5 mm., claval suture of elytra whitish. *albolinea.*

AA. Vertex distinctly produced medially.
- B. Pronotum with a pale median line, nervures of elytra pale. *alboneura.*
- BB. Pronotum without pale line, nervures not pale.
  - C. Pronotum with six or eight white spots on anterior margin. *mali.*
  - CC. Pronotum with three white spots on anterior margin. *flavescens.*

Empoasca trifasciata Gill.

Empoasca trifasciata Gill., Proc. U. S. Natl. Mus., xx, p. 726, 1898.
Empoasca trifasciata Osb., 20th Rept. N. Y. St. Ent., p. 542, 1905.
Empoasca trifasciata DeL., Tenn. St. Bd. Ent., Bul. 17, p. 99, 1916.
Empoasca trifasciata Van D., Cat. Hemip. N. A., p. 702, 1917.
Empoasca trifasciata Weiss & Dick., Can. Ent., L, p. 201, 1918.
Empoasca trifasciata Weiss, Ent. News, xxix, p. 310, 1918.

Form: Length, 4 to 4.25 mm. Vertex very slightly longer at middle than next the eyes, obtusely rounded apically, twice as wide as long. Pronotum long, one-half wider than long, lateral margins long, widening posteriorly, humeral margins shorter, posterior margin slightly emarginate. Elytra very long, greatly exceeding abdomen.

Color: Greenish. Vertex greenish-yellow. Pronotum yellowish anteriorly, with a dark brown band on the posterior part. Scutellum yellowish basally, greenish apically. Elytra greenish, with broad smoky or brownish bands across middle of clavus and at apex. Face yellowish above, greenish below, sometimes with a white median longitudinal line.

External genitalia: Female, last ventral segment long, posterior margin roundingly produced medially; pygofers moderately robust, long, slightly exceeded by ovipositor.

Distribution: Douglas and Riley counties seem to be the only counties in the state where this species has yet been taken.

Hosts: Weiss and Dickerson give Carolina and Lombardy poplars as hosts.

Empoasca obtusa Walsh.

Empoasca obtusa Walsh, Proc. Bost. Soc. Nat. Hist., ix, p. 316, 1864.
Empoasca obtusa G. & B., Hemip. Colo., p. 109, 1895.
Empoasca obtusa Gill., Proc. U. S. Natl. Mus., xx, p. 733, 1898.
Empoasca obtusa Webs., Ent. News, xxi, p. 265, 1910.
Empoasca obtusa Osb., Me. Agr. Exp. Sta., Bul. 238, p. 153, 1915.
Empoasca obtusa Leon., Ent. News, xxvii, p. 49, 1916.
Empoasca obtusa DeL., Tenn. St. Bd. Ent., Bul. 17, p. 100, 1916.
Empoasca obtusa Van D., Cat. Hemip. N. A., p. 703, 1917.
Empoasca obtusa McAt., Can. Ent., L, p. 360, 1918.
Empoasca obtusa Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 111, 1919.

Form: Rather robust. Length, 4 mm. Head broad; vertex slightly longer medially than next the eye, over twice as wide as long, broadly rounded apically. Pronotum long, less than twice as wide as long, lateral margins long and widening posteriorly, humeral margins short, posterior margin distinctly emarginate. Elytra long and narrow, greatly exceeding the abdomen.

Color: Pale green or yellowish-green. Vertex sometimes marked with fuscous. Pronotum usually with three fairly large white spots on anterior margin, and sometimes the posterior margin marked with bright green. Scutellum frequently with a broad white median line. Elytra yellowish or greenish, subhyaline, sometimes smoky and with some of the nervures bright green.

External genitalia: Female, last ventral segment long, posterior margin roundingly produced, but with the sides not sinuous; pygofers long, rather bristly, slightly exceeded by ovipositor. Male, last ventral segment over twice the length of the preceding, broad, posterior margin broadly rounding, covering the valve; plates broad and long, spiny, the upturned tips being laterally compressed and obtuse apically; pygofers very short, completely hidden by the plates.

Distribution: Fairly common in the eastern portion of the state as indicated by its occurrence in Douglas, Pottawatomie, Riley and Sedgwick counties.

Hosts: This species is usually abundant on willow. Leonard gives poplar as another host.

Empoasca albolinea Gill.

Empoasca albolinea Gill., Proc. U. S. Natl. Mus., xx, p. 732, 1898.
Empoasca albolinea Tuck., Kan. Univ. Sci. Bul., iv, p. 68, 1907.
Empoasca albolinea Van D., Cat. Hemip. N. A., p. 704, 1917.

Form: Length, 3.5 mm. Head not as broad and more rounding anteriorly than in *obtusa* Vertex slightly longer on middle than next the eye, over twice as wide as long, broadly rounding apically. Pronotum nearly three times as long as the vertex, less than twice as wide as long. Elytra characteristic of the genus.

Color: Greenish-yellow. Vertex with median white line and two white lateral spots or lines. Pronotum with three white spots on anterior margin and a characteristic pale median longitudinal line. Scutellum with white median line. Elytra yellowish, sometimes smoky, the claval suture broadly pale. Face yellowish above, greenish below, sometimes unmarked, sometimes with a median longitudinal line, a line next each eye, and a line between these and the median line, white.

External genitalia: Female, last ventral segment long, posterior margin produced and entire; pygofers moderately robust, spiny mesally, exceeded by ovipositor. Male, last ventral segment broad and long, covering the valve; plates as in *obtusa* but with a much thicker covering of much longer spines and hairs; pygofers very short, completely hidden by the plates.

Distribution: Our only records for this species are from Douglas county.

Hosts: Our specimens were taken at electric lights. Gillette gives willows as the host plant.

Empoasca alboneura Gill.

Empoasca alboneura Gill., Proc. U. S. Natl. Mus., xx, p. 743, 1898.
Empoasca alboneura DeL., Tenn. St. Bd. Ent., Bul. 17, p. 101, 1916.
Empoasca alboneura Van D., Cat. Hemip. N. A., p. 705, 1917.

Form: Short and fairly robust. Length about 3 mm. Vertex about one-third longer at middle than next the eye, over twice as wide as long.

Pronotum twice as wide as long, anterior margin strongly convex, lateral and humeral margins about equal, posterior margin distinctly concave. Elytra moderately long.

Color: Greenish-yellow. Vertex yellowish, a median line, a spot on either side, and one on posterior margin near each eye, white. Pronotum yellowish, becoming greenish posteriorly, anterior margin with three white spots, and with a distinct pale median longitudinal line. Scutellum yellowish, often with a broad white median line. Elytra greenish, apices smoky, nervures broadly pale. Face yellowish above, greenish below.

External genitalia: Female, last ventral segment long, posterior margin medially produced; pygofers rather robust, spiny, considerably exceeded by the ovipositor. Male, last ventral segment large, concave, and therefore the posterior margin appearing notched; plates long and narrow, each bearing two rows of long bristles, the tips upturned; pygofers very short, completely hidden by the plates.

Distribution: Gillette's record of specimens from Greeley county is our only record of this species in the state.

Hosts: De Long reports sweeping this species from weeds, grass, and red clover, and also taking it around lights.

Empoasca mali (LeB.).

(Pl. 16, figs. 7-8.)

Tettigonia mali LeB., Prairie Farmer, xiii, p. 330, 1853.
Empoa albopicta Forbes, 13th Rept. Ill. St. Ent., p. 181, pl. 14, 1884.
Empoasca mali Osb., Proc. Ia. Acad. Sci., i, pt. 2, p. 126, 1892.
Empoasca mali Gill., Proc. U. S. Natl Mus., xx, p. 744, 1898.
Empoasca mali Lugg., 6th Rept. Minn. St. Ent., p. 131, 1900.
Empoasca albopicta Washb., 9th Rept. Minn. St. Ent., p. 59, 1904.
Empoasca mali Washb., 9th Rept. Minn. St. Ent., p. 91, 1904.
Empoasca mali Osb., 20th Rept. N. Y. St. Ent., p. 543, 1905.
Empoasca mali Washb., U. S. Dept Agr., Bur. Ent., Bul. 52, p. 43, 1905.
Empoasca mali Washb., 12th Rept. Minn. St. Ent., p. 11, 1908.
Empoasca mali Webs., Jl. Ec. Ent.. ii, p. 211, 1909.
Empoasca mali Webs., Ent. News, xxi, p. 266, 1910.
Empoasca mali Webs., Ia. St. Col. Exp. Sta., Bul. 111, 1910.
Empoasca mali Washb., Jl. Ec. Ent., iii, p. 162, 1910.
Empoasca mali Sand., Jl. Ec. Ent., iii, p. 210, 1910.
Empoasca mali Washb., 13th Rept. Minn. St. Ent., p. 31, 1910.
Empoasca mali Osb., U. S. Dept. Agr., Bur. Ent., Bul. 108, p. 100, fig. 28, 1912.
Empoasca mali Hase., Jl. Ec. Ent., vi, p. 240, 1913.
Empoasca mali Ess., Inj. Benef. Ins. Calif., edn. 2. p. 62, 1915.
Empoasca mali Osb., Me. Agr. Exp. Sta., Bul. 238, p. 153, 1915.
Empoasca mali Webs., Ia. St. Col. Exp. Sta., Bul. 155, p. 395, 1915.
Empoasca mali Gibs., Can. Ent., xlviii, p. 178, 1916.
Empoasca mali DeL., Tenn. St. Bd. Ent., Bul. 17, p. 102, 1916.
Empoasca mali Van D., Cat. Hemip. N. A., p. 705, 1917.
Empoasca mali Lathr., Jl. Ec. Ent., xi, p. 144, 1918.
Empoasca mali Lathr., N. Y. Agr. Exp. Sta., Bul. 451, p. 185, 1918.
Empoasca mali Fent., Ohio Jl. Sci., xviii, p. 186, 1918.
Empoasca mali Ball, Jl. Ec. Ent., xii, p. 149, 2 pl., 1919.
Empoasca mali Ball, Wisc. Dept. Agr., Bul. 23, p. 76, 5 pl., 1919.
Empoasca mali Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 122, 1919.
Empoasca mali Fluke, Jl. Ec. Ent., xii, p. 256, 1919.
Empoasca mali Ack., U. S. Dept. Agr., Bur. Ent., Bul. 805, p. 1, 1919.

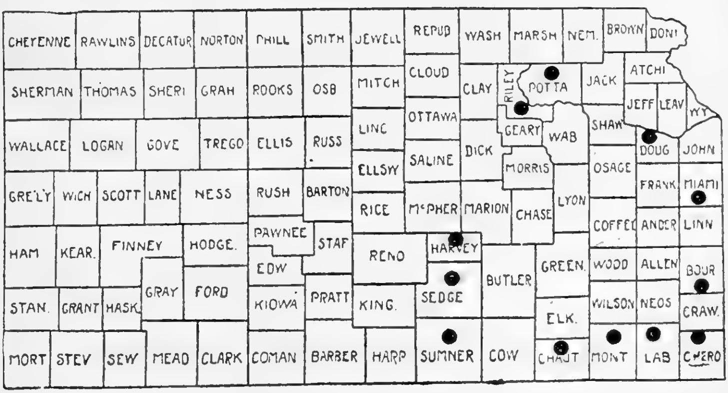
Form: Length, about 3.5 mm. Vertex one-third longer on middle than next the eye, distinctly produced, less than twice as wide as long. Pronotum twice as wide as long, anterior margin strongly convex, lateral and humeral margins about equal, posterior margin distinctly emarginate. Elytra long and narrow.

Color: Yellowish-green. Vertex with median line, dashes on either side anteriorly and posteriorly, white. Pronotum with six, sometimes with eight, white spots along anterior margin. Scutellum with a white "H" on anterior portion, and three white lines on posterior half. Elytra greenish, sometimes smoky. Face yellowish above, greenish below, with white median line and other white markings between it and the eyes.

External genitalia: Female, last ventral segment long, posterior margin slightly produced or truncate; pygofers rather robust, spiny mesally, exceeded by the ovipositor. Male, last ventral segment very large, posterior margin rounding; plates long and narrow, apices obtuse, upturned, and laterally compressed, thickly covered with white hairs and spines; pygofers very short, completely covered by the plates.

Internal male genitalia: Styles long and slender, sinuate; connective the form of an equilateral triangle with the corners rounded and the sides slightly concave; œdagus long and slender, very slender basally, then widening and again narrowing to tip when viewed laterally. Viewed dorsally it is enlarged apically into a blunt spearhead.

Distribution: This is by far the commonest member of this genus. Its recorded distribution for the state is shown by the following map:



Hosts: Taken on a large variety of hosts and very abundantly at lights. Because of feeding on so many cultivated plants it is of decided economic importance. It is common on many members of the family *Leguminosæ,* especially on alfalfa and beans. It is often an apple pest. In the last year it has been attracting much attention due to its work on potatoes. Doctor Ball has shown that it is the means of producing "hopperburn" on this crop, and he has therefore proposed the name of "potato leafhopper" for this species, for it is now known to pass its life cycle on potato.

Empoasca flavescens (Fabr.).

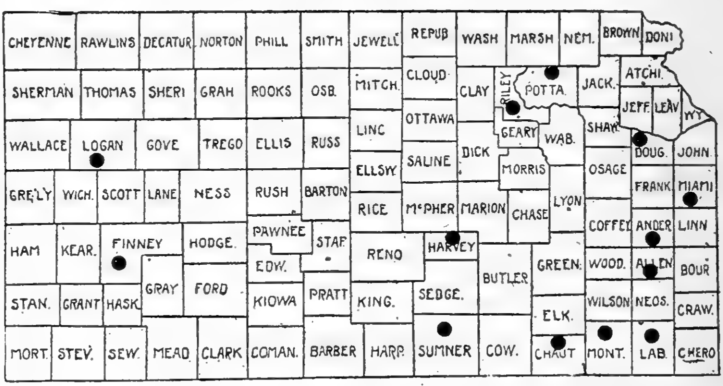
Cicada flavescens Fabr., Ent. Syst., iv, p. 46, 1794.
Typhlocyba flavescens Flor., Rhyn. Livl., ii, p. 394, 1861.
Cicadula flavescens Sahlb., Cicad., p. 161, 1871.
Chlorita flavescens Fieb., Revue d'Ent., iii, p. 57, 1884.
Empoasca flavescens Gill., Proc. U. S. Natl. Mus., xx, p. 745, 1898.
Empoasca flavescens Osb., 20th Rept. N. Y. St. Ent., p. 543, 1905.
Empoasca flavescens DeL., Tenn. St. Bd. Ent., Bul. 17, p. 102, 1916.
Empoasca flavescens Van D., Cat. Hemip. N. A., p. 706, 1917.
Empoasca flavescens Fent., Ohio Jl. Sci., xviii, p. 186, 1918.
Empoasca flavescens Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 112, 1919.

Form: Very much like *mali.* Length, about 3.5 mm. Vertex one-third longer at middle than next the eye, distinctly produced, one-half longer than wide. Pronotum less than twice as wide as long, anterior margin broadly convex, posterior margin distinctly concave. Elytra long and narrow.

Color: Yellowish or yellowish-green. Vertex with median line, and a pair each of anterior and posterior oblique lines, white. Pronotum usually with three white anterior spots. Scutellum usually with three white longitudinal lines on basal portion and a broad transverse white band back of impressed line. Elytra pale green, nervures indistinct, apically hyaline. Face yellowish above, greenish below, with broad white median line and whitish markings between this and the eye.

External genitalia: Female, last ventral segment long, posterior margin produced; pygofers rather robust, spiny mesally, exceeded by ovipositor. Male, last ventral segment over twice the length of the preceding; plates broad basally, regularly tapering to the rounded upturned apices, with a row of submarginal spines, and hairy marginally and apically; pygofers short, completely hidden by the plates.

Distribution: A very common species which is distributed all over the state as shown by the following map:



Hosts: Taken in abundance at lights. De Long records it from the same hosts as *mali,* namely, beans, peas, alfalfa, and apple.

Genus EUPTERYX Curt.

No members of this genus have yet been reported from Kansas. Unlike the three preceding genera the sectors of the hind wings end in the wing margin instead of in a marginal vein, and they differ from the two following genera in having four sectors instead of three.

McAtee shows that the old name *Eupteryx* should be retained for the genus rather than the name *Typhlocyba* as used by Van Duzee in his catalogue.

Genus TYPHLOCYBA Germ.

The members of this genus are characterized by having the first and third apical cells of the elytra contiguous at the base, by lacking a marginal vein in the hind wings, and having only three sectors reaching the margin of the wing.

Only one species has been taken in the state.

Typhlocyba rosæ (Linn.).

(Pl. 16, figs. 9-10.)

Cicada rosæ Linn., Syst. Nat. edn. 10, i, p. 439, 1758.
Cicada (Tettigonia) rosæ Geoff., Hist. Aberg. des Ins., i, p. 428, 1762.
Typhlocyba rosæ Burm., Handb. d. Ent., ii, p. 107, 1835.
Cicadula rosæ Zett., Ins. Lapp., column 300, 1840.
Tettigonia rosæ Harr., Ins. Inj. to Veg., p. 199, 1842.
Typhlocyba pteridis Dahlb., Kongl. Vet. Akad. Handl. for 1850, p. 179.
Tettigonia rosæ Harr., Rept. Ins. Mass., edn. 2, p. 182, 1852.
Typhlocyba lactea Dougl., Ent. Mo. Mag., xii, p. 77, 1875.
Anomia rosæ Fieb., Revue d'Ent., iii, p. 124, 1884.
Tettigonia rosæ Lint., 2nd Rept. N. Y. St. Ent., p. 31, 1885.
Tettigonia rosæ Lint., 6th Rept. N. Y. St. Ent., p. 166, 1890.
Tettigonia rosæ Lint., 7th Rept. N. Y. St. Ent., p. 345, 1891.
Empoa rosæ Lint., 8th Rept. N. Y. St. Ent., p. 256, 1893.
Typhlocyba rosæ G. & B., Hemip. Colo., p. 112, 1895.
Typhlocyba rosæ Gill., Proc. U. S. Natl. Mus., xx, p. 771, 1898.
Typhlocyba rosæ Lugg., Minn. Agr. Exp. Sta., Bul. 69, p. 131, 1900.
Typhlocyba rosæ Osb., 20th Rept. N. Y. St. Ent., p. 545, 1905.
Typhlocyba rosæ Felt, 25th Rept. N. Y. St. Ent., p. 90, 1910.
Typhlocyba rosæ Webs., Ent. News, xxi, p. 267, 1910.
Typhlocyba rosæ Felt, Jl. Ec. Ent., iv, p. 413, 1911.
Typhlocyba rosæ Felt, 27th Rept. N. Y. St. Ent., 1912.
Typhlocyba rosæ Ess., Inj. Benef. Ins. Calif., p. 62, 1915.
Typhlocyba rosæ Osb., Me. Agr. Exp. Sta., Bul. 238, p. 158, 1915.
Typhlocyba rosæ Wils. & Childs, 2d Bien. Crop Pest Rept., Ore. Agr. Exp. Sta., p. 189, 1915.
Typhlocyba rosæ Britt., Proc. Ent. Soc. Nova Scotia, No. 2, p. 48, 1916.
Typhlocyba rosæ DeL., Tenn. St. Bd. Ent. Bul. 17, p. 109, 1916.
Typhlocyba rosæ Britt., Nova Scotia Col. Agr., Circ. 17, 1917.

Empoa rosæ Van D., Cat. Hemip. N. A., p. 710, 1917.
Empoa rosæ Childs, Ore. Agr. Col. Exp. Sta., Bul. 148, 1918.
Empoa rosæ Lathr., Jl. Ec. Ent., xi, p. 144, 1918.
Empoa rosæ Lathr., N. Y. Agr. Col. Exp. Sta., Bul. 451, 1918.
Typhlocyba rosæ McAt., Can. Ent., l, p. 361, 1918.
Empoa rosæ Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 119, 1919.
Empoa rosæ Ack., U. S. Dept. Agr., Bur. Ent., Bul. 199, p. 20, 1919.

Form: Length, about 3.5 mm. Vertex one-third longer on middle than next the eye, less than twice as wide as long. Pronotum less than twice as wide as long, lateral margins long and broadening posteriorly, posterior margin emarginate. Elytra very long and narrow.

Color: Uniformly white or yellowish-white except for dark eyes and tarsal claws.

External genitalia: Female, last ventral segment twice as long as the preceding, narrowed posteriorly, posterior margin truncate; pygofers moderately broad, rather short, slightly exceeded by ovipositor, sparsely spiny apically. Male, valve broad but very short, lateral margins strongly narrowed posteriorly; plates long and narrow, lateral margins slightly concave just before middle and rather strongly emarginate apically, the black-tipped apices being divergent and curved dorsad; pygofers large, touching the tips of the plates, with a small terminal dorsal tooth.

Internal male genitalia: Styles very large, with a long cephalic process, after which is a distinct dorsal process, the tip of which is spiny, the terminal portion long and curving strongly apically; connective short, with three basal processes, the inner one more pointed than the outer two, the base broad; œdagus with a basal dorsally directed process which is narrow and straight at first, then widening and forming a large curving process running caudo-dorsad, terminal portion long and slender, curving, deeply bifid into two processes whose tips are suddenly narrowed and acute.

Distribution: This species is not as common in the state as might be expected. It perhaps is distributed well over the eastern part, but it is recorded as having been taken only in Douglas and Pottawatomie counties.

Hosts: Childs gives the following as hosts of this species: Wild and cultivated rose, apple, blackberry, raspberry, Loganberry, strawberry, dogwood, prune, cherry, and *Cratægus*. Gillette gives plum, cherry, currant, and grape in addition.

Genus HYMETTA McAtee.

This monotypic genus was lately erected by McAtee for the species till lately known as *Typhlocyba trifasciata*, but which Van Duzee placed under the genus *Erythroneura* in his catalogue. It differs from the latter genus, however, in having the scutellum thickened and distinctly elevated apically. Moreover, the second apical vein is curved, reaching the margin at the exterior angle of the elytra and often nearly or quite forming a stalk with the first apical vein. In *Erythroneura,* on the other hand, the second vein clearly reaches the posterior margin of the elytra and does not form a stalk with the first apical vein. It agrees with the latter genus in having the second apical cell oblong instead of stalked as in *Typhlocyba.*

Hymetta trifasciata (Say).

(Pl. 16, figs. 11-12.)

Tettigonia trifasciata Say, Jl. Acad. Nat. Sci. Phila., iv, p. 343; Compl. Writ., ii, p. 259.
Typhlocyba trifasciata Woodw., Psyche, v, p. 213, 1889.
Typhlocyba trifasciata Gill., Proc. U. S. Natl. Mus., xx, p. 755, 1898.
Typhlocyba trifasciata Osb., 20th Rept. N. Y. St. Ent., p. 544, 1905.
Typhlocyba trifasciata DeL., Tenn. St. Bd. Ent., Bul. 17, p. 106, 1916.
Erythroneura trifasciata Van D., Cat. Hemip. N. A., p. 712, 1917.
Hymetta trifasciata McAt., Proc. Biol. Soc. Wash., xxxii, p. 121, 1919.
Erythroneura trifasciata Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 113, 1919.

Form: Rather robust, widest at the middle. Length, about 3 mm. Head narrower than pronotum; vertex strongly produced, nearly twice as long at middle as next the eye, about one-half wider than long. Pronotum long, less than twice as wide as long, widest at lateral angles, anterior margin strongly convex, lateral margins widening posteriorly, posterior margin slightly concave. Elytra rather short and broad, nearly truncate apically.

Color: Vertex, pronotum, and scutellum creamy-yellow, elytra milky-white. Vertex and pronotum often unmarked, former sometimes with a pair of apical dashes and a pair of small circles on disc, red, besides other red marks. Pronotum sometimes with reddish marks back of the eyes and a red median line. Scutellum with tip always black. Elytra more or less irrorate with red, with a broad brownish to reddish transverse band just back of apex of scutellum, a faint smoky band, bounded posteriorly near the costa by a red line, and another faint band near the tip. Face pale, unmarked, or with a few reddish lines.

External genitalia: Female, last ventral segment about two-thirds as wide as preceding segment, triangular, about three-fourths as long as wide, the margins concavely tapering on the posterior two-thirds to the blunt apex; pygofers rather stout, spiny along ovipositor, exceeded by the latter. Male, valve broad but short, posterior margin truncate; plates broad basally, suddenly narrowed just before the middle, then tapering to acute upturned tips which exceed the short pygofers, margins with three or four spines at point where plates are narrowed.

Internal male genitalia: Styles with long anterior process, widening after union with connective, then narrowing again before their widest portion just cephalad of the preapical lateral incision which is very deep and U-shaped, the outer angle before the incision very prominent, the terminal process quite narrow basally but widening apically into two lateral teeth, the outer being longer and more pointed than the mesal one, the apex distinctly concave; connective stout, U-shaped; œdagus with two pairs of slender and acute lateral processes and a large curved terminal process, the blunt tip of which is serrate on the dorsal margin.

Distribution: Probably occurs throughout the eastern part of the state. Reported from Dauglas, Pottawatomie and Riley counties.

Hosts: Very common on grape and easily gathered from leaves in winter. McAtee also gives hickory as a host.

Genus ERYTHRONEURA Fh.

The members of this genus are very similar to the members of the genus *Typhlocyba,* but differ in having the second apical cell of the elytra completely separating the first and third apical cells. The hind wings lack a marginal vein and there are but three sectors extending to the margin.

After studying the internal male genitalia of the material available we find our state list to contain thirteen species and five varieties of this genus. In this paper six of the varieties have been given specific rank.

KEY TO SPECIES.

- A. General color above yellowish or whitish.
  - B. Elytra with definite transverse bars.
    - C. Bands across pronotum and middle and apex of elytra. *tricincta.*
    - CC. Broad brownish band across base of elytra. *basalaris.*
  - BB. Elytra without definite transverse bands.
    - C. Species marked with red spots above.
      - D. Vertex and pronotum usually marked with red spots.
        - E. Scutellum entirely red. *rubroscuta.*
        - EE. Scutellum not entirely red.
          - F. Vertex, pronotum, and scutellum each with a red spot. *illinoiensis.*
          - FF. Vertex, pronotum, and scutellum each with several red spots. *maculata.*
      - DD. Vertex and pronotum usually marked with red lines.
        - E. Scutellum black. *scutelleris.*
        - EE. Scutellum not black.
          - F. Elytra blood red to near the cross veins. *crevecœuri.*
          - FF. Elytra with zigzag red or blood red lines or spots. *comes.*
    - CC. Species marked with oblique red lines above.
      - D. Species yellowish, oblique lines distinct. *obliqua.*

A. General color above—*concluded.*

DD. Species smoky or, if yellowish, with oblique lines fused.

E. Species yellowish with broad dorsal stripe running the length of the insect. *dorsalis.*

EE. Species smoky, without dorsal stripe. *fumida.*

AA. General color dark above.

B. Reddish brown species. *vulnerata.*

BB. Species black above, marked with white. *nigra.*

Erythroneura tricincta Fh.

(Pl. 16, figs. 15-16.)

Erythroneura tricincta Fh., Homop. N. Y. St. Cab., p. 63, 1851.
Typhlocyba tricincta Woodw., Psyche, v, p. 213, 1889.
Typhlocyba tricincta G. & B., Hemip. Colo., p. 113, 1895.
Typhlocyba tricincta Gill., Proc. U. S. Natl. Mus., xx, p. 753, 1898.
Typhlocyba tricincta Osb., 20th Rept. N. Y. St. Ent., p. 544, 1905.
Typhlocyba tricincta DeL., Tenn. St. Bd. Ent., Bul. 17, p. 104, 1916.
Erythroneura tricincta Van D., Cat. Hemip. N. A., p. 712, 1917.
Erythroneura tricincta Fent., Ohio Jl. Sci., xviii, p. 186, 1918.
Erythroneura tricincta Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 113, 1919.

Form: Length, about 3 mm. Vertex strongly produced, nearly twice as long on middle as next the eye, one-half wider than long. Pronotum about twice as wide as long, anterior margin broadly convex, lateral margins moderately long, slightly widening posteriorly, humeral margins rounding into slightly concave posterior margin. Elytra moderately long, widest at middle, giving insect oval outline.

Color: Vertex, pronotum, and scutellum pale yellow, elytra whiter. All but median anterior portion of pronotum, and usually base of scutellum, with a red to black transverse band. Elytra with a broad red band near middle, becoming black costally, and with a brown band apically, and with transverse veins, red, and sometimes with red streaks running backward from the middle band.

External genitalia: Female, last ventral segment long, posterior margin strongly medially produced; pygofers fairly robust, spiny along mesal margin, exceeded by the ovipositor. Male, last ventral segment concave posteriorly; valve large, longer than last ventral segment and wide, closely appressed to plates; plates broad basally, then suddenly narrowing and tapering to acute upturned and black-tipped apices, margins with three or four spines on basal third; pygofers fairly long, but completely hidden by plates.

Internal male genitalia: Styles long, anterior portion slender and with straight margins, lateral margins broadly rounded after attachment to connective, the style then narrowing till just before a sharp tooth on the inner margin, after which it is of about the same width as before the tooth to the broad two-cornered apex, between which it is slightly concave distally; connective rather slender, cup-shaped; œdagus with a club-shaped dorsal process near the base which has an anterior process at about its middle, the main portion broad basally, then rapidly narrowed to the slender curving terminal portion, which is composed of two acutely-pointed terminal straps.

Distribution: Specimens are at hand from Douglas, Pottawatomie, Riley and Johnson counties. Probably occurs throughout the eastern part of the state.

Hosts: This species is very common on grape. Often it is nearly as injurious to its host plant as *comes.* It is also very common in leaves in winter and is attracted in numbers to lights in summer.

basalaris (Say.)

Erythroneura ~~*rubroscuta* (Gill.)~~.

(Pl. 17, figs. 5-6.)

Tettigonia basalaris Say, Jl. Acad. Nat. Sci. Phila., iv, p. 344, 1825; Compl. Writ., ii, p. 260.

Erythroneura affinis Fh., Homop. N. Y. St. Cab., p. 63, 1851.

Erythroneura basalaris Walsh, Proc. Bost. Soc. Nat. Hist., ix, p. 317, 1864.

Typhlocyba affinis Woodw., Psyche, v, p. 213, 1889.

Typhlocyba comes var. *basalaris* Gill., Proc. U. S. Natl. Mus., xx, p. 760, 1898.

Typhlocyba comes var. *basalaris* DeL., Tenn. St. Bd. Ent., Bul. 17, p. 107, 1916.

Typhlocyba comes var. *basalaris* Van D., Cat. Hemip. N. A., p. 713, 1917.

Form: Like *comes* in size and structure.

Color: Yellowish, marked with blood brown. Vertex brownish, unicolorous, or marked with white median line and two white spots on either side. Pronotum brownish, the anterior portion marked with white spots. Scutellum with the basal angles darker than the tip. Elytra with the basal third brownish or reddish, posterior half with faint reddish oblique bands and with a black spot in the first apical cell. Face brownish, unicolorous, or marked with white median line or spots.

External genitalia: As in *comes,* except that leaving the pygofers at about the middle of their dorsal margin, are two long and sinuate processes whose acute tips considerably exceed the pygofers. These processes arise from the thickened and chitinized margin of the pygofers, these margins being thickest and giving off a slender branch that runs caudad into the pygofers, just before the large processes leave the pygofers. The corresponding processes in *comes* are U-shaped, and therefore these two species are not to be confused.

Internal male genitalia: Here, too, we see distinct differences from *comes.* The styles, while of the same general form, differ strongly apically, the upturned portion being much longer here, its sides running straight to the short anterior or upper tooth, and to the much longer lower one. The connective is much flatter than in *comes,* being very broadly V-shaped and lacking the distinct stem at the apex as in *comes.* The œdagus shows still greater differences. It curves broadly from the connective and sends up a short dorsal process after the middle, which curves caudad and then sends out an anterior and a pair of very slender latero-caudal processes. Then it continues on backward, terminating in a single, heavy, dorsally roughened and obtusely pointed process.

Distribution: While undoubtedly occurring throughout the eastern portion of the state, yet specimens have been recorded only from Douglas and Pottawatomie counties.

Hosts: This species is very common in Douglas county on wild gooseberry in the spring. In winter it is found hibernating in leaves.

Erythroneura rubroscuta (Gill.).

Typhlocyba rubroscuta Gill., Proc. U. S. Natl. Mus., xx, p. 755, 1898.
Erythroneura rubroscuta Van D., Cat. Hemip. N. A., p. 712, 1917.

Form: Length, 3.25 mm. Vertex about twice as long on middle as next the eye, one-half wider than long, rather acutely pointed. Pronotum about one-half longer than vertex, scarcely wider than head, less than twice as wide as long, lateral margins longer than the humeral margins, posterior margin clearly emarginate. Elytra long and narrow.

Color: Vertex pale yellow, tip and a basal spot near each eye usually reddish. Pronotum varying from yellow, tinged with red, to bright red with a large yellow median spot on anterior margin. Scutellum entirely red or with a median rectangular paler portion. Elytra pale yellow with broad red band just before tip of clavus which does not reach the costal margin, and with base of costal margin and cross nervures reddish. Face yellow, with reddish tinge.

External genitalia: Female, last ventral segment half longer than preceding, narrowed posteriorly, posterior margin with a large median lobe; pygofers narrow, slightly exceeded by the black-tipped ovipositor, with a few apical spines. Male, valve nearly as broad and fully as long as last ventral segment, posterior margin very slightly emarginate; plates over twice as long as the valve, lateral margins slightly concave medially, with a few bristles in the concavity, apices subacute, exceeding the short pygofers.

Distribution: This species has been taken only in Douglas and Pottawatomie counties.

Hosts: The writer swept one specimen from *Symphoricarpos orbiculatus.* Crevecoeur took many specimens hibernating in leaves.

Erythroneura illinoiensis (Gill.).

(Pl. 16, figs. 13-14.)

Typhlocyba illinoiensis Gill., Proc. U. S. Natl. Mus., xx, p. 758, 1898.
Typhlocyba illinoiensis Osb., 20th Rept. N. Y. St. Ent., p. 545, 1905.
Typhlocyba illinoiensis DeL., Tenn. St. Bd. Ent., Bul. 17, p. 109, 1916.
Erythroneura illinoiensis Van D., Cat. Hemip. N. A., p. 714, 1917.
Erythroneura illinoiensis Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 118, 1919.

Form: Long and slender, tapering at both ends. Length, 3 mm. Vertex nearly twice as long on middle as next the eye, about one-half wider than long. Pronotum long, scarcely twice as wide as long, anterior margin broadly convex, lateral margins long and widening posteriorly, humeral margins fused with slightly concave posterior margin. Elytra very long and narrow.

Color: Whitish or pale yellow. Vertex pale yellow with large red spot just back of apex. Pronotum with similar spot in the middle. Tip of scutellum with large red spot. Elytra whitish, irregularly marked with pale yellow or reddish spots and each with three large black spots, the largest one just laterad of the middle of the clavus, one near the middle of the costal margin, and one at the base of the inner apical cell. A red spot also on the mesopleuræ. Any or all of the red spots may be entirely absent or present only as yellowish spots.

External genitalia: About as in *comes.*

Internal male genitalia: Styles of the general form of the other members of the genus but with the broad apex distinctly convex between the two terminal teeth. Connective stout, broadly U-shaped; œdagus broad basally, with a small Y-shaped dorsally directed process at about its middle, and terminating apically in a large obtusely pointed process below which are two slender acutely pointed and terminally diverging strap-like processes.

Distribution: While undoubtedly occurring over a large portion of the eastern part of the state, the only specimens at hand are from Douglas county.

Hosts: This is a very common species in Douglas county on grape.

Erythroneura maculata (Gill.).

(Pl. 17, figs. 3-4.)

Typhlocyba comes var. *maculata* Gill., Proc. U. S. Natl. Mus., xx, p. 764, 1898.
Typhlocyba comes var. *maculata* Tuck., Kans. Univ. Sci. Bul., iv, p. 68, 1907.
Erythroneura comes var. *maculata* Van D., Cat. Hemip. N. A., p. 714, 1917.

Form: In size and structure like *comes.*

Color: Yellowish with bright red spots. Vertex with apical red spot and transverse band on disc which is curved strongly caudad medially. Pronotum with two broad red lateral lines and a broader, often Y-shaped median stripe. Scutellum with red lines on margins near the base and a large apical spot. Elytra with three spots on clavus, the first two often fused, five spots on corium forming a zigzag line, and the transverse veins, red. Face marked with red above.

External genitalia: As in *comes.* The chitinous process on the dorsal margin of the pygofers is, however, entirely different. It is not U-shaped as in *comes,* but consists of a long process which for most of its length is not in the pygofer, and which ends in two widely separated prominent teeth. This difference alone is enough to justify its separation from *comes.*

Internal male genitalia: Styles for the most part as in *comes,* but the terminal or upturned portion is much larger, the preapical tooth on the mesal margin being much further back. The terminal tooth is always long, sometimes very long, thus also differing from *comes*. The connective is V-shaped. The œdagus is entirely different to that of *comes*. It sends up a small dorsal process which has a small anteriorly directed portion, while the terminal part is a large obtusely pointed and roughened process, instead of being composed of two slender, curving, and acutely pointed processes as in *comes*. Viewed dorsally, the œdagus consists of a heavy portion terminating in three small lobes, the median one larger than the outer, and a terminal, more slender portion.

Distribution: Specimens of this species seem to have been taken only in Douglas and Riley counties. It is undoubtedly distributed over much of the eastern part of the state.

Hosts: The specific host is unknown, all of our specimens being taken when hibernating in leaves.

Erythroneura scutelleris (Gill.).

(Pl. 17, fig. 7.)

Typhlocyba comes var. *scutelleris* Gill., Proc. U. S. Natl. Mus., xx, p. 764, 1898.
Typhlocyba comes var. *scutelleris* Tuck., Kans. Univ. Sci. Bul., iv, p. 68, 1907.
Typhlocyba comes var. *scutelleris* DeL., Tenn. St. Bd. Ent., Bul. 17, p. 108, 1916.
Erythroneura comes var. *scutelleris* Van D., Cat. Hemip. N. A., p. 714, 1917.

Form: Size and structure of *comes*.

Color: Most of our specimens are yellowish except that the posterior portion or most of the pronotum and all of the scutellum are dark brown. Occasionally the head too is washed with brown. The elytra are sometimes unmarked, and at times faintly marked with red as in *comes*. The black spots near the middle of the costal margin and just beyond the clavus are quite distinct and constant.

External genitalia: As in *comes* except for the chitinous process of the dorsal margin of the pygofers of the male. In this species the process is as in *maculata* but instead of ending in two rather short and widely separated teeth, it terminates in two long teeth which are close together, the dorsal one being slightly but distinctly longer than the ventral.

Internal male genitalia: Practically as in *maculata* except that the small dorsal process of the œdagus has two small but distinct lateral processes.

Distribution: Specimens are at hand from Douglas county. It surely occurs in many more counties of the eastern part of the state.

Hosts: Its definite host is unknown. DeLong reports beating it from grape and honey locust. It is also very common at lights.

Erythroneura crevecœuri (Gill.).

Typhlocyba crevecœuri Gill., Proc. U. S. Natl. Mus., xx, p. 767, 1898.
Erythroneura crevecœuri Van D., Cat. Hemip. N. A., p. 716, 1917.

Form: Length, 3 to 3.5 mm. Vertex nearly twice as long on the middle as next the eye, one-half wider than long, obtusely angled apically. Pronotum one-half longer than the vertex, widest at the lateral angles, lateral margins long, humeral margins shorter, posterior margin slightly emarginate. Elytra long and narrow.

Color: Vertex and pronotum yellow, with two broad longitudinal red lines which sometimes widen enough to cover the vertex. Scutellum entirely red or blackish. Elytra red up to tip of clavus, yellow beyond except for reddish veins, the base of costal margin more or less yellow. Middle portion of reddish area usually smoky in color. Face and beneath yellow, marked with reddish.

External genitalia: Female, last ventral segment long, narrowing posteriorly, posterior margin with a prominent median lobe; pygofers robust, slightly exceeded by the black-tipped ovipositor, very sparsely spined. Male, valve broad, as long or longer than last ventral segment, posterior margin truncate or slightly emarginate; plates about twice as long as valve, lateral margins concave near middle and spined in the concavity, subacute apices exceeding the pygofers.

Distribution: Our specimens were taken in Douglas and Pottawatomie counties.

Hosts: The writer has taken specimens of this species from grape. It is also found hibernating in leaves.

Erythroneura comes (Say.).

(Pl. 17, figs. 1-2.)

Tettigonia comes Say, Jl. Acad. Nat. Sci. Phila., iv, p. 343, 1825; Compl. Writ., ii, p. 259.
Typhlocyba comes Woodw., Psyche. v, p. 213, 1889.
Typhlocyba comes G. & B., Hemip. Colo., p. 111, 1895.
Typhlocyba comes Gill., Proc. U. S. Natl. Mus., xx, p. 759, 1898.
Typhlocyba comes Sling., Corn. Univ. Exp. Sta., Bul. 215, 1904.
Typhlocyba comes Smith, Rept. N. J. Agr. Col. Exp. Sta., p. 651, 1904.
Typhlocyba comes Quaint., U. S. Dept. Agr., Farmer's Bul. 284, p. 19, 1907.
Typhlocyba comes Quayle, Calif. Agr. Exp. Sta., Bul. 192, p. 111, 1907.
Typhlocyba comes Quayle, Jl. Ec. Ent., i, p. 182, 1908.
Typhlocyba comes Quayle, Calif. Agr. Exp. Sta., Bul. 198, 1908.
Typhlocyba comes Hartz., N. Y. Agr. Exp. Sta., Bul. 331, p. 568, 1910.
Typhlocyba comes Johns., U. S. Dept. Agr., Bur. Ent., Bul. 97, pt. i, 1911.
Typhlocyba comes Hartz., N. Y. Agr. Exp. Sta., Bul. 344, 1912.
Typhlocyba comes Sand., Ins. Pests of Farm, Garden and Orchard, p. 520, 1912.
Typhlocyba comes O'Kane, Inj. Ins., p. 311, 1912.
Typhlocyba comes Johns., U. S. Dept. Agr., Bur. Ent., Bul. 116, pt. i, 1912.
Typhlocyba comes Johns., U. S. Dept. Agr., Bur. Ent., Bul. 19, 1914.
Typhlocyba comes Osb., Me. Agr. Exp. Sta., Bul. 238, p. 156, 1915.
Typhlocyba comes Ess., Inj. Benef. Ins. Calif., edn. 2, p. 64, 1915.
Typhlocyba comes DeL., Tenn. St. Bd. Ent., Bul. 17, p. 106, 1916.
Erythroneura comes Van D., Cat. Hemip. N. A., p. 712, 1917.
Erythroneura comes Fent., Ohio Jl. Sci., xviii, p. 186, 1918.
Erythroneura comes Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 114, 1919.

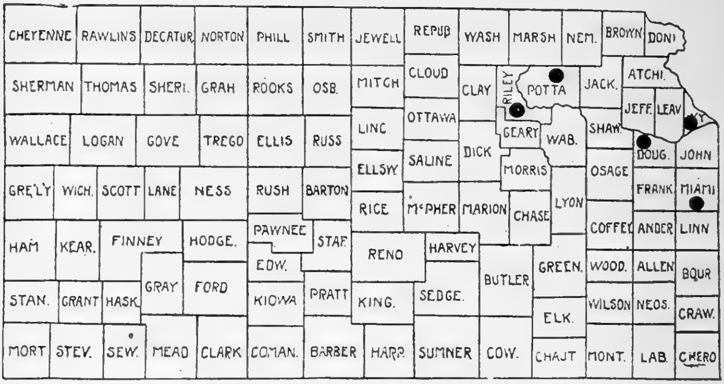
Form: Length, 2.75 to 3 mm. Vertex over one-half longer at middle than next the eye, nearly one-half longer than wide. Pronotum twice as wide as long, anterior margin strongly convex, lateral margins long and gradually widening posteriorly, humeral margins indistinct, fusing with slightly concave posterior margin. Elytra long and narrow.

Color: Pale yellow. Vertex with two longitudinal red lines, often meeting apically, thus forming an inverted V. Pronotum with two lateral lines and a median Y-shaped line, red. Basal angles of scutellum red. Elytra marked with red, clavus with red band along claval suture, widened at base and extending to the elytral suture at about the middle of the clavus, also a red spot at tip of clavus; corium with a long red line, narrow basally, then suddenly widening and reaching to claval suture and again reaching toward apical claval spot, finally ending in the red transverse nervures, laterally reaching to costal black spot at about the middle of costal margin, with a black spot on inner margin just beyond tip of clavus and another, often lacking, in second apical cell, the apical portion of the elytra often smoky. The above markings all vary greatly in intensity, being light in the summer and becoming brighter and darker in the fall and winter.

External genitalia: Female, last ventral segment large, triangular, posterior margin strongly produced medially, slightly concave on either side of the obtuse apex; pygofers moderately robust, with a row of spines on either side of the usually black-tipped ovipositor which slightly exceeds the pygofers. Male, valve large, broad, posterior margin truncate or slightly concave; plates wide basally, suddenly narrowed and spiny at basal third, then gradually narrowed to upturned and usually black tips which slightly exceed the pygofers. The latter bear a U-shaped chitinous process on the dorsal margin near the apex, of which the lower tooth is the larger.

Internal male genitalia: Styles long, with long anterior portion nearly parallel-margined, a lateral constriction opposite swollen place of attachment to connective, then widening laterally to widest point, again narrowing and then slightly widened just before lateral preapical incision, tips turned outward, ending in two acute points, the outer the larger, between which the end is slightly concave, and with a large tooth on the mesal margin a short distance back of the apex; connective V-shaped, stout, the apex with a distinct dorsally directed portion; œdagus sending up an anterior process a short distance from the base, which expands dorsally and shows, when viewed dorsally, an anterior tooth and two pairs of lateral processes, the anterior ones more slender and more acute than the shorter but much stouter posterior pair, the apex quite obtuse. Then the main or posterior part curves dorsad and divides into two slender and acute processes, the tips of which are seen one on either side of the bifid apex of the anterior process.

Distribution: Occurs throughout the state where wild or cultivated grapes are found. The following map shows where specimens have been taken:



Hosts: The nymphs seem to be confined to the grape. On this host it is of great economic importance, as shown by the bulletins listed in the above bibliography. The adults, however, are known to feed on almost any host that happens to be convenient. It is frequently found on various trees, grasses, and shrubs, though the grape is the favorite plant.

Erythroneura comes var. *ziczac* Walsh.

Erythroneura ziczac Walsh, Proc. Bost. Soc. Nat. Hist., ix, p. 317, 1864.
Typhlocyba ziczac Woodw., Psyche, v, p. 214, 1889.
Typhlocyba comes var. *ziczac* Gill., Proc. U. S. Natl. Mus., xx, p. 761, 1898.
Typhlocyba comes var. *ziczac* Osb., Me. Agr. Exp. Sta., Bul. 238, p. 156, 1915.
Typhlocyba comes var. *ziczac* DeL., Tenn. St. Bd. Ent., Bul. 17, p. 107, 1916.
Erythroneura comes var. *ziczac* Van D., Cat. Hemip. N. A., p. 713, 1917.
Erythroneura comes var. *ziczac* Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 116, 1919.

Form: Like *comes* in size and structure.

Color: Pale yellow, marked with red and reddish-brown. Vertex with two reddish longitudinal lines. Pronotum with lateral margins and a Y on disc reddish or blood-brown. Scutellum with basal angles and tip blood-brown. Elytra with a zigzag blood-brown line on basal half of clavus, then to black spot at about middle of costal margin, from there to dark spot just beyond apex of clavus, and then as a smoky band nearly reaching black spot near tip of wing, the edges of this line and the spots on tip of clavus sometimes red, as in *comes*.

External genitalia: As in *comes*.

Internal male genitalia: There seem to be slight differences between the œdagus of this and typical *comes*, but seemingly not enough to make it a distinct species.

Distribution: Should occur throughout the eastern portion of the state wherever its host occurs. Specimens are at hand from Douglas county.

Hosts: Our specimens were all taken from *Ampelopsis quinquefolia.* Gillette records it as sometimes occurring on grape.

Erythroneura comes var. *vitis* (Harr.).

Tettigonia vitis Harr., Encyc. Am., viii, p. 43, 1831.
Erythroneura vitis Fh., Homop. N. Y. St. Cab., p. 63, 1851.
Erythroneura vitis Saund., Ins. Inj. to Fruits, p. 286, fig. 297, 1883.
Typhlocyba vitis Woodw., Psyche, v, p. 213, 1889.
Typhlocyba comes var. *vitis* Gill., Proc. U. S. Nat. Mus., xx, p. 761, 1898.
Typhlocyba comes *var. vitis* DeL., Tenn. St. Bd. Ent., Bul. 17, p. 107, 1916.
Erythroneura comes var. *vitis* Van D., Cat. Hemip. N. A., p. 713, 1917.

Form: Like typical *comes* in size and structure.

Color: Head yellow, vertex sometimes marked with reddish lines or the base reddish. Pronotum with anterior portion yellowish, remainder reddish or blood-brown, the lateral margins often brighter. Base of elytra reddish, followed by a yellow transverse bar, back of which is a large red spot which reaches the black spots on the costal margin, the interior of this spot often being brownish-red. Back of this spot is another yellow transverse band which reaches just beyond the red transverse veins. The apex of the elytra is smoky with a black spot in the second apical cell.

External genitalia: As in typical *comes.*

Internal male genitalia: Very much as in typical *comes.* The œdagus, however, seems to show some differences, which, should further study reveal as constant, would justify us in advancing this variety to specific rank.

Distribution: Specimens of this variety have been taken in Douglas, Pottawatomie and Riley counties. It of course has a larger distribution in the state than this indicates.

Hosts: Our specimens were taken on grape.

Erythroneura comes var. *infuscata* (Gill.).

Typhlocyba comes var. *infuscata* Gill., Proc. U. S. Natl. Mus., xx, p. 764, 1898.
Typhlocyba comes var. *infuscata* DeL., Tenn. St. Bd. Ent., Bul. 17, p. 108, 1916.
Erythroneura comes var. *infuscata* Van D., Cat. Hemip. N. A., p. 714, 1917.
Erythroneura comes var. *infuscata* Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 116, 1919.

Form: In size and structure like typical *comes*

Color: Yellowish. With a dark blood-brown band starting at apex of vertex, gradually widening on head and pronotum, and forming zigzag bands on the elytra. Most of costal margin of elytra yellow, and on each elytron are three yellow spots around the reddish tip of the clavus.

External genitalia: As in typical *comes.*

Internal male genitalia: The terminal tooth of the styles seems to be distinctly longer than in typical *comes*. Should this prove to be constant, this variety ought to be recognized as a distinct species. At present, however, we do not have enough material at hand to enable us to determine this point.

Distribution: There are specimens in the Snow collection from Douglas county and from Kansas City, Mo.

Hosts: Unknown.

Erythroneura comes var. *coloradensis* (Gill.).

Typhlocyba vitifex var. *coloradensis* Gill., Colo. Agr. Exp. Sta., Bul. 19, p. 16, 1892.
Typhlocyba vitifex var. *coloradensis* G. & B., Hemip. Colo., p. 113, 1895.
Typhlocyba coloradensis Cock., N. M. Agr. Exp. Sta., Bul. 19, p. 114, 1896.
Typhlocyba comes var. *coloradensis* Gill., Proc. U. S. Natl. Mus., xx, p. 763, 1898.
Typhlocyba comes var. *coloradensis* DeL., Tenn. St. Bd. Ent., Bul. 17, p. 108, 1916.
Erythroneura comes var. *coloradensis* Van D., Cat. Hemip. N. A., p. 714, 1917.

Form: In size and structure like typical *comes*.

Color: Yellowish. Vertex with large red spot or unmarked. Pronotum with red lines on lateral margins and a V-shaped mark on middle or unmarked. Scutellum with two large black basal spots, the anterior portion showing through the pronotum. Elytra marked much as in typical *comes*, though the markings on the corium are usually less distinct. The three black spots of the elytra are usually very distinct. Tip of ovipositor black.

External genitalia: As in typical *comes*

Internal male genitalia: These show some fairly distinct differences from those of typical *comes* yet in many respects they are so alike that it does not now seem wise to give this variety specific rank. The styles seem to be more slender, especially the part just before the broadly expanded apex. The œdagus seems to lack the terminal process of the dorsal expansion of the anterior process.

Distribution: Specimens are at hand from Douglas and Sedgwick counties. It undoubtedly occurs throughout the eastern part of the state.

Hosts: Our specimens were taken on grape.

Erythroneura obliqua (Say).

(Pl. 17, figs. 10-11.)

Tettigonia obliqua Say, Jl. Acad. Nat. Sci. Phila., iv, p. 342, 1825; Compl. Writ., ii, p. 259.
Erythroneura obliqua Fh., Homop. N. Y. St. Cab., p. 63, 1851.
Typhlocyba obliqua Woodw., Psyche, v, p. 213, 1889.
Typhlocyba obliqua G. & B., Hemip. Colo., p. 112, 1895.
Typhlocyba obliqua Gill., Proc. U. S. Natl. Mus., xx, p. 756, 1898.
Typhlocyba obliqua Osb., 20th Rept. N. Y. St. Ent., p. 545, 1905.
Typhlocyba obliqua Osb., Me. Agr. Exp. Sta., Bul. 238, p. 155, 1915.
Typhlocyba obliqua DeL., Tenn. St. Bd. Ent., Bul. 17, p. 105, 1916.
Erythroneura obliqua Van D., Cat. Hemip. N. A., p. 714, 1917.
Erythroneura obliqua Fent., Ohio Jl. Sci., xviii, p. 186, 1918.
Erythroneura obliqua Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 117, 1919.

Form: Length, 3 mm. Vertex one-half longer on middle than next the eye, one-half wider than long. Pronotum twice as wide as long, anterior margin strongly convex, lateral margins moderately long and widening posteriorly. Elytra long and narrow.

Color: Vertex, pronotum, and scutellum pale yellowish, elytra whitish. Vertex with two broad red lines which meet at the apex and then extend back across the pronotum. Scutellum red except for yellow median line on basal half. Elytra with oblique reddish or orange lines on clavus and on disc, and with the basal portion of costal margin red. Face marked irregularly with reddish which sometimes covers the front and the clypeus.

External genitalia: Female, last ventral segment long, produced posteriorly into a large obtuse median lobe, on either side of which the margins are distinctly concave; pygofers robust, slightly exceeded by the black-tipped ovipositor. Male, valve large, quadrate, posterior margin slightly concave; plates broad basally, margins suddenly narrowed near base and spiny at this point, apices upturned and acute.

Internal male genitalia: Styles large, widest at point of attachment to connective and just before upturned apex, between which it is slightly narrowed, the terminal claw very characteristic, being large, curving, and pointed mesad; connective V-shaped, its arms about of equal thickness throughout; œdagus, when viewed laterally, with long anterior arm to connective, a pair of delicate ventral processes, a stout but tapering median process and a large dorsal process of which the anterior two-thirds projects cephalad.

Distribution: Specimens are at hand from Cherokee, Douglas, and Pottawatomie counties. It probably occurs throughout the eastern portion of the state.

Hosts: Found very commonly on grape and hibernating in leaves.

Erythroneura obliqua var. *nœvus* (Gill.).

Typhlocyba obliqua var. *nœvus* Gill., Proc. U. S. Natl. Mus., xx, p. 757, 1898.
Typhlocyba obliqua var. *nœvus* Tuck., Kans. Univ. Sci. Bul., iv, p. 68, 1907.
Typhlocyba obliqua var. *nœvus* DeL., Tenn. St. Bd. Ent., Bul. 17, p. 105, 1916.
Erythroneura obliqua var. *nœvus* Van D., Cat. Hemip. N. A., p. 715, 1917.

Form: In size and structure like typical *obliqua.*

Color: Just like typical *obliqua* except that the scutellum has the basal angles black or is entirely black, and the pronotum often has the posterior margin darkened.

External genitalia: As in typical *obliqua.*

Internal male genitalia: Agree in every particular with typical *obliqua.*

Distribution: Specimens are at hand from Douglas and Pottawatomie counties.

Hosts: Usually taken on grapevines.

Erythroneura dorsalis (Gill.).

(Pl. 17, fig. 14.)

Typhlocyba obliqua var. *dorsalis* Gill., Proc. U. S. Natl. Mus., xx, p. 757, 1898.

Typhlocyba obliqua var. *dorsalis* Van D., Trans. San Diego Soc. Nat. Hist., ii. p. 57, 1914.

Typhlocyba obliqua var. *dorsalis* DeL., Tenn. St. Bd. Ent., Bul. 17, p. 105, 1916.

Erythroneura obliqua var. *dorsalis* Van D., Cat. Hemip. N. A., p. 715, 1917.

Erythroneura obliqua var. *dorsalis* Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 118, 1919.

Form: Length, 3 mm. Like *obliqua* except that vertex seems to be proportionally longer.

Color: Yellowish or whitish, with a broad dark red stripe running the length of the insect to the smoky apical cells of the elytra. In addition the costal margin of the wing, especially basally, is reddish, and there are one or two dark spots before the transverse veins, just outside of the red discal stripe. The face is red except for two broad white stripes just below the margin of the vertex and whitish spots on the loræ.

External genitalia: As in *obliqua.*

Internal male genitalia: Styles as in *obliqua* except apically where they are entirely different, for instead of having one long curving apical tooth, there are two much shorter and practically straight ones; connective V-shaped and as in *obliqua;* œdagus very different from that of the latter for the dorsal process is very much smaller, the main terminal process is more slender, and has two apical and curving lateral processes, and in addition the base of the œdagus bears a pair of very large and conspicuous horn-like processes which extend laterad. The pair of small ventral processes are present as in *obliqua.*

Distribution: The only specimens at hand are from Douglas county.

Hosts: Grape seems to be the common host of this species.

The very clear differences in the tips of the styles and in the whole structure of the œdagus, show clearly that this cannot possibly be a variety of *obliqua.* Its genitalia are very characteristic and seem to be very constant, the specimens dissected agreeing in every particular, as did those of typical *obliqua* among themselves.

Erythroneura fumida (Gill.).

(Pl. 17, figs. 8-9.)

Typhlocyba obliqua var. *fumida* Gill., Proc. U. S. Natl. Mus., xx, p. 758, 1898.

Erythroneura obliqua var. *fumida* Van D., Trans. San Diego Soc. Nat. Hist., ii, p. 57, 1914.

Typhlocyba obliqua var. *fumida* DeL., Tenn. St. Bd. Ent., Bul. 17, p. 105, 1916.

Erythroneura obliqua var. *fumida* Van D., Cat. Hemip. N. A., p. 715, 1917.

Form: Length, 3 mm. Like *obliqua,* except that vertex seems relatively shorter.

Color: Yellowish, but smoky throughout. Vertex and pronotum unmarked or with the red bands as in *obliqua*. Elytra marked as in *obliqua*, though faintly, or the reddish coloration evenly diffused over the anterior two-thirds.

External genitalia: As in typical *obliqua*.

Internal male genitalia: Very different from that of typical *obliqua*. Syles very broad just before the very characteristic slender terminal tooth; connective V-shaped; œdagus with an anterior dorsal process which expands horizontally and a very large and stout terminal process which terminates in two small lateral teeth.

Distribution: Specimens are at hand from Douglas and Pottawatomie counties.

Hosts: The writer has taken this species by the hundreds from wild gooseberry in the spring. It is also reported from grape.

The very characteristic styles, and especially the œdagus, show such great differences from the corresponding organs in typical *obliqua*, that it is certain that the two forms cannot belong to the same species. Accordingly this variety is here given specific rank.

Erythroneura vulnerata Fh.

(Pl. 17, figs. 12-13.)

Erythroneura vulnerata Fh., Homop. N. Y. St. Cab., p. 62, 1851.
Typhlocyba vulnerata Woodw., Psyche, v, p. 213, 1889.
Typhlocyba vulnerata G. & B., Hemip. Colo., p. 113, 1895.
Typhlocyba vulnerata Gill., Proc. U. S. Natl. Mus., xx, p. 764, 1898.
Typhlocyba vulnerata Osb., 20th Rept. N. Y. St. Ent., p. 545, 1905.
Typhlocyba vulnerata Osb., Me. Agr. Exp. Sta., Bul. 238, p. 156, 1915.
Typhlocyba vulnerata DeL., Tenn. St. Bd. Ent., Bul. 17, p. 110, 1916.
Erythroneura vulnerata Van D., Cat. Hemip. N. A., p. 715, 1917.
Erythroneura vulnerata Fent., Ohio Jl. Sci., p. 186, 1918.
Erythroneura vulnerata Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 114, 1919.

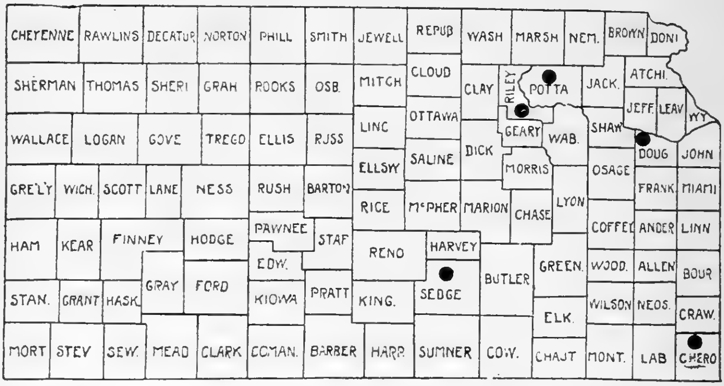
Form: Length, 2.5 to 3 mm. Vertex nearly twice as long on middle as next the eye, over one-half wider than long. Pronotum long, scarcely twice as wide as long, anterior margin strongly convex, posterior margin slightly concave. Elytra moderately long.

Color: Whitish, marked with reddish or brownish. Vertex, pronotum, and scutellum dull reddish, but with distinct white median line and lateral white lines or spots on the vertex and pronotum. Elytra whitish, strongly marked with red on clavus and corium, the costal margin in the main white, the apex strongly smoky.

External genitalia: Practically like *obliqua*, though the plates of the male seem usually to be more produced and acute apically.

Internal male genitalia: Styles of about the form characteristic of the tribe, the terminal upturned portion long, posterior terminal tooth long, anterior one very short; connective V-shaped; œdagus widening posteriorly into a very broad, three-pointed organ, the lateral points longer than the middle one, also with a small dorsal process extending backward from before the apex.

Distribution: Found in the eastern part of the state, as shown by the following map:



Hosts: Gillette gives Virginia creeper, grape and *Clematis* as hosts for this species.

Erythroneura nigra (Gill.).

(Pl. 17, fig. 15.)

Typhlocyba vulnerata var. *niger* Gill., Proc. U. S. Natl. Mus., xx, p. 765, 1898.
Erythroneura vulnerata var. *nigra* Van D., Cat. Hemip. N. A., p. 716, 1917.

Form: Length, 2.5 to 2.75 mm. Vertex over one-half longer on middle than next the eye, one-half wider than long. Pronotum long, less than twice as wide as long. Elytra moderately long.

Color: Black or dark brown above, marked with white. Vertex with median line and a pair of short lateral lines, white. Pronotum with short white median line on anterior part, usually a pair of lateral spots, and sometimes several white spots along anterior margin. Elytra with large white spot just back of the scutellum, tip of clavus and transverse veins usually light and broad, the white costal band on posterior two-thirds interrupted near the middle and apically. Face pale yellow.

External genitalia: As in *vulnerata.*

Internal male genitalia: Styles with long apical portion, posterior tooth longer than anterior; connective V-shaped; œdagus dividing apically into an anterior and a posterior process, the latter ending in an obtuse apex with a dorsal and two ventral small processes.

Distribution: Specimens of this species have been taken in Cherokee, Douglas, Pottawatomie, and Hodgeman counties.

Hosts: Unknown, probably grape.

The great differences between the œdagus of this species and *vulnerata* preclude the possibility of their belonging to the same species.

Explanation of Plates.

PLATE II.

Agalliopsis novella—

1. Lateral view.
2. Caudal view.
3. Anal tube collar.
4. Style.

Agallia 4-punctata—

5. Lateral view.
6. Dorsal view of connective and styles.

Agallia constricta—

7. Lateral view.
8. Ventral view of connective and œdagus.
9. Ventral view of style.
10. Anal tube collar.

Aceratagallia cinerea—

11. Lateral view.
12. Ventral view of style.
13. Ventral view of connective and œdagus.

PLATE II.

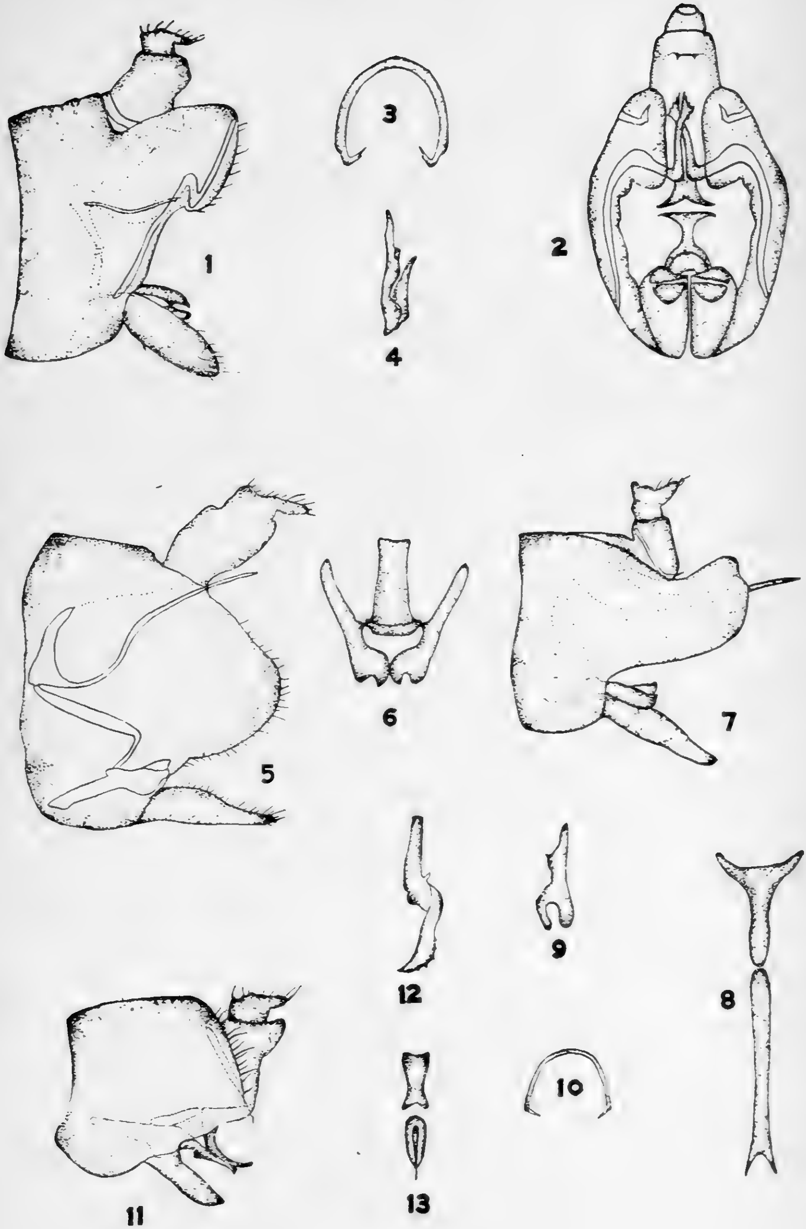


PLATE III.

Aceratagallia uhleri—

1. Lateral view.
2. Ventral view of style, connective and œdagus.
3. Dorsal view of styles, connective and œdagus.
4. Anal tube collar.

Aceratagallia sanguinolenta—

5. Lateral view.
6. Dorsal view of styles, connective and œdagus.
7. Ventral view of a style.
8. Anal tube collar.

Idiocerus snowi—

9. Lateral view.
10. Anal tube collar.
11. Ventral view of style, connective and œdagus.

PLATE III.

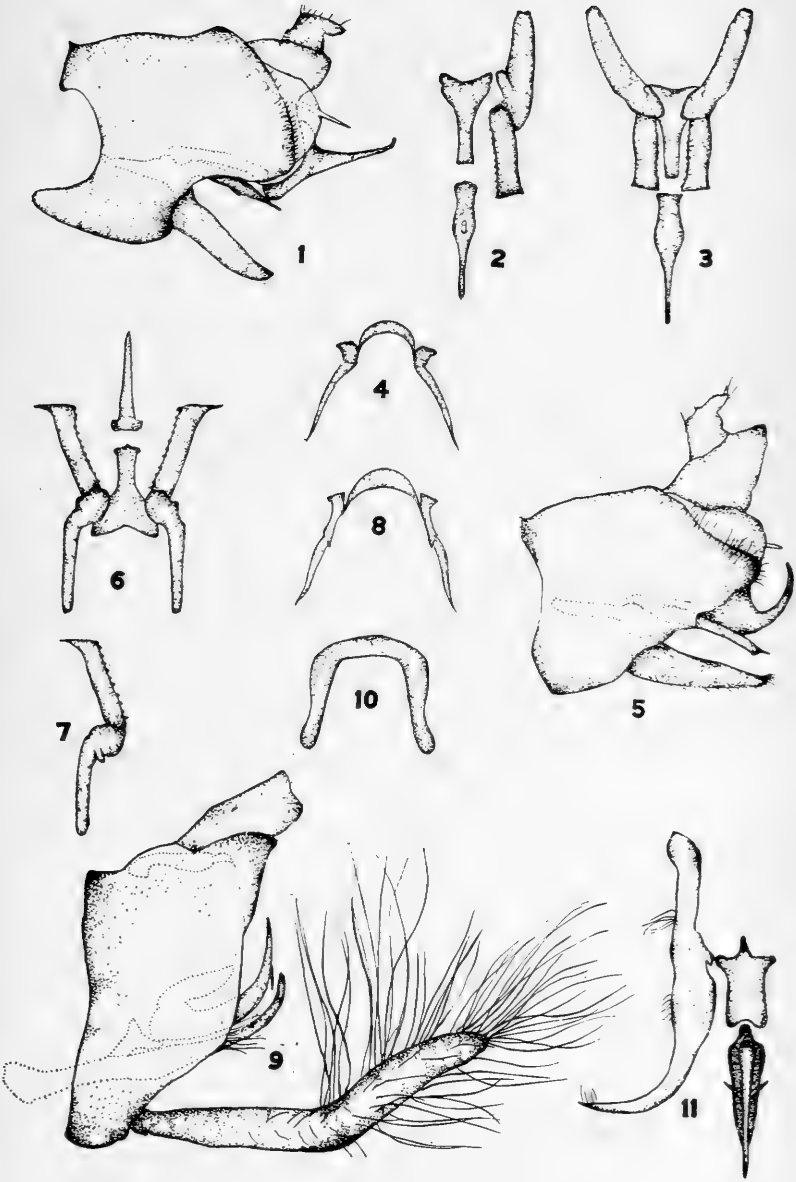


PLATE IV.

Idiocerus pallidus—

1. Lateral view.
2. Ventral view of style, connective and œdagus.
3. Anal tube collar.

Idiocerus verticis—

4. Lateral view.
5. Ventral view of style and connective.
6. Anal tube collar.

Idiocerus nervatus—

7. Lateral view.
8. Ventral view of style, connective and œdagus.
9. Anal tube collar.

PLATE IV.

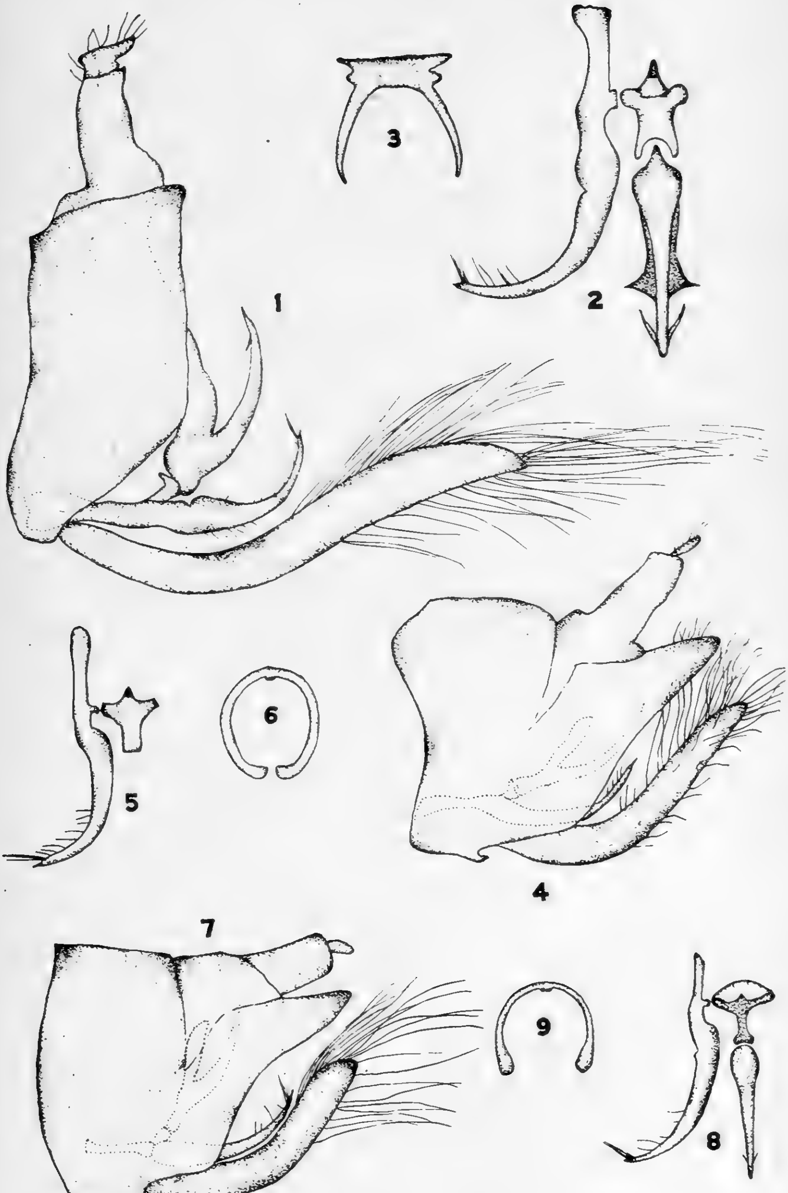


PLATE V.

Bythoscopus apicalis—

1. Lateral view.
2. Ventral view of plates and part of connective.
3. Ventral view of œdagus.
4. Remainder of connective.

Oncopsis distinctus—

5. Lateral view.
6. Ventral view of styles, connective and œdagus.

Macropsis virdis—

7. Lateral view.
8. Ventral view of styles, connective and œdagus.
9. Anal tube collar.

PLATE V.

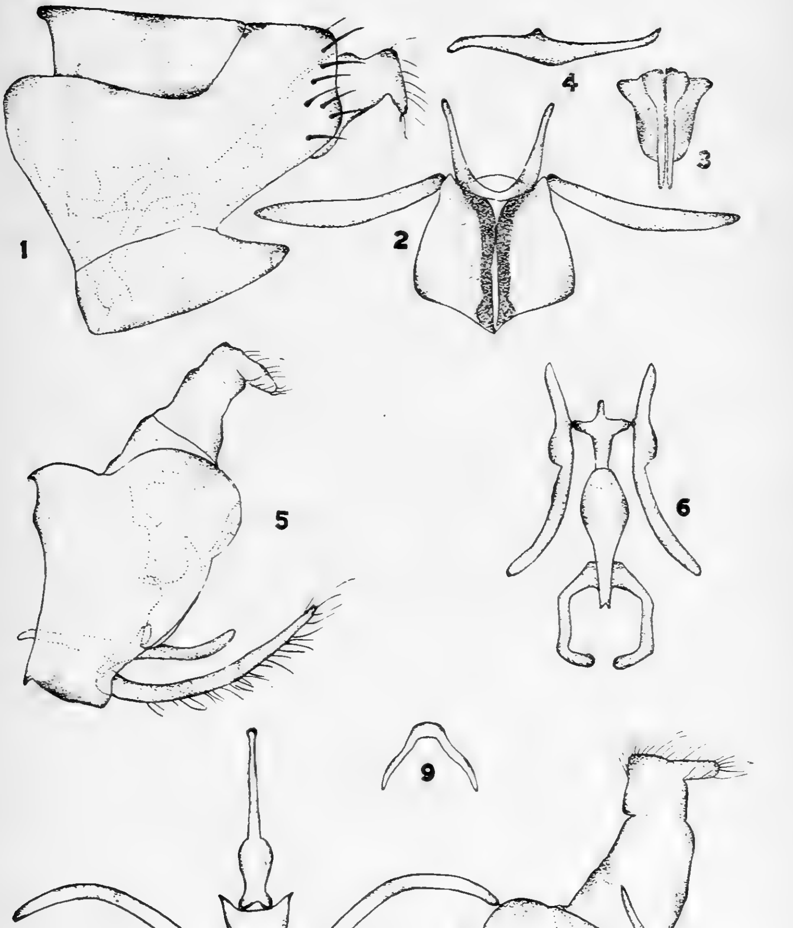


PLATE VI.

Aulacizes irrorata—

1. Lateral view.
2. Styles and connective.
3. Caudal view of œdagus.

Homalodisca triquetra—

4. Lateral view.
5. Caudal view of œdagus.
6. Dorsal view of styles and connective.

PLATE VI.

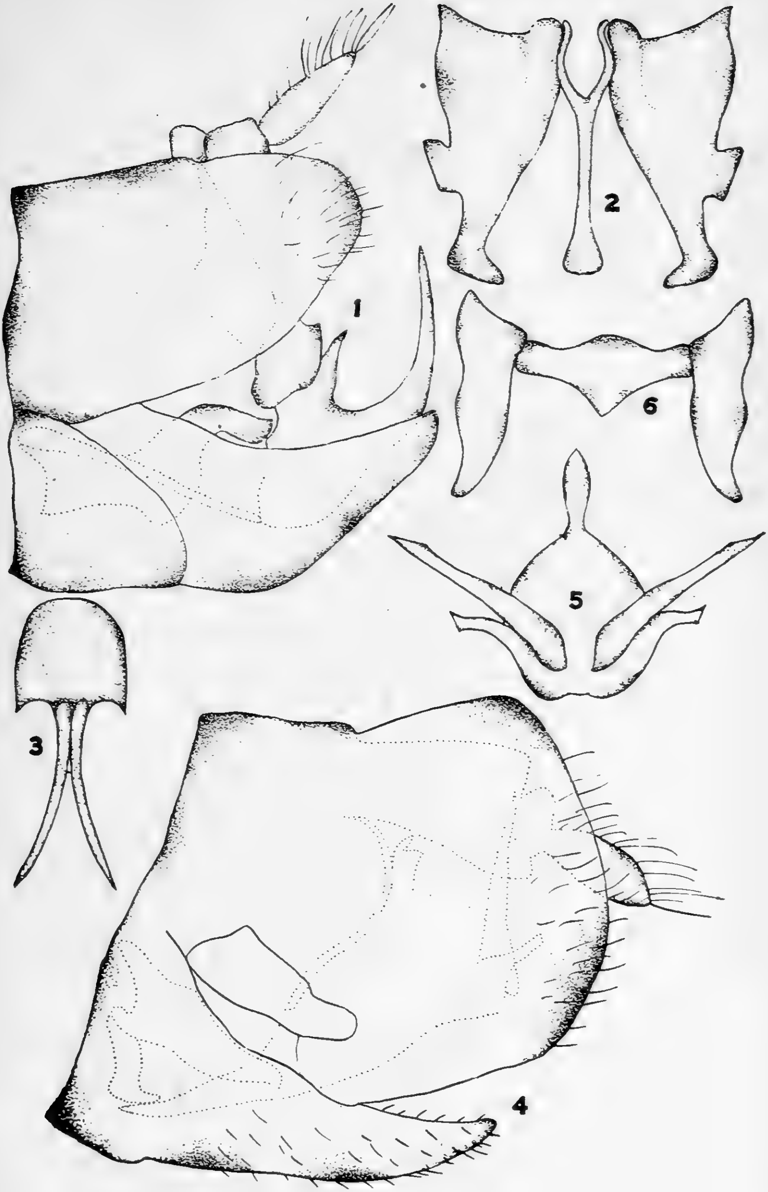


PLATE VII.

Oncometopia undata—

1. Lateral view.
2. Dorsal view of styles and connective.
3. Plate, showing chitinized style attachment.

Kolla bifida—

4. Lateral view.
5. Ventral view of style, connective and œdagus.

Kolla hartii—

6. Lateral view.
7. Ventral view of style, connective and œdagus.

PLATE VII.

PLATE VIII.

Oncometopia lateralis—

1. Lateral view.
2. Styles and connective.

Graphocephala coccinea—

3. Lateral view.
4. Ventral view of styles, connective and œdagus.

Kolla geometrica—

5. Lateral view.
6. Ventral view of style, connective and œdagus.

PLATE VIII.

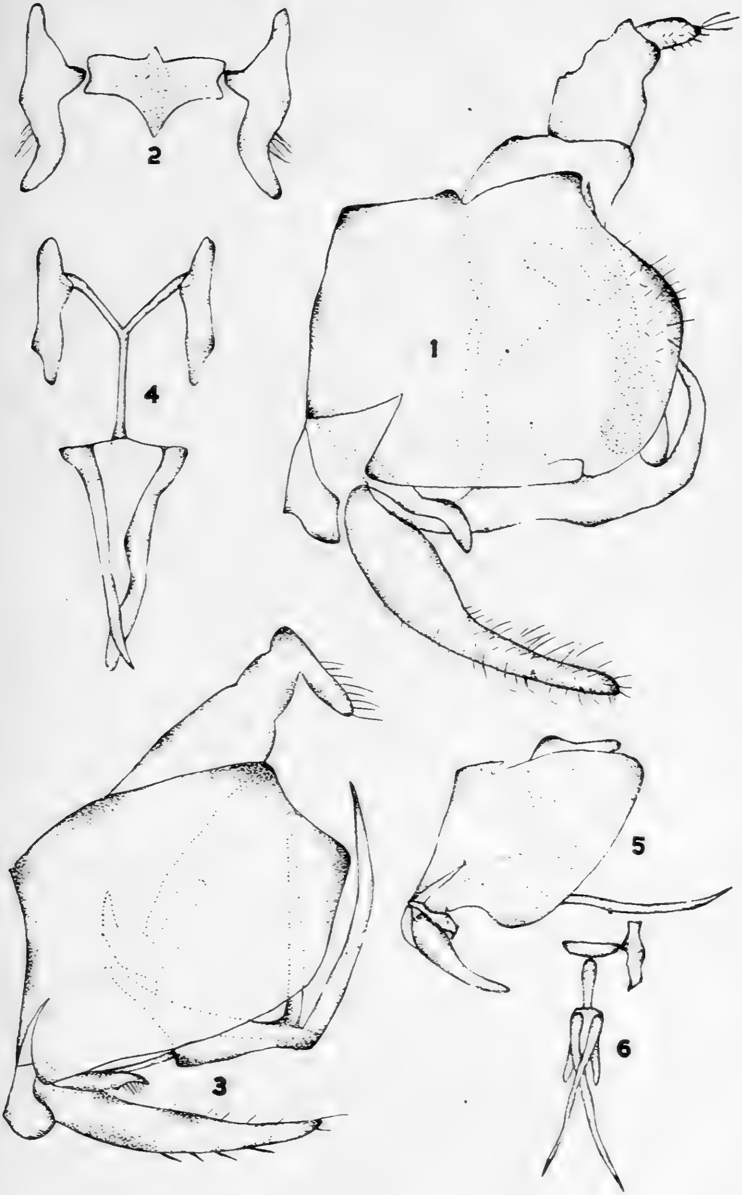


PLATE IX.

Cicadella hieroglyphica—

1. Lateral view.
2. Styles and connective.
3. Ventral view of œdagus.

Cicadella atropunctata—

4. Lateral view.
5. Ventral view of style, connective and œdagus.

Dræculacephala mollipes—

6. Lateral view.
7. Ventral view of styles, connective and œdagus.

Dræculacephala reticulata—

8. Lateral view.
9. Ventral view of styles, connective and œdagus.

PLATE IX.

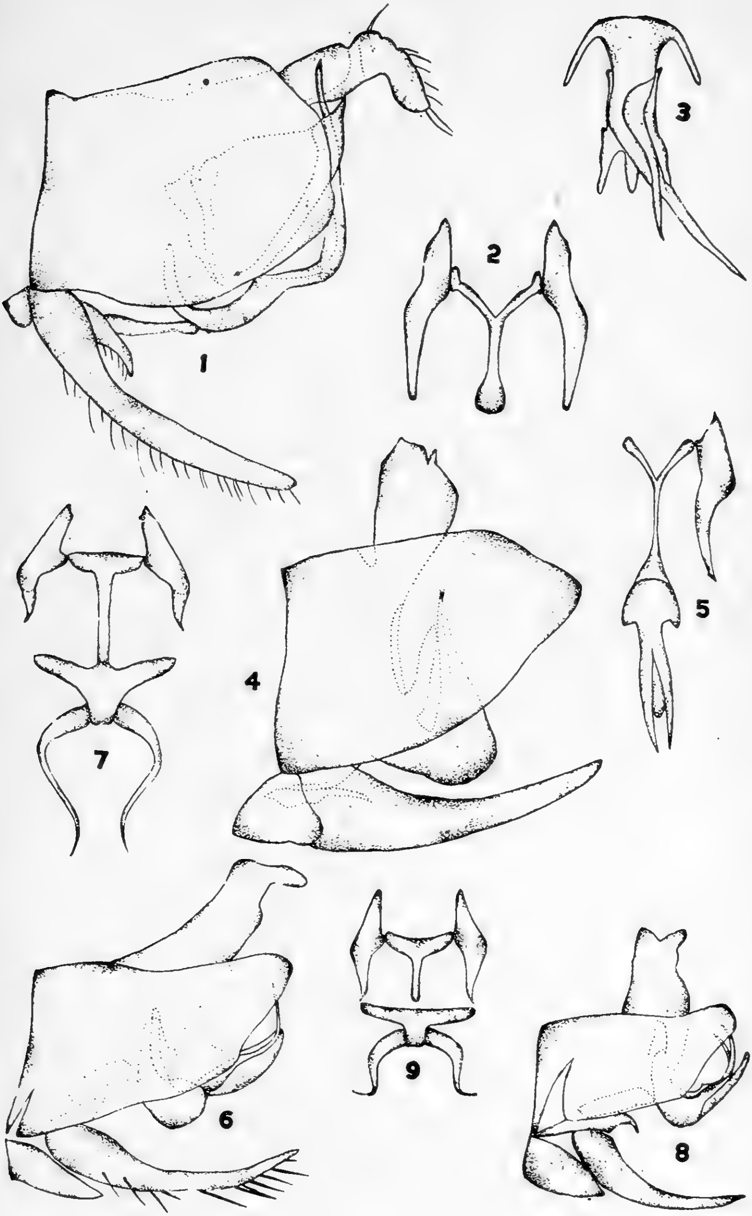


PLATE X.

Gypona 8-lineata—

1. Lateral view.
2. Ventral view of styles, connective and œdagus.

Helochara communis—

3. Lateral view.
4. Ventral view of styles, connective and œdagus.

Xerophlœa viridis—

5. Lateral view.
6. Ventral view of styles, connective and œdagus.

PLATE X.

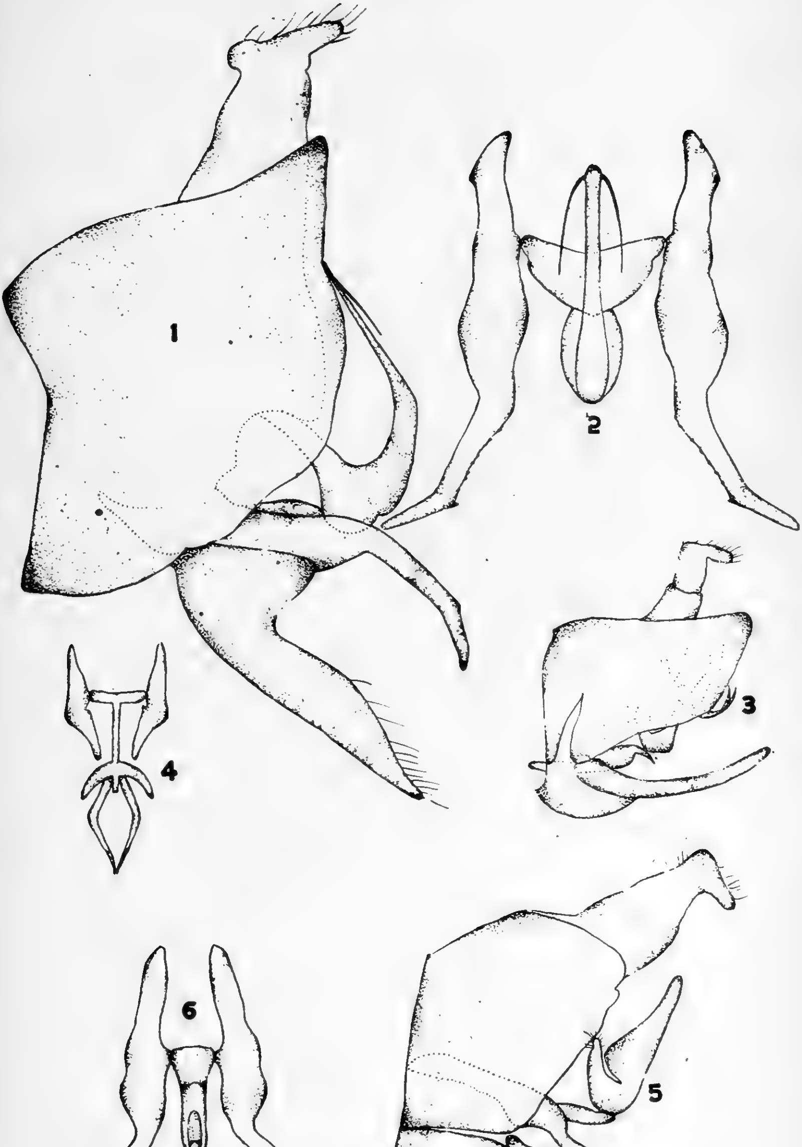


PLATE XI.

Scaphoideus immistus—

1. Lateral view.
2. Dorsal view of style, connective and œdagus.

Platymetopius cinereus—

3. Lateral view.
4. Style and connective.

Platymetopius acutus—

5. Lateral view.
6. Style and connective, latter without one terminal process.
7. Ventral view of œdagus.

Platymetopius frontalis—

8. Lateral view.
9. Styles and connective.

PLATE XI.

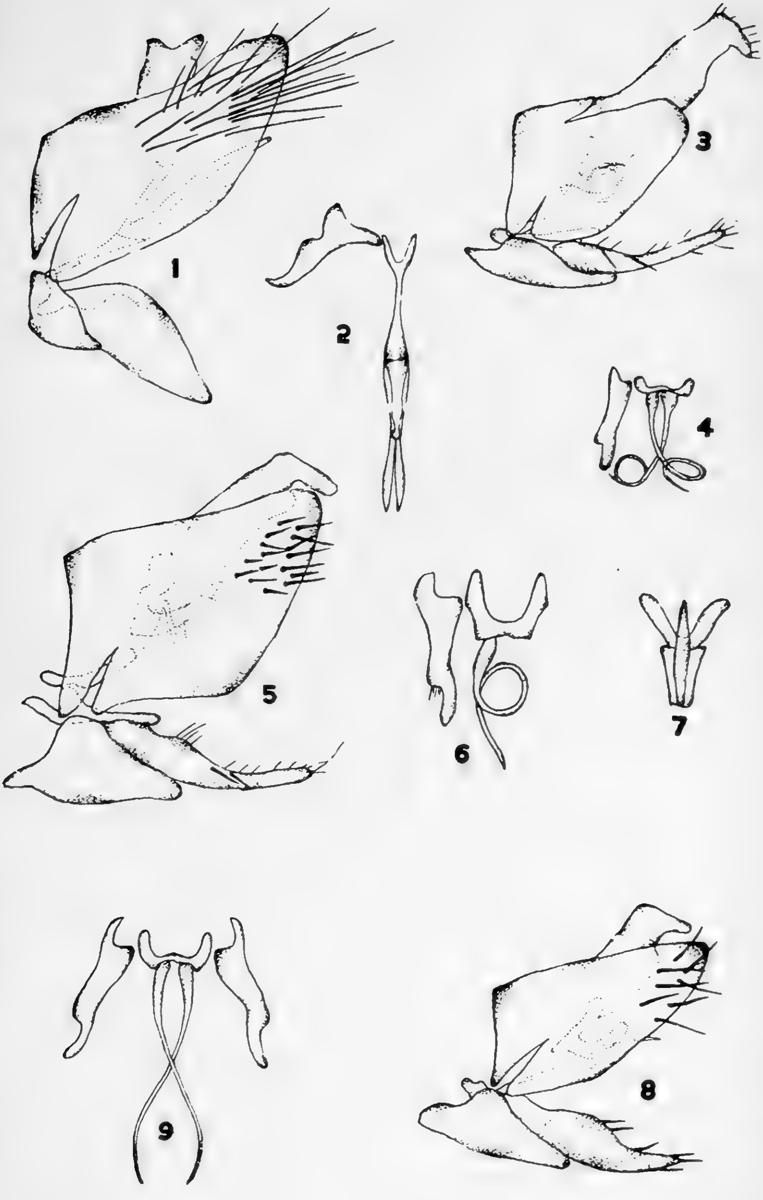


PLATE XII.

Deltocephalus inimicus—

1. Lateral view.
2. Dorsal view of style, connective and œdagus.

Deltocephalus flavicosta—

3. Lateral view.
4. Dorsal view of style, connective and œdagus.

Deltocephalus affinis—

5. Lateral view.
6. Dorsal view of style, connective and œdagus.

Deltocephalus sayi—

7. Lateral view.
8. Dorsal view of style, connective and œdagus.

Euscelis exitiosus—

9. Lateral view.
10. Dorsal view of style, connective and œdagus.

PLATE XII.

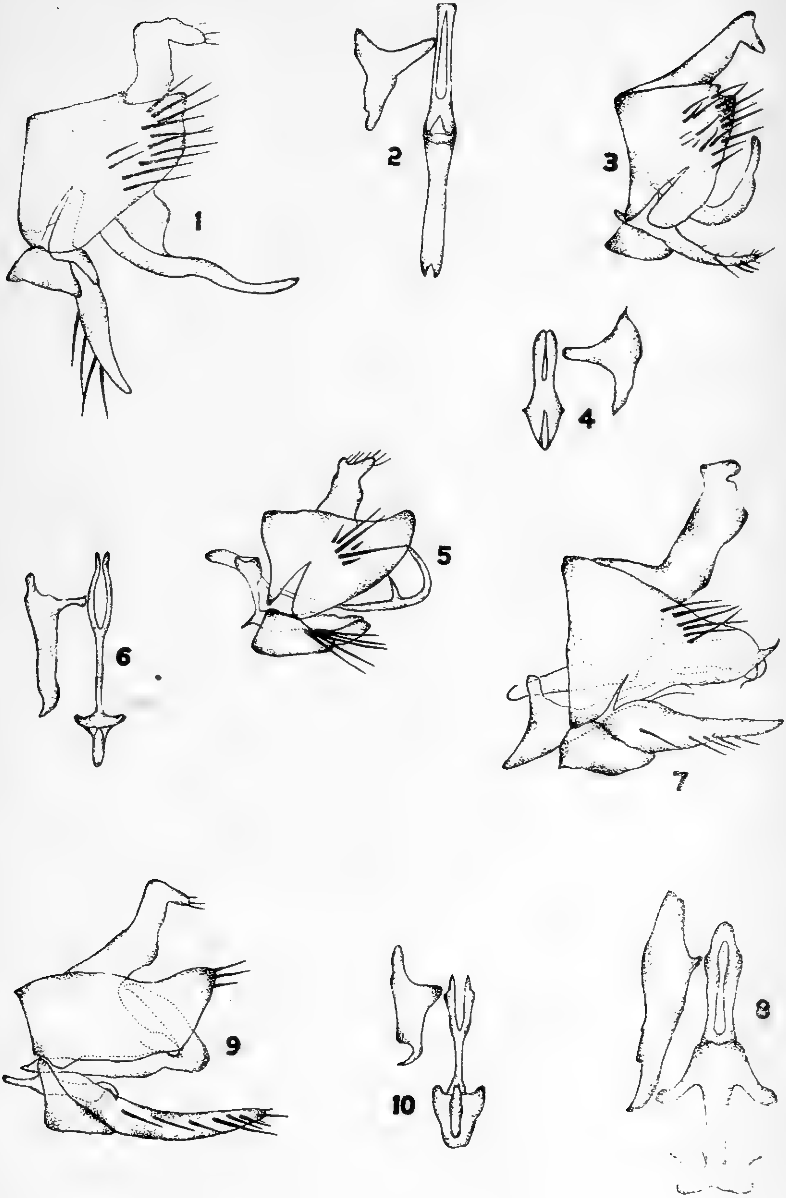


PLATE XIII.

Euscelis bicolor—

1. Lateral view.
2. Dorsal view of style, connective and œdagus.

Eutettix strobi—

3. Lateral view.
4. Dorsal view of style, connective and œdagus.

Eutettix seminudus—

5. Lateral view.
6. Dorsal view of style, connective and œdagus.

Eutettix cinctus—

7. Lateral view.
8. Dorsal view of style, connective and œdagus.

PLATE XIII.

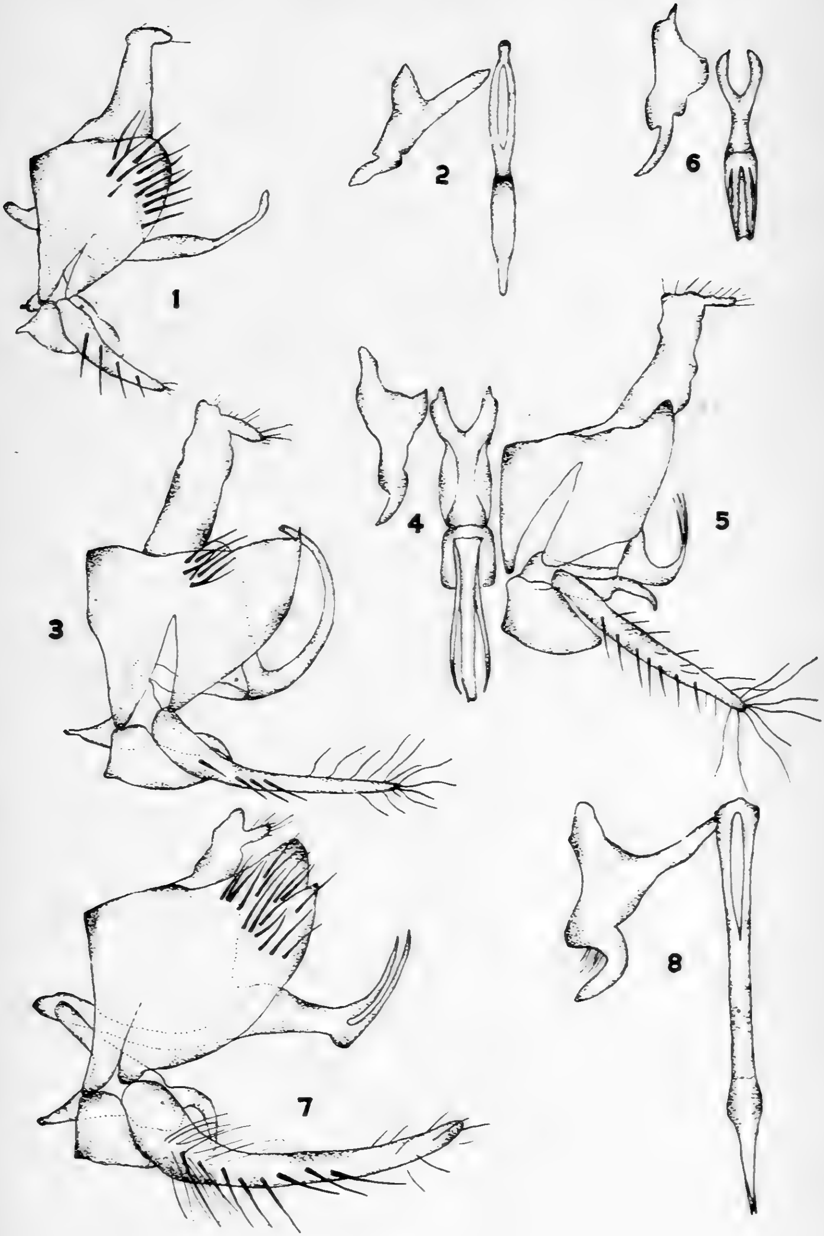


PLATE XIV.

Phlepsius irroratus—

1. Lateral view.
2. Dorsal view of style, connective and œdagus.

Acinopterus acuminatus—

3. Lateral view.
4. Dorsal view of plate, style and connective.

Thamnotettix clitellarius—

5. Lateral view.
6. Dorsal view of style, connective and œdagus.

Thamnotettix longulus—

7. Dorsal view of style, connective and œdagus.

Chlorotettix spatulatus—

8. Dorsal view of style, connective and œdagus.

PLATE XIV.

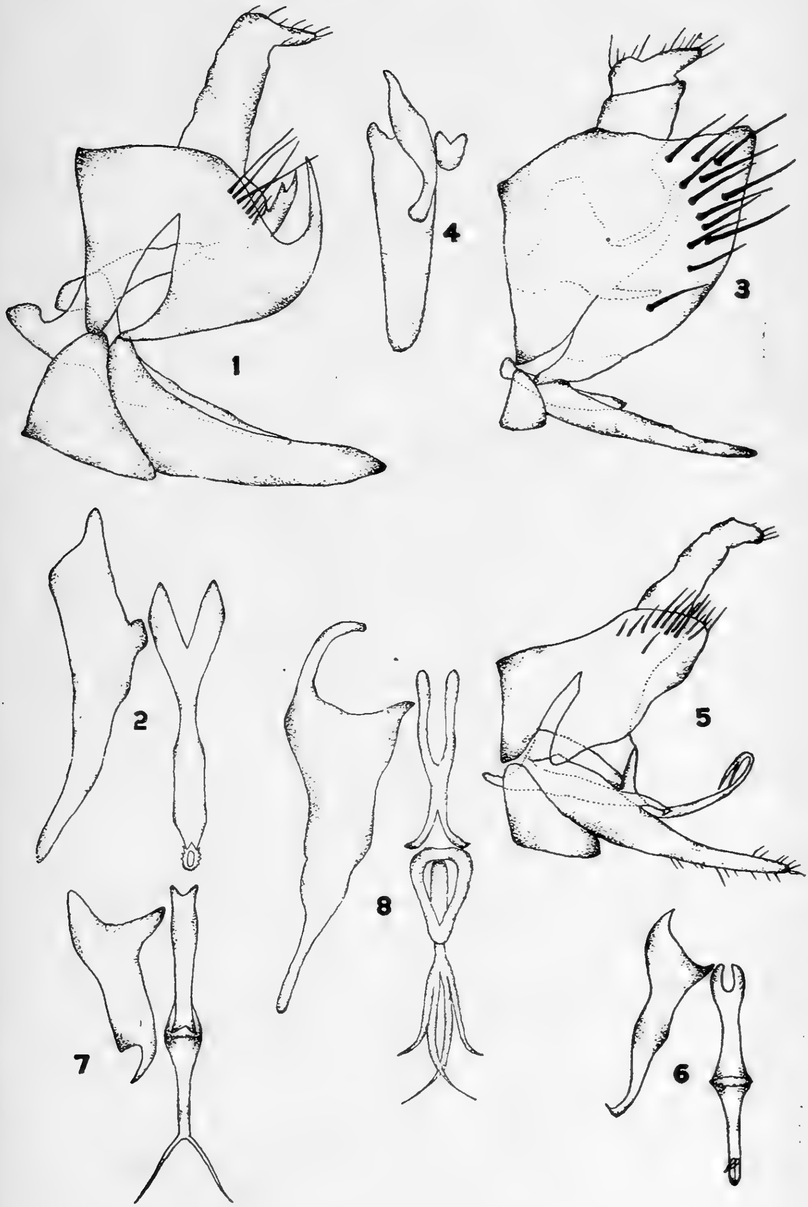


PLATE XV.

Jassus olitorius—

1. Lateral view.
2. Dorsal view of plates, styles, connective and œdagus.

Cicadula punctifrons var. repleta—

3. Lateral view.
4. Dorsal view of plate, style, connective and œdagus.

Cicadula 6-notata—

5. Lateral view.
6. Dorsal view of style, connective and œdagus.

PLATE XV.

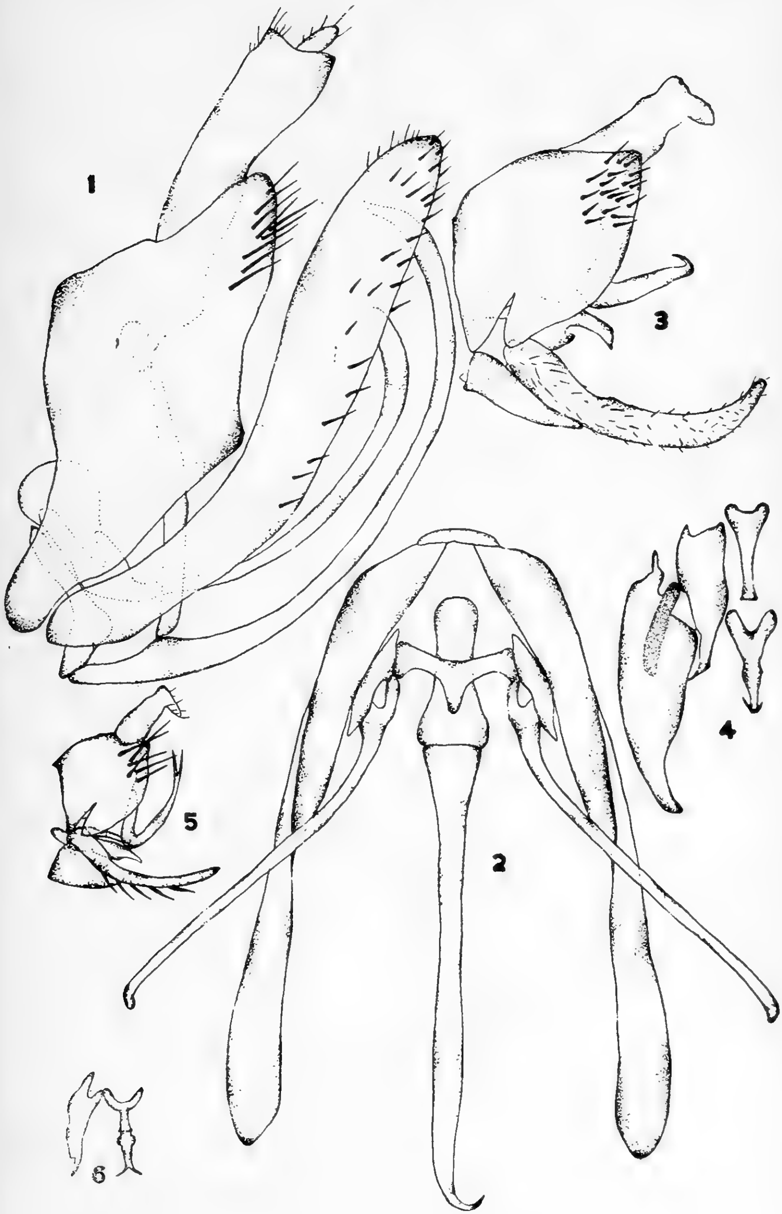


PLATE XVI.

Balclutha punctata—

1. Lateral view.
2. Dorsal view of style, connective and œdagus.

Balclutha impicta—

3. Lateral view.
4. Dorsal view of style, connective and œdagus.

Eugnathodus abdominalis—

5. Lateral view.
6. Dorsal view of style, connective and œdagus.

Empoasca mali—

7. Lateral view.
8. Dorsal view of style, connective and œdagus.

Typhlocyba rosæ—

9. Lateral view.
10. Dorsal view of style, connective and œdagus.

Hymetta trifasciata—

11. Lateral view.
12. Dorsal view of styles, connective and œdagus.

Erythroneura illinoiensis—

13. Lateral view.
14. Dorsal view of style, connective and œdagus.

Erythroneura tricincta—

15. Lateral view.
16. Dorsal view of style, connective and œdagus.

PLATE XVI.

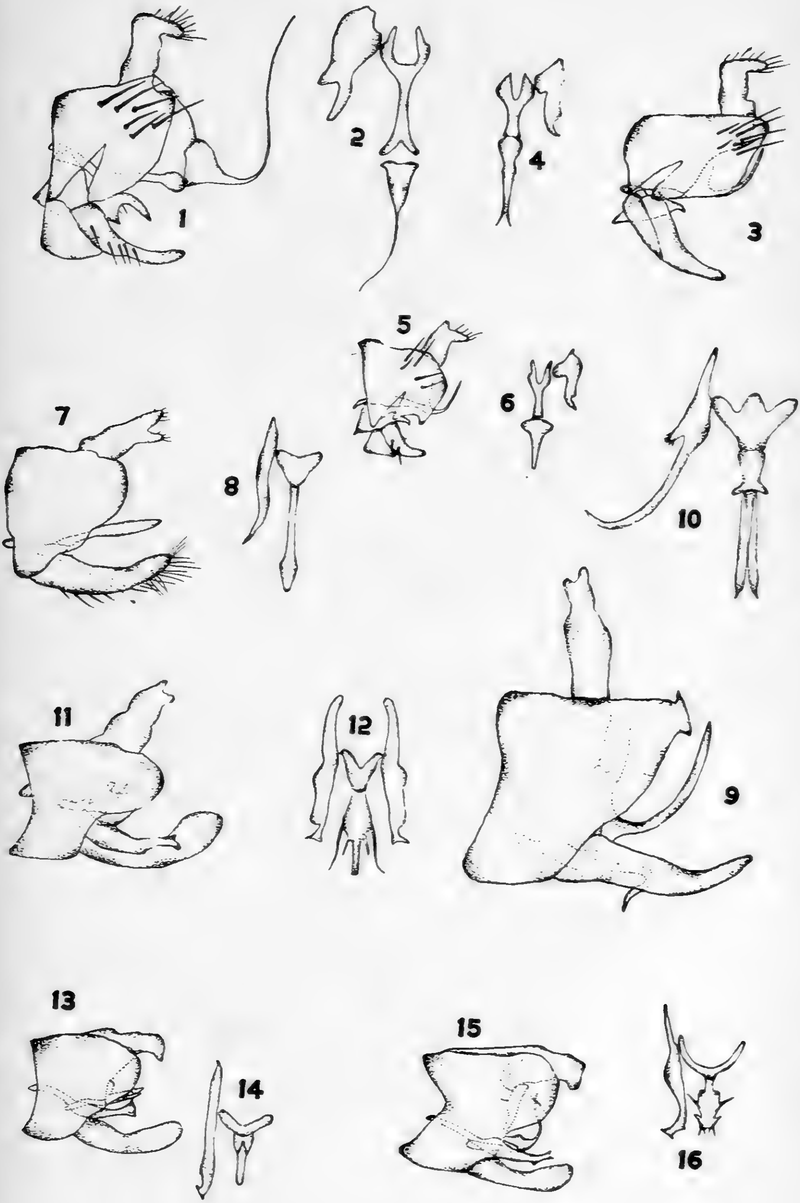


PLATE XVII.

Erythroneura comes—

1. Lateral view.
2. Dorsal view of style, connective and œdagus.

Erythroneura maculata—

3. Lateral view.
4. Dorsal view of style, connective and œdagus.

Erythroneura basalaris—

5. Lateral view.
6. Dorsal view of style, connective and œdagus.

Erythroneura scutelleris—

7. Dorsal view of style, connective and œdagus and lateral view of process in dorsal margin of pygofer.

Erythroneura fumida—

8. Lateral view.
9. Dorsal view of style, connective and œdagus.

Erythroneura obliqua—

10. Lateral view.
11. Dorsal view of style, connective and œdagus.

Erythroneura vulnerata—

12. Lateral view.
13. Dorsal view of style, connective and œdagus.

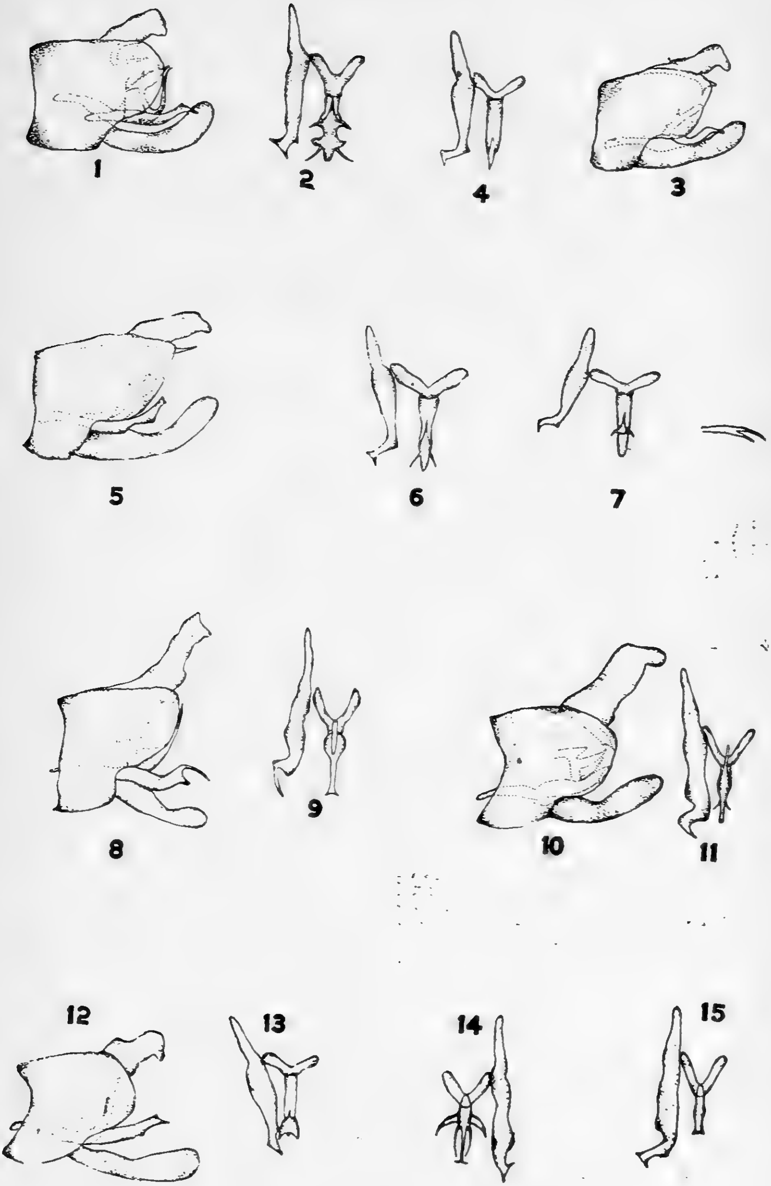
Erythroneura dorsalis—

14. Dorsal view of style, connective and œdagus.

Erythroneura nigra—

15. Dorsal view of style, connective and œdagus.

PLATE XVII.



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(Whole Series, Vol. XXII, No. 2.)

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THE KANSAS UNIVERSITY SCIENCE BULLETIN.

Vol. XII, No. 2.] MARCH 15, 1920. [Whole Series, Vol. XII, No. 2.

The Cicadidæ of Kansas.

BY P. B. LAWSON.

For several years the writer has been interested in the Homopterous fauna of Kansas. He has in recent years written systematic papers on the *Coccidæ* and *Cicadellidæ* found in the state, and after working on the latter family, found himself much interested in the *Homoptera-Auchenorhynchi* as a group.

In looking over the material belonging to this group in the Snow collections, he found that a very representative collection of cicadas was on hand and at once became interested in studying them. Most of this material had been gathered and arranged by Mr. R. H. Beamer, formerly assistant curator of the Snow collections. He himself had intended to publish on the group, but just as he was about ready to undertake the work, he gave up active work in entomology, and so his material fell into the writer's hands. The writer wishes therefore to acknowledge his indebtedness to him and also to Mr. Wm. T. Davis, who not only identified all the material sent him by Mr. Beamer and myself, but also sent me for study other specimens necessary for the prosecution of the work.

In the Journal of the New York Entomological Society, Vol. xxvi, Nos. 3 and 4, 1918, Mr. Davis published a paper on the cicadas of Mississippi. In this paper he records eighteen species from that state and remarks on this relatively large number of species within a single state. Records show that twenty-one species have been taken in Kansas, and specimens of these are now in the Snow collection. A pair of *Tibicen resonans* was very kindly given us by Mr. Davis for the collec-

Received for publication, March 1, 1920.

tion as this species has been taken only a single time in the state.

It is very likely that with more thorough and extensive collecting several more species will be found in Kansas. The writer has been greatly impressed with the number of cicadas that apparently reach one of the limits of their geographical distribution in the state. Thus the Kansas members of the western genus *Okanagana* seem to reach their eastern limit in the state. Similarly the eastern and southern genus *Tibicina* seems to reach its western limit with us. Various members of the genus *Tibicen* also just enter Kansas. Thus we have *T. bifidus* reaching eastward into the western counties. The eastern *T. pruinosa* seems to be very common in eastern Kansas but does not occur in the western part. The eastern and southern *T. lyricen* seems to reach its northwestern limit in the southeastern counties of our state. The southern *T. vitripennis* reaches its northern limit in the southern counties. The relatively eastern *T. marginalis* is found in the eastern two-thirds of the state, while the closely related *T. dealbata* evidently does not go much further east than central Kansas. Again, *T. linnei* seems to reach its western limit with us while *T. superba* and *T. eugraphica* are not found further north. *Proarna venosa* likewise finds its northern boundary in the state, and *Tibicinoides hesperius* is confined to the western counties and likely reaches its eastern limits with us.

This convergence in one state of so many species of varied distribution is undoubtedly due to its central geographical position, to the extremes of its rainfall, and to its varying elevation. Thus the eastern part of the state is distinctly mesophytic, starting with an elevation of 800 feet and with an average rainfall of as high as 45 inches. This condition gradually changes as one goes west over the gradually rising and drier portions of the state, till at its western border the elevation has reached 3,600 feet and the average rainfall has decreased to as low as 16 inches. With this change one finds a corresponding change both in the flora and fauna which is very evident even to the casual observer, at least as far as the flora is concerned. This latter change, combined with those causes which produce it, is undoubtedly responsible for the variety of insect forms and their distribution in the state, for it has repeatedly been found that in many if not all groups of insects, the eastern and western faunas meet somewhere in the central portions of our state. This condition seems to prevail in spite of the fact that most life zone maps show nearly all of the state as belonging to the Upper Austral while just a few southeastern counties come into the northern limits of the Lower Austral.

An attempt has been made in this paper to start on a study of various structural characters to determine their importance as aids in systematic work. Thus a beginning has been made in the study of the ovipositors of the species occurring in the state. Much more work will be necessary before one could be dogmatic about their value, but at present it seems certain that in some cases at least the ovipositors are characteristic of the species. The writer hopes to continue this study with a larger series of each species as well as with more species and give his results in a future paper. Similarly the study of the last ventral segments of both sexes will in some cases reveal good taxonomic characters.

The form of the descriptions here given will also be rather new, but the attempt has been made to bring this form more into harmony with that used to describe the members of the other families of the same group. It is hoped that this might be an aid in the study of these families.

Characteristics of the Cicadidæ.

The *Cicadidæ* are a very interesting family belonging to the *Homoptera-Auchenorhynchi,* this group being distinguished from the *Homoptera-Sternorhynchi* by having the beak arising from the lower part of the head instead of apparently arising from between the prothoracic legs, as in the latter group.

To the *Homoptera-Auchenorhynchi* belong five families, of which the *Cicadidæ* are easily the largest insects. Aside, however, from their relatively larger size, there are very distinct and characteristic structural differences between this family and the others. Thus the members of the *Cercopidæ* and *Cicadellidæ* usually have their fore wings distinctly thicker than the hind wings, whereas in the *Cicadidæ* both pairs of wings are similar in texture. The antennæ of some of the *Fulgoridæ* are very irregular and peculiar in form, while those of the Cicadids are always setiform. Rarely do the members of the other families, the *Aphididæ* excepted, ever have three ocelli, this being a distinct characteristic of the *Cicadidæ.* The front femora also of these insects are quite characteristic, being thickened and toothed beneath. Finally the group is characterized by having males which are musical, so that each species has its peculiar song, a condition unknown in any other *Homoptera.*

Systematic Treatment of the Kansas Species.

Van Duzee in his catalogue has divided the *Cicadidæ* into three subfamilies, each of which is represented by one or more genera in Kansas. The following is his key to these subfamilies:

KEY TO SUBFAMILIES.

Tympanal coverings present in the male, 1.

Tympanal coverings absent in the male.
Subfamily 3 *Tibicininæ* (Dist.)

1. Tympanal coverings entirely concealing the orifices.
Subfamily 1 *Tibiceninæ* Van D.

Tympanal coverings imperfect, leaving the orifices more or less exposed. Subfamily 2 *Cicadinæ* Van D.

Subfamily TIBICENINÆ Van D.

The members of this subfamily are distinguished from those of the other two subfamilies by having the tympanal coverings entirely concealing the tympanal orifices. Most of our cicadas belong here.

The genus *Tibicen* is the only genus belonging to the *Tibiceninæ* that is represented in our Kansas fauna.

Genus TIBICEN Latr.

This genus contains species that vary much in size, ranging from very large to rather small forms. They all, however, have characteristically broad heads and their opaque abdomens taper regularly behind. The mesonotum completely covers the middle of the metanotum and the tympanal orifices of the male are completely hidden by the tympanal coverings. The opercula are large and usually are close together or overlap medially.

This is by far the largest genus in Kansas, fourteen of the twenty-one species of the state belonging here. These may be separated by the following key:

KEY TO SPECIES.

A. Large, heavy bodied species; uncus simple.
B. Uncus distinctly longer than broad, not triangular.
C. Uncus long, slender and curved, bifid apically.
bifida.

A. Large, heavy bodied species—*concluded.*

CC. Uncus broader, with broadly rounded apex.

D. Species light, not strongly marked with black; apex of wings strongly infuscated. *superba.*

DD. Species dark, strongly marked with black; apex of wings slightly infuscated.

E. Hind margin of pronotum or collar greenish.

F. Larger species, averaging 30 mm. or over in length, and with a distinct longitudinal black band on under side of the abdomen.

G. Margin of fore wings not bent; opercula broad, broadly rounded behind; males usually with attenuated pruinose stripe on dorsum of third segment. *pruinosa.*

GG. Margin of fore wings suddenly bent near the middle; opercula narrowed apically and more angulate behind. *linnei.*

FF. Smaller species, averaging about 25 mm. in length and without a distinct longitudinal black band on the under side of the abdomen. *aurifera*

EE. Hind margin of pronotum or collar blackish. *lyricen.*

BB. Uncus usually about as wide as long, usually triangular, but with the apex often truncate.

C. Wings long and slender; a large ferrugineous and black species. *resonans.*

CC. Wings broader; species greenish and black.

D. Very large species, expanding over 110 mm. Flaps of wings gray. *auletes*

DD. Smaller species, seldom expanding 110 mm. Flaps of wings usually with yellowish or orange tinge.

E. Fore wings with cross veins between R_3 and R_{4+5} and between the latter and M_1 distinctly darkened. Posterior margins of abdominal terga not lighter.

F. Abdominal terga with a dorsal row of pruinose spots; uncus somewhat triangular, apex obtuse. *dorsata.*

FF. Abdominal terga without dorsal pruinose spots; uncus broadly truncate apically. *resh.*

EE. Fore wings with cross veins between R_3 and R_{4+5} and between the latter and M_1 not at all or slightly darkened. Posterior margin of abdominal terga lighter.

F. Head broad, wings rather narrow; abdominal terga without dorsal pruinose spots and not strongly pruinose laterally. *marginalis*

FF. Head narrower, wings broader; abdominal terga with dorsal row of pruinose spots and strongly pruinose laterally. *dealbata.*

AA. Small species; uncus wishbone shaped.

B. Orange and black species; arms of uncus strongly curved and widely separated apically, arms of ventral piece stout when viewed caudally. *eugraphica.*

BB. Green and black species; arms of uncus straighter and not as widely separated apically, arms of ventral piece slender when viewed caudally. *vitripennis.*

Tibicen bifidus (Davis).

(Pl. xxi, figs. 1-2; pl. xxv, fig. 4; pl. xxvi, fig. 9; pl. xxvii, fig. 13.)
Cicada bifida Davis, Jl. N. Y. Ent. Soc., xxiv, p. 47, 1916.
Tibicen bifidus Van D., Cat. Hemip. N. A., p. 489, 1917.

A black and yellowish-brown species of medium size. Specimens at hand measure from 25 to 29 mm.

Color: Head black, with the following marked with yellowish-brown, sometimes tinged with green: The antennal ledges, a triangular spot in front of ocelli, a spot of varying size just in front of this, and irregular spots along the caudal margin laterad of the ocelli. Pronotum yellowish- to brownish-green, pruinose in spots, with a large black median T-shaped or triangular spot extending from the collar to the head, which often contains a yellowish-green spot. The grooves are blackened in varying degree and often have black spots between them. Collar with black spots in the humeral angles and often some between these and the median spot. Mesonotum black, often pruinose in spots, with the W-shaped mark and the sides yellowish-green, as is also the cruciform elevation, the anterior arms of the latter almost touching the W. Abdominal terga black with the sides brownish-yellow, the last tergum being almost wholly light, with a faint dorsal row of pruinose spots and often with pruinose markings laterally. Wings with the branches of the veins nearly all black, the costal margin and the bases of the veins, radius and extreme base of media excepted, yellowish-brown; cross veins between R_3 and R_{4+5} and between latter vein and M_1 distinctly darkened. Basal areoles of fore wings with dark dash; flaps of both wings whitish, those of fore wings often with an orange tinge. Beneath nearly unicolorously yellowish-brown except for darker head. Legs, especially prothoracic pair, streaked with dark.

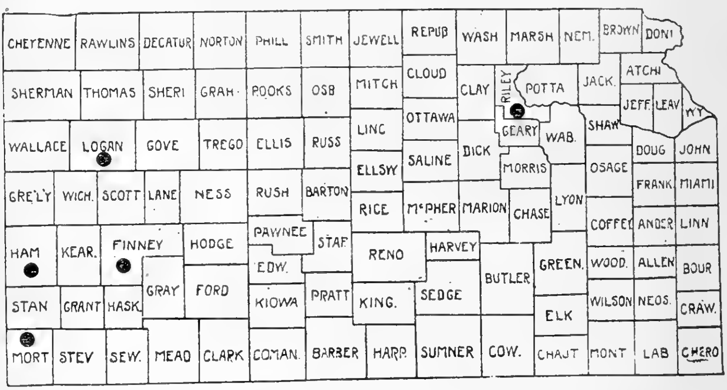
Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	25 to 29
Width of head	9 to 9.5
Expanse of fore wings	71 to 74
Greatest width of fore wing	11.5 to 12.5
Greatest width of operculum	6
Greatest length of operculum	9

The opercula are fully half as long as the abdomen, overlapping nearly two-thirds their length, then evenly narrowing on both margins to the subacute apices.

Genitalia: Supra-anal plate of male with small, stout, median process and with the lateral angles rounded. The uncus, when viewed laterally is long and slender and strongly curved and when viewed caudally is widest at the base, then narrowed till near the broadened and distinctly bifid apex. The ventral piece is strongly U-shaped, the arms stout, slightly notched apically, and connected with membranous tissue till near their apices. The last ventral segment of the male is over one-half longer than wide, lateral margins nearly straight, the posterior margin distinctly but not deeply emarginate. The pygofers of the female have a strong median process. The last ventral segment is broadly notched posteriorly nearly one-third the distance to the base. Each of the lateral pieces of the ovipositor bears about fourteen teeth or ridges, at least in the specimen examined, of which the basal ones are small and far apart, the median four or five being quite large, and the terminal four small and crowded.

Distribution: The specimens at hand were taken in the western part of the state in Morton, Hamilton, Logan and Finney counties. In the collection of the Kansas State Agricultural College are specimens from Logan and Riley counties. Outside of Kansas this species is reported to occur in Colorado, Utah and Arizona. The following map shows its distribution in Kansas as far as is now known:



Remarks: Of the large number of specimens at hand four are paratypes.

Tibicen superba (Fh.).

(Pl. xxi, figs. 3-4; pl. xxiv, fig. 4; pl. xxvi, fig. 12; pl. xxvii, fig. 18.)

Cicada superba Fh., Trans. N. Y. St. Agr. Soc., xiv, (1854), p. 745, 1855.
Cicada superba Uhl., Trans. Md. Acad. Sci., i, p. 152, 1892.
Tibicen superba Van D., Cat. Hemip. N. A., p. 494, 1917.

A fairly large insect of a beautiful greenish-buff color, sparingly marked with black. Specimens at hand measure from 30 to 33 mm.

Color: Head greenish-buff with a broad transverse black band between the eyes and two small black spots at the base of the front. Pronotum in our specimens is entirely greenish-buff. Mesonotum of the same color with black spots as follows: A pair between the arms of the W, a small triangular pair laterad of these, a still smaller pair just above base of fore wings, and a small spot mesad of the tips of the anterior arms of the cruciform elevation. Abdominal terga not as green as the rest of the body, with small pruinose spots laterally at the base of the first segment and with the base of the second segment sometimes narrowly black. The wings are distinctly smoky apically, the veins being olive-green basally, becoming brown apically. The cross veins between R_3 and R_{4+5} and between the latter and M_1 are strongly and widely infuscate. The basal areoles of the fore wings are greenish anteriorly. The flaps of both wings are dark gray. Beneath the insect is brownish or buff and entirely pruinose. The legs are of the same color as the underside, distinctly striped and slightly darkening apically.

Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	30	to	33
Width of head	13.5	to	13.75
Expanse of fore wings	86	to	90
Greatest width of fore wing	12	to	12.5
Greatest width of operculum	6.5	to	7
Greatest length of operculum	9.5	to	10

The opercula are distinctly longer than wide, the lateral margins are slightly sinuate, the mesal margins slightly overlap, and the posterior margins are rounded but with the mesal portion distinctly longer and straighter than the outer part.

Genitalia: Supra-anal plate of male with a stout median tooth which exceeds the rounded lateral angles. The uncus, viewed laterally, is distinctly curved and widens distally to the obtuse apex. Viewed caudally it is a large sclerite nearly twice as long as wide, scarcely narrowing to the broadly rounded apex, and with the usual depression on the dorsal part of its caudal aspect. The ventral piece has its arms widely but not deeply separated. The last ventral segment of the male is distinctly less than twice as wide as long and is strongly rounded posteriorly. The pygofers of the female have a stout and rather short median spine which exceeds the obtusely angulate lateral angles. The last ventral segment of the female has the lateral margins distinctly sinuate, the posterior margin with a broad angular emargination which reaches half way to the base. The lateral pieces of the ovipositor each bear at first five low ridges followed by two prominent teeth and then about six small and indistinct teeth.

Distribution: The only record we have of the occurrence of this species in the state is from Barber county. It seems to be a distinctively southern species as shown by its distribution as given by Van Duzee, who records it from Arkansas, Oklahoma, New Mexico and Texas.

Tibicen pruinosa (Say).

(Pl. xviii, figs. 3-4; pl. xxiv, fig. 3; pl. xxvi, fig. 10; pl. xxvii, fig. 10.)

Cicada pruinosa Say, Jl. Acad. Nat. Sci. Phila., iv, p. 330, 1825; Compl. Writ., ii, p. 251.

Cicada pruinosa Harris, Rept. Ins. Mass., p. 176, 1841.

Cicada bruneosa Wild, Ann. Soc. Ent. Fr., ser. 2, x, Bul., p. xviii, 1852.

Cicada pruinosa Harris, Treat. Ins. Inj. Veg., edn. 3, p. 218, 1862.

Cicada canicularis Prov., Pet. Faune Ent. Can., iii, p. 211, 1889.

Cicada pruinosa Davis & Jout., Ent. News, xvii, p. 237, 1906.

Cicada pruinosa Sm. & Grsb., Ent. News, xviii, p. 123, 1907.

Tibicen pruinosa Van D., Cat. Hemip. N. A., p. 490, 1917.

Tibicen pruinosa Davis, Jl. N. Y. Ent. Soc., xxvi, p. 145, 1918.

A green and black species of fairly large size. Specimens at hand measure from 29 to 33 mm.

Color: Head black, with the following marked with green or brownish-green: The antennal ledges and the space between them and the eyes, a median elliptical spot on upper portion of front, sometimes three spots at base of the front, and the posterior margin between the ocelli and the compound eyes. Pronotum green or brownish-green except for two large black median spots which taper caudad, uniting just before the collar, and enclosing an elongate greenish spot. Frequently some of the grooves, parts of the lateral margins, and the portions just behind the eyes, are tinged with black. Mesonotum green, marked with black as follows: The spaces between the arms of the W, a spot on each side laterad of the arms which are joined sometimes by a slender line with a spot on the posterior margin, laterad of these a third pair of spots which may join the second pair posteriorly, and with a large spot between the W and the light cruciform elevation, its apex reaching up between the inner arms of the former. Abdominal terga entirely black, first segment with large lateral pruinose spots which sometimes reach over to the second segment, the third segment sometimes with attenuated lateral stripes, the eighth segment and the seventh of the female also pruinose laterally. Wings with veins greenish basally, except the base of media, becoming brown on apical half, and with the cross veins between R_3 and R_{4+5} and between the latter vein and M_1 distinctly darkened. Basal areoles of the fore wings greenish but without distinct dash; flaps of fore wings grayish, those of hind wings gray, becoming white posteriorly. Beneath more or less strongly pruinose except for shining black median portion of the abdomen. Legs light, darkening towards the tips of the tibiæ.

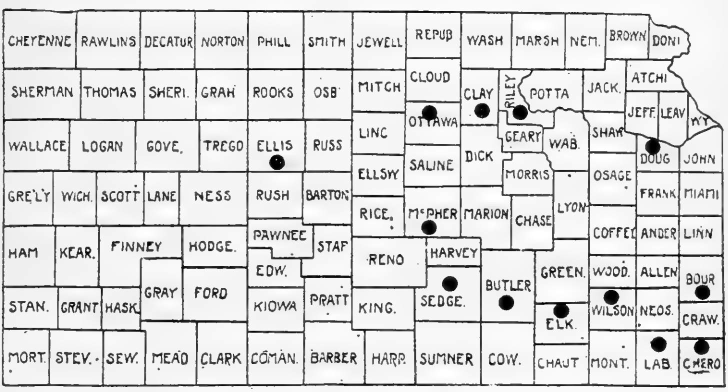
Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	25	to	29
Width of head	12	to	13.5
Expanse of fore wings	96	to	100
Greatest width of fore wing	13.5	to	15
Greatest width of operculum	7	to	7.5
Greatest length of operculum	9.25	to	9.75

Opercula, excluding the extension beyond the coxal cavity, about as long as broad, overlapping medially, and rounded apically but with inner apical margin straighter and longer than the outer.

Genitalia: Supra-anal plate of male with a strong median process which exceeds the rounded lateral angles. Uncus, when viewed laterally, is stout, straight, and parallel-margined till near the apex, when the caudal margin suddenly tapers to the acute apex. Viewed caudally it is a large sclerite, over one-half longer than wide, with a broadly rounding, nearly truncate, subapically depressed apex, and with a large triangular depression on the dorsal part of its caudal aspect. The ventral piece is strongly V-shaped, with the arms rather slender when viewed caudally but appearing stout from a lateral view. The last ventral segment of the male is twice as wide as long, the lateral margins very slightly sinuate, the apex broadly rounded. The pygofers of the female have a slender and acute median process which greatly exceeds the lateral angles. Last ventral segment of the female with a broad, distinctly angulate notch reaching nearly half way to the base. In the specimen examined the lateral pieces of the ovipositor each bore about a dozen ridges or teeth, of which the first four were ridge-like and the rest more tooth-like.

Distribution: This is one of our commonest species. In and around Lawrence it is by far the commonest form. As shown by the following map it is decidedly eastern in its distribution in the state. The record from Riley county is that of the Kansas State Agricultural College. Van Duzee records it from the following other states: Pennsylvania, Indiana, Missouri, Nebraska and Texas. Davis says its distribution is that of the general region of the valley of the Mississippi.



Remarks: Davis speaks of the song of this species as follows: "The song of *pruinosa* is quite unlike that of any of the other large native cicadas, and may be rendered as *z-zape, z-zape, z-zape.* The insect often remains quiet all day, singing from about 3 or 4 p. m. until dark."

Tibicen linnei (Sm. & Grsb.).

(Pl. xviii, figs. 1-1; pl. xxiv, fig. 2; pl. xxvi, fig. 11; pl. xxvii, fig. 16.)

Cicada linnei Sm. & Grsb., Ent. News, xviii, p. 127, 1907.
Cicada tibicen Germ., Mag. d. Ent., iv, p. 95, 1821.
Fidicina tibicen Walk., List Homop., i, p. 94, 1850.
Thopha chloromera Walk., List Homop., i, p. 43, 1850.
Cicada tibicen Fh., Trans. N. Y. St. Agr. Soc., xv, p. 367, No. 73, 1856.
Cicada tibicen Harris, Treat. Ins. Inj. Veg., edn. 3, p. 219, 1862.
Cicada tibicen Uhl., Stand. Nat. Hist., ii, p. 227, 1884.
Cicada tibicen Woodw., Psyche, v, p. 68, 1888.
Cicada tibicen Uhl., Trans. Md. Acad. Sci., i, p. 149, 1892.
Cicada tibicen Macg., Can. Ent., xxxiii, p. 82, 1901.
Cicada tibicen Felt, N. Y. St. Mus. Memoir, 8, i, p. 237, pl. 46, fig. 1, 1905.
Rihana tibicen Dist., Cat. Homop., Cicadidæ, p. 36, 1906.
Cicada tibicen Davis & Jout., Ent. News, xvii, p. 238, 1906.
Cicada tibicen Tuck., Kans. Univ. Sci. Bul., iv, p. 64, 1907.
Cicada linnei Davis, Jl. N. Y. Ent. Soc., xxiii, p. 10, 1915.
Tibicen linnei Van D., Cat. Hemip. N. A., p. 490, 1917.
Tibicen linnei Davis, Jl. N. Y. Ent Soc., xxvi, p. 146, pl. 7, fig. 1, 1918.

A green and black species looking like *T. pruinosa* in form and color. Specimens at hand measure from 30.5 to 33 mm.

Color: Head mostly black, with the following marked with green: A broad stripe on each side along antennal ledge from front to eyes, these stripes each with a small black spot near the front, an elliptical spot on upper portion of front connected with a median triangular spot at base of front, and with irregular marks along posterior margin laterad of each lateral ocellus. Pronotum green, with two large black posteriorly tapering median spots which enclose a wedge-shaped green mark, and with the grooves and back of the eyes frequently black, there sometimes being a black spot also on the lateral margins. Mesonotum green, marked with black as follows: Between the arms of the W, a large spot on each side laterad of this which extends taperingly to posterior margin, a smaller spot on each side laterad of these, and a large spot cephalad of the light cruciform elevation, this spot having a narrow anterior process which reaches between the median arms of the W. Abdominal terga black, the posterior margins sometimes being testaceous. First segment in males with a pair of small but distinct pruinose spots. The wings have the veins, with the exception of media, greenish basally and becoming brownish apically. The cross veins between R_3 and R_{4+5} and between the latter vein and M_1, are strongly and broadly infuscated. The basal areoles of the fore wings are green. The flaps of both wings are grayish or brownish. Beneath the insect varies from greenish to testaceous, the opercula being lighter than the rest of the under side and fresh specimens are entirely pruinose with the exception of the black median portion of the abdomen. The legs are light brown or greenish with a tendency to darken apically.

Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	30.5	to	33
Width of head	14.25	to	15
Expanse of fore wings..............	94	to	100
Greatest width of fore wings.......	14	to	14.5
Greatest width of operculum........	6.5		
Greatest length of operculum.......	8	to	8.5

The costal margin of the fore wings is slightly but distinctly bent near the middle. The opercula are longer than broad. They slightly overlap along their mesal margins, the lateral margins are sinuately narrowed posteriorly and the posterior margin runs cephalo-mesad in a straight line from the rounded lateral angles.

Genitalia: Supra-anal plate of male with a very broad but short median spine which scarcely exceeds the rounded lateral angles. Uncus, when viewed laterally, is curved on its posterior margin to the semi-obtuse apex. When viewed caudally it is a large sclerite less than twice as long as wide and gradually tapering from the base to the broadly rounded apex. The upper portion of the caudal aspect shows a large triangular depression. The ventral piece is U-shaped with the arms fairly deeply divided. The last ventral segment of the male is over twice as wide as long, and slightly emarginate apically. The pygofers of the female have a prominent and acute median spine which strongly exceeds the strongly-angled lateral angles. The last ventral segment of the female has the lateral margins sinuate and the posterior margin broadly and angularly emarginate nearly one-half the distance to the base. The lateral pieces of the ovipositor each bear about twelve teeth or ridges, of which the median four alone are distinct.

Distribution: The only Kansas records for this species are from Sedgwick, Douglas and Clay counties, the former two by E. S. Tucker and the last by Wm. T. Davis. Outside of Kansas it is found in Massachusetts, New York, Michigan, Tennessee, North Carolina, Illinois, and Mississippi, so that Kansas would seem to be its western limit.

Remarks: Davis says that the song of this species is a continuous *z-ing*, generally of a short duration. All the specimens examined by the writer were from North Carolina.

Tibicen aurifera (Say).

(Pl. xxii, fig. 1-2; pl. xxiv, fig. 5; pl. xxvi, fig. 15; pl. xxvii, fig. 12.)

Cicada aurifera Say, Jl. Acad. Nat. Sci. Phila., iv, p. 332, 1825; Compl. Writ., ii, p. 252.

Cicada aurifera Woodw., Psyche, v, p. 68, 1888.

Cicada aurifera Uhl., Trans. Md. Acad. Sci., i, p. 153, 1892.

Cicada aurifera Kirk., Ent., xxxiii, p. 242, 1900.

Cicada aurifera Macg., Can. Ent., xxxiii, p. 80, 1901.

Cicada aurifera Davis, Jl. N. Y. Ent Soc., xxiv, p. 44, 1916.

Tibicen aurifera Van D., Cat. Hemip. N. A., p. 492, 1917.

A rather small species usually green and black but sometimes varying to reddish-brown and black, having the body covered with a golden pubescence. Specimens at hand vary from 23 to 26 mm. in length.

Color: Head black, with the following marked with greenish to brownish: The antennal ledges and a broad spot between them and the eyes, a median elliptical spot on upper portion of the front with sometimes a spot caudad of this, spots at basal angles of the front, a spot laterad of each lateral ocellus, and irregular spots between these and the eyes along the posterior margin. Pronotum largely greenish, sometimes varying to reddish-brown, with two irregular black spots enclosing a median wedge-shaped green spot. Mesonotum green to reddish-brown, marked with black as follows: Between the arms of the W, a large spot tapering to posterior margin on each side laterad of the W, and a smaller spot on each side laterad of this, the latter two spots on each side often fusing, and a large black spot in front of the cruciform elevation with a long slender point reaching between the two middle arms of the W. Abdominal terga usually black, though sometimes the posterior margins are testaceous. Wings with veins all greenish to reddish-brown basally, becoming darker apically. The cross veins between R_3 and R_{4+5} and between the latter and M_1 are distinctly darkened and practically spot-like. The basal areoles of the fore wings are greenish anteriorly; the flaps of both wings are grayish. Beneath brownish, entirely pruinose when fresh, rubbed specimens showing oblong black spot at base of each abdominal sternite. Opercula usually lighter than rest of under side. Legs light, excepting front legs, becoming darker apically.

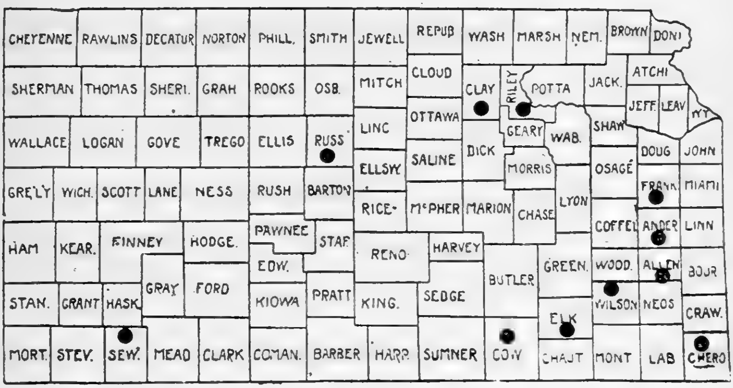
Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	23	to	26
Width of head	10	to	12
Expanse of fore wings	66	to	76
Greatest width of fore wing	10	to	11
Greatest width of operculum	5	to	5.5
Greatest length of operculum	7.5	to	8

The opercula are slightly overlapping medially, the apices are very broadly rounded, the inner margin being slightly longer than the outer.

Genitalia: The supra-anal plate of the male has a stout but acute median spine, which clearly exceeds the rounded lateral angles. The uncus when viewed laterally is curved and widens till near the apex, when the inner margin suddenly tapers and forms an angle with the outer margin. Viewed caudally it is a large sclerite, about twice as long as wide, scarcely tapering to the broadly rounded apex, and broadly and rather deeply emarginate dorsally. The ventral piece is deeply U-shaped. The last ventral segment of the male is fully twice as wide as long and hemispherical in outline. The pyfogers of the female have a stout but very acute median spine which strongly exceeds the lateral angles. The last ventral segment of the female is distinctly sinuate laterally and the posterior margin is broadly but angularly emarginate fully one-half of the distance to the base. The ovipositor has lateral pieces, each bearing about fourteen teeth or ridges, which are for the most part separated by deeper incisions than in the other species examined. The ovipositor in this case seems to be specifically distinct.

Distribution: This species has so far been reported from Kansas only. It is apparently most abundant in the eastern part of the state, as shown by the county records on the following map. The records from Riley, Cowley and Russell counties are those of the Kansas State Agricultural College. Further collecting will doubtless reveal this species from the neighboring states.



Tibicen lyricen (De G.).

(Pl. xviii, figs. 5-6; pl. xxiv, fig. 1; pl. xxvi, fig. 8; pl. xxvii, fig. 11.)

Cicada lyricen DeG., Memoires, iii, p. 212, pl. 32, fig. 23, 1773.
Cicada fulvula Osb., Ent. News, xviii, p. 322, 1906.
Cicada lyricen Sm. & Grsb., Ent. News, xviii, p. 125, 1907.
Cicada lyricen Barb., Proc. Ent. Soc. Wash., xiv, p. 210, 1912.
Tibicen lyricen Van D., Cat. Hemip. N. A., p. 491, 1917.
Tibicen lyricen Davis, Jl. N. Y. Ent. Soc., xxvi, p. 147, pl. 8, fig. 1, 1918.

A black and fulvous species of about the same size or slightly larger than *T. pruinosa*. Specimens at hand measure from 31 to 34 mm.

Color: Head black, with the following marked with fulvous: The antennal ledges and a spot from them to the eyes, a median elliptical spot on the upper portion of the front, caudad of this a triangular median spot, a spot laterad of this at each corner of the front, a spot laterad of each lateral ocellus, and irregular spots on posterior margin of head laterad of the latter. The eyes are dark fulvous. Pronotum mostly fulvous in our specimens but with collar and lateral margins always black, and with two large black median lines which, narrowing posteriorly, meet at the collar, thus enclosing an elongate, median, fulvous spot. Mesonotum fulvous, with space between outer arms of W entirely black, a black spot on each side laterad of this, a black line on each side near the margin, and a large black spot between the W and the usually fulvous cruciform elevation. Abdominal terga black, the posterior margin of the first segment sometimes fulvous. Pruinose markings on first segment either absent, reduced to lateral spots, or forming a narrow line. In some specimens lateral pruinose spots on the seventh tergite are visible from above. Wings, with the exception of the black basal portion of media, have the veins greenish on basal half and dark fulvous apically. Sometimes the green is largely replaced by the fulvous. The cross veins between R_3 and R_{4+5} and between the latter vein and M_1 are distinctly darkened. The basal areoles of the fore wings for the most part are greenish; flaps of fore wings dark gray, those of hind wings lighter. Beneath the body is entirely pruinose with the exception of the black median portion of the abdomen. The opercula are paler than the rest of the body. The legs are fulvous, becoming paler apically.

Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	31	to	34
Width of head	14	to	15
Expanse of fore wings	100	to	102
Greatest width of fore wing	14	to	15
Greatest width of operculum	6.5	to	7
Greatest length of operculum	9	to	10

The opercula are about as broad as long, excluding the extension beyond the coxal cavity. They overlap medially and the posterior margins are broadly rounded, the inner margin of the apex being longer and straighter than the outer margin.

Genitalia: The supra-anal plate of the male has a stout median spine which scarcely exceeds the rounded lateral angles. The uncus, when viewed laterally, is stout and curved, the inner margin tapering rather suddenly apically to the obtuse apex. Viewed caudally it is a large sclerite, distinctly narrowed toward the obtusely rounded apex, and with a large triangular depression on the dorsal portion of its caudal aspect. The ventral piece is strongly U-shaped. The last ventral segment of the male is fully twice as broad as long and slightly but distinctly emarginate apically. The pygofers of the female have a slender and acute median process which greatly exceeds the lateral angles. The last ventral segment of the female is very broad and narrow, the lateral margins distinctly sinuate, and the posterior margin with a large and broadly rounded emargination which reaches about one-third of the distance to the base. The ovipositor is rather sparsely toothed, each lateral piece bearing about ten rather blunt teeth or ridges.

Distribution: Specimens of this species have been taken in Cherokee, Wilson, Elk, and Riley counties. It may be that this state is its northwestern limit for Van Duzee records it as an eastern and southern form found in Ontario, Rhode Island, New York, New Jersey, North Carolina, Florida, Alabama, Ohio, and Indiana. Smith and Grossbeck record it from New Brunswick also.

Remarks: Davis states that the song of this species is a monotonous *zing*.

Tibicen resonans (Walk.).

(Pl. xix, figs. 3-4; pl. xxiv, fig. 6; pl. xxvi, fig. 13; pl. xxvii, fig. 9.)

Cicada resonans Walk., List Homop., i, p. 106, 1850.
Cicada resonans Davis, Jl. N. Y. Ent. Soc., xxiii, p. 6, pl. 1, fig. 2, 1915.
Tibicen resonans Van D., Cat. Hemip. N. A., p. 493, 1917.
Tibicen resonans Davis, Jl. N. Y. Ent. Soc., xxvi, p. 148, 1918.

A ferrugineous and black species of large size. Specimens at hand measure from 38 to 40 mm.

Color: Head black, with ferrugineous spots as follows: Along the antennal ledges and on to the eyes, a median and two lateral spots at the base of the front, and irregular marks along the posterior margin laterad of the lateral ocelli to the eyes. Pronotum mostly ferrugineous with the grooves, an almost continuous line along the anterior margin, parts of the lateral margins and other variable spots, black. Mesonotum ferrugineous with black spots as follows: Between the arms of the W, a usually smaller spot on each side laterad of this, a spot along each lateral margin, and a large transverse spot cephalad of the ferrugineous cruciform elevation which has a slender anterior process reaching between the median arms of the W. The wings have the veins entirely ferrugineous as are the basal areoles of the fore wings. The cross veins between R_3 and between R_{4+5} and between the latter vein and M_1 are clearly but not strongly darkened. The flaps of both wings are grayish or buff. The abdominal terga are black. Beneath the insect is dark brown or ferrugineous with the opercula lighter. The specimens at hand are partly pruinose. The legs are ferrugineous.

Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	38 to 40
Width of head	17 to 17.5
Expanse of fore wings	115
Greatest width of fore wing	15
Greatest width of operculum	8
Greatest length of operculum	8

Opercula, excluding extension beyond the coxal cavity, broader than long, overlapping for a short distance medially, the posterior margins forming a broad and nearly regular curve.

Genitalia: Supra-anal plate of male with a broad but shallow median emargination which bears a broad and short but distinct median tooth which is shorter than the lateral angles. The uncus, when viewed laterally, is broad basally, narrowed medially, and then expanding apically much like a horse's foot. Viewed caudally it is broader than long, slightly narrowing to the broad, truncate apex. The ventral piece is strongly U-shaped, its arms turning strongly laterad apically. The last ventral segment of the male is distinctly less than twice as broad as long, the lateral margins regularly narrowing to the broad truncate apex. The pygofers of the female have an acute median tooth which distinctly exceeds the lateral angles. Last ventral segment of the female with sinuate lateral margins, the posterior margin broadly and angularly emarginate half way to the base. The ovipositor is characterized by the regularity of the teeth of the lateral pieces each of which bears about ten teeth or ridges.

Distribution: The only record of this species for the state is that given by Mr. Wm. T. Davis who reports a single specimen from Kansas in the Museum of Comparative Zoölogy. Van Duzee gives North Carolina, Georgia, Florida, and Alabama as the other states in which it occurs. Davis reports specimens from Mississippi and Louisiana in addition. Thus it is seen to be a distinctively southern species.

Remarks: Davis reports this species as being found in the sand ridges in North Carolina. The specimens examined were kindly sent me by him from this state.

Tibicen auletes (Germ.).

(Pl. xix, figs. 5-6; pl. xxv, fig. 1; pl. xxvi, fig. 1; pl. xxvii, fig. 1.)

Cicada auletes Germ., Silb. Rev. Ent., ii, p. 65, 1834.
Tettigonia grossa? Fabr., Syst. Ent., p. 678, 1775.
Cicada grossa Oliv., Encyc. Meth., v, p. 747, 1790.
Cicada auletes Harris, Rept. Ins. Mass., p. 176, 1841.
Cicada sonora? Walk., List Homop., i, p. 105, 1850.
Cicada literata Walk., List Homop., i, p. 91, 1850.
Cicada auletes Harris, Treat. Ins. Inj. Veg., edn. 3, p. 218, 1862.
Cicada marginata How., Insect Book, p. 232 (*emarginata*), pl. 28, fig. 19, 1905.
Cicada marginata Sm. & Grsb., Ent. News, xviii, pl. 3, fig. 1, 1907.
Rihana grossa Dist., Genera Ins., fasc. 142, p. 29, 1912.
Cicada auletes Davis, Jl. N. Y. Ent. Soc., xxiii, p. 2, pl. 1, fig. 1, 1915.
Cicada auletes Weiss, Ent. News, xxvii, p. 162, 1916.
Tibicen auletes Van D., Cat. Hemip. N. A., p. 492, 1917.
Tibicen auletes Davis, Jl. N. Y. Ent. Soc., xxvi, p. 149, 1918.

A greenish-brown and black or nearly fulvous and black species of very large size. This is the largest of our cicadas, the specimens at hand measuring from 40.5 to 42 mm.

Color: Head black, marked with greenish-brown as follows: A spot along antennal ledges which broadens on towards the eyes, an elongate median spot on upper portion of front, a median and two lateral spots at base of front, and irregular spots beginning laterad of the lateral ocelli and extending along posterior margin to the eyes. Pronotum mostly greenish-brown, with two, black, triangular, median spots tapering posteriorly to the collar and enclosing an elongate light stripe and each, in our specimens, with a fulvous spot in anterior portion. The portion back of the eyes is also black and connects with a black narrow line which runs along the groove in front of the collar. The lateral margins are narrowly black. Mesonotum mostly black, the median arms of the W being fulvous, these fulvous lines broadening and extending laterad and caudad to the cruciform elevation which is greenish-brown. The lateral margins of the mesonotum are also fulvous. Abdominal terga black, the basal segment and the last three segments being pruinose in fresh specimens. The wings have the veins, with the exception of the basally fulvous media, greenish-brown basally, becoming darker apically. The cross veins between R_3 and R_{4+5} and between the latter and M_1 are distinctly darkened. The basal areoles of the fore wings are greenish-brown. The flaps are grayish to brownish in color. Beneath the insect is olive-green and pruinose in fresh specimens. The legs are of about the same color.

Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	40.5 to 42
Width of head	18.5 to 19
Expanse of fore wings	116 to 122
Greatest width of fore wing	19 to 19.5
Greatest width of operculum	9.5
Greatest length of operculum	12

The opercula are very large and broad, separated at base medially, but overlapping quite strongly for a short distance, the outer margins slightly sinuate, and the apices broadly rounding.

Genitalia: The supra-anal plate of the male has a very broad but short median process which does not equal the rounded lateral angles. The uncus, when viewed laterally, is broad basally, narrowed medially, and then enlarged at the apex which somewhat resembles a horse's hoof. Viewed caudally it is a comparatively short and very broad sclerite with its truncate apex slightly but distinctly emarginate. The last ventral segment of the male is fully twice as wide as long, the margins slightly sinuately tapering to the rounded, almost truncate apex. The pygofers of the female have a broad and short but acutely-pointed median spine which scarcely exceeds the lateral angles. The last ventral segment of the female has the lateral margins practically straight and the broad angular emargination of the posterior margin extends half way to the base. The lateral pieces of the ovipositor each bears three slight ridges followed by about ten fairly distinct, rounded teeth.

Distribution: In the collection of the Kansas State Agricultural college are specimens which were taken in Riley county. Davis records specimens from Labette county also. As far as the writer knows these are the only two records of the occurrence of this insect in the state. Davis states that it is found from eastern Kansas and Nebraska to Michigan and Massachusetts, and southward along the coast to Florida. Van Duzee records it from Massachusetts, New York, New Jersey, Maryland, District of Columbia, North Carolina, South Carolina, Georgia, Florida, Alabama, Louisiana, Mississippi, Michigan, Missouri, and Kansas. It would seem, therefore, that Kansas is its western limit.

Remarks: Concerning the song of this species Davis writes: "Its song is monotonous in tone and not loud, considering the size of the insect. It often commences to sing late in the afternoon and continues off and on until dark."

The specimens examined by the writer were taken in Georgia.

Tibicen dorsata (Say).

(Pl. xx, figs. 5-6; pl. xxiv, fig. 8; pl. xxvi, fig. 4; pl. xxvii, fig. 7.)

Cicada dorsata Say, Jl. Acad. Nat. Sci. Phila., iv, p. 331, 1825; Compl. Writ., ii, p. 252.
Thopha caria Walk., List Homop., i, p. 42, 1850.
Fidicina crassa Walk., Ins. Saund., Homop., p. 10, 1858.
Cicada dorsata Uhl., Bul. U. S. Geol. Geog. Surv., i, p. 342, 1876.
Cicada dorsata Uhl., Trans. Md. Acad. Sci., i, p. 152, 1892.
Cicada dorsata Tuck., Kans. Univ. Sci. Bul., iv, p. 64, 1907.
Cicada dorsata Davis, Jl. N. Y. Ent. Soc., xxiii, pp. 161, 164, 1915.
Tibicen dorsata Van D., Cat. Hemip. N. A., p. 495, 1917.

A large greenish-yellow and black species. Specimens at hand vary in length from 31 to 38 mm.

Color: Head mostly black but with yellowish-green spots running along antennal ledges to eyes, each of which spots usually contains a small black spot, and with irregular light spots along posterior margin laterad of the lateral ocelli. Also on the upper part of the front there is a small elliptical light spot. Pronotum yellowish-green, usually with the two attenuated, black, median triangles which enclose a light median line, and usually widen out making the groove cephalad of the collar black. Often only parts of these triangles are present. Sometimes the part back of the eyes is black as is also a very narrow portion of the lateral margins. The mesonotum has the following parts black: Between the arms of the W, a long posteriorly narrowing line on each side laterad of this, and a pair of narrower lines on the lateral margins, also a large triangular spot cephalad of the light cruciform elevation which sends an anterior process cephalad between the inner arms of the W. The arms of the W apically, the lateral margins and the depressions around the cruciform elevation, are all heavily pruinose. The abdominal terga are black with a row of dorsal white spots. The first segment has lateral white spots, the third segment often with a narrow pruinose line along the anterior margin, and the rest of the segments pruinose laterally, the last segment often being entirely pruinose. The wings have the veins, with the exception of the usually black base of media, yellowish-brown and becoming darker apically. The cross veins between R_3 and R_{4+5} and between the latter and M_1 are distinctly darkened. The basal areoles of the fore wings are brownish, and the flaps of both wings are grayish, the first ones with an orange tinge. The wings appear strongly vitreous due to the unusual corrugation of the membrane, and are slightly clouded apically. Beneath the insect is testaceous, the opercula lighter, and in fresh specimens is entirely pruinose. The legs are of about the same color as the under side, the posterior ones being darkest. They are distinctly striped.

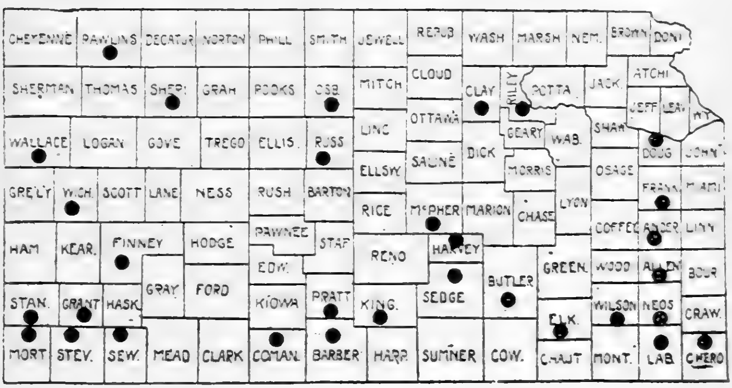
Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	31	to	38
Width of head	12.5	to	15
Expanse of fore wings	90	to	105
Greatest width of fore wing	15	to	19
Greatest width of operculum	6.5	to	8.5
Greatest length of operculum	9	to	14

The opercula are distinctly longer than broad, slightly overlapping medially, the lateral margins recurved, and the posterior margins evenly and broadly rounded.

Genitalia: Supra-anal plate of male roundly emarginate posteriorly, without any signs of a median tooth, the lateral angles strongly angulate. Uncus, viewed laterally, is broadest at the base, curving, the apex obtuse. Viewed caudally the general form is triangular, but the apex is quite broad and almost truncate. The ventral piece has two short and stout arms which are not deeply cleft. The last ventral segment of the male is not quite twice as broad as long and is very broadly rounded or nearly truncate posteriorly. The pygofers of the female have a short median spine which does not exceed the well-rounded lateral margins. The last ventral segment of the female has the lateral margins straight, the posterior margin with a rounded emargination reaching half way to the base. The lateral pieces of the ovipositor have well-developed teeth or ridges, about six of the thirteen on each side being prominent.

Distribution: Our records indicate that this species is our most widely distributed form in the state. It has been taken in over thirty counties from all parts of the state. The records from Russell and Riley counties are those of the Kansas State Agricultural College. Those from Clay and McPherson counties are by Davis. Van Duzee records it from the following other states: Missouri, Iowa, Nebraska, Arkansas, New Mexico, Texas and Colorado. The following map shows its distribution in Kansas:



Tibicen resh (Hald.).

(Pl. xx, figs. 3-4; pl. xxiv, fig. 7; pl. xxvi, fig. 2; pl. xxvii, fig. 5.)

Cicada resh Hald., Stansb. Salt Lake Exped., p. 369, pl. 9, fig. 17, 1852.
Cicada robertsoni Fh., Trans. N. Y. Agr. Soc., xiv, (1854), p. 745, 1855.
Cicada robertsoni Davis, Jl. N. Y. Ent. Soc., xxiii, p. 164, 1915, (synon. of *resh*).
Cicada resh Davis, Jl. N. Y. Ent. Soc., xxiii, p. 5, pl. 1, fig. 3, 1915.
Tibicen resh Van D., Cat. Hemip N. A., p. 493, 1917.
Tibicen resh Davis, Jl. N. Y. Ent. Soc., xxvi, p. 149, 1918.

A large yellowish-green and black species. Specimens at hand measure from 32 to 35 mm.

Color: Head mostly black, but with large triangular spots along antennal margins to eyes, an oval spot on upper portion of front, triangular spots at base of front, a spot just caudad of this, and irregular spots on each side along posterior margin laterad of the lateral ocelli, yellowish-green. Pronotum yellowish-green, marked with black as follows: Two small triangular spots on anterior margin which sometimes run backward and fuse with the black converging lines in the grooves which run back to the collar, and with two spots laterally in groove cephalad of collar. In dark specimens the entire anterior margin of the pronotum may be black, as well as the entire groove cephalad of the collar. Such forms have the two large black characteristic median triangles which enclose a median elongate greenish spot. Mesonotum largely black, with two elongate lateral greenish to brownish spots on each side and a median pair of spots of the same color which form the Hebrew letter *resh* inverted. The abdominal terga are black as a rule, but often have the posterior margins brownish. The wings have the veins greenish basally, with the possible exception of media, but they become brownish apically. The cross veins between R_3 and R_{4+5} and between the latter and M_1 are strongly darkened. The basal areole of the fore wings is greenish while the flaps of both wings are a brownish-gray. Beneath the insect is usually testaceous and in fresh specimens is pruinose. The legs are also testaceous, the femora streaked, and the tarsi and tibiæ darker.

Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	32	to	35
Width of head	14.5	to	16.5
Expanse of fore wings	98	to	107
Greatest width of fore wing	15	to	16
Greatest width of operculum	7	to	7.5
Greatest length of operculum	9	to	9.5

The opercula are about as broad as long excluding the extension beyond the coxal cavity. They overlap very slightly medially, and the posterior margins are broadly and evenly rounded.

Genitalia: The supra-anal plate of the male has a broad and stout but very low median process which does not equal the rather pointed lateral angles. The uncus, viewed laterally, is widest at the base, somewhat curving, and widened again apically, with the apex rather truncate. Viewed caudally it is a broad and short sclerite, the apex quite truncate and shallowly notched. The ventral piece has the slender arms widely and deeply separated and each curves laterad apically. The last ventral segment of the male is nearly twice as wide as long, with the apex broad and truncate and with a very slight median emargination. The pygofers of the female have the usual stout and acute median tooth which far exceeds the distinctly angulate lateral angles. The last ventral segment of the female has the lateral margins distinctly sinuate and the broad angular emargination of the posterior margin reaches fully half way to the base. Each of the lateral pieces of the ovipositor bears about seven very indistinct and rounded teeth. Should this condition prove constant it would be of taxonomic value.

Distribution: While we have a goodly number of specimens of this species, an examination shows that they were all taken in Elk county and this seems to be our only record for the state. Van Duzee gives Mississippi, Louisiana, Oklahoma, Texas and Utah as the states in which it has been taken. Thus it seems to be more common in the South, and may prove to be distinctly southern if, as Davis surmises, the Utah record may not be authentic.

Tibicen marginalis (Walk.).

(Pl. xix, figs. 1-2; pl. xxiv, fig. 9; pl. xxvi, fig. 5; pl. xxvii, fig. 3.)

Cicada marginalis Walk., List Homop., iv, p. 1128, 1852 (n. n. for *marginata* Say).
Cicada marginata Say, Jl. Acad. Nat. Sci. Phila., iv, p. 330, 1825; Compl. Writ., ii, p. 251.
Cicada marginata Uhl., Stand. Nat. Hist., ii, p. 227, 1884.
Cicada marginata Woodw., Psyche, v, p. 68, 1888.
Cicada marginata Uhl., Trans. Md. Acad. Sci., i, p. 150, 1892.
Cicada marginata Macg., Can. Ent., xxxiii, p. 81, 1901.
Cicada marginata Sm. & Grsb., Ent. News, xviii, p. 128, 1907.
Cicada marginata Davis, Jl. N. Y. Ent. Soc., xxiii, p. 4, pl. 2, fig. 1, 1915.
Cicada marginata Davis, Jl. N. Y. Ent. Soc., xxiii, p. 240, pl. 18, figs. 2, 4, 1915.
Tibicen marginalis Van D., Check List Hemip., p. 55, 1916.
Tibicen marginalis Van D., Cat. Hemip. N. A., p. 493, 1917.
Tibicen marginalis Davis, Jl. N. Y. Ent. Soc., xxvi, p. 150, 1918.

A very large greenish and black or greenish-yellow and black species. Specimens at hand measure from 36 to 39 mm. Smith and Grossbeck state that specimens examined by them averaged over 40 mm.

Color: Head mostly black, with a broad greenish-yellow stripe along anterior margin from the front to the eyes, a spot of the same color on upper portion of front and also along posterior margin laterad of the lateral ocelli. Pronotum greenish-yellow with two, small, black, median, triangular spots at anterior margin and sometimes with black spots extending cephalad from collar to meet these, thus enclosing an elongate, light, median dash which frequently contains a black median line. Mesonotum mostly black, the W being greenish-yellow with the angles greatly enlarged and laterad of this is a large, almost fulvous spot on each side. The cruciform elevation is of about the same color as these lateral spots. Abdominal terga black with the posterior margins fulvous or testaceous as are also the tympanal coverings of the male. The wings have the veins greenish basally and brownish apically. The cross veins between R_3 and

R_{4+5} and between the latter and M_1 are not at all, or only slightly, infuscated. The basal areoles of the fore wings are green; the flaps of both wings are greenish-yellow. Beneath, the entire surface is brownish or testaceous and fresh specimens are pruinose, with the exception of the median portion of the abdomen in rubbed specimens. Legs of the same color as the under side, slightly darkening apically, and showing distinct ridges on the femora.

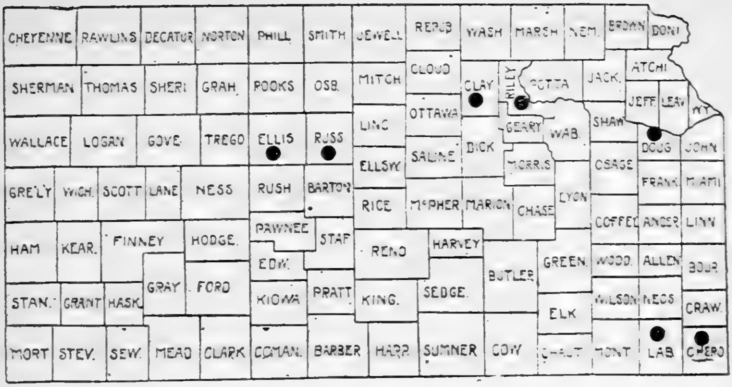
Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	36	to	39
Width of head	17	to	17.25
Expanse of fore wings	107	to	112
Greatest width of fore wing	17	to	18
Greatest width of operculum	7.5	to	8
Greatest length of operculum	8.5	to	9

The costal margin of the fore wings is distinctly bent near its middle. The opercula are only slightly longer than broad, overlap slightly for a short distance medially, and the posterior margins are broadly and evenly rounded.

Genitalia: The supra-anal plate of the male is roundingly and deeply concave between the lateral angles, and there are no signs of a median tooth. The uncus, viewed laterally, is stout and curving, and tapers to a rather obtuse apex. Viewed caudally it is triangular, the apex distinctly pointed but obtuse, and with the usual triangular depression on the upper portion of its dorsal aspect. The ventral piece is strongly V-shaped, the arms being quite stout. The last ventral segment of the male is nearly twice as broad as long, the sides slightly sinuate and the apex very broadly rounded or nearly truncate. The pygofers of the female have distinct but rounded lateral angles and a rather long, slender and acute median tooth. The last ventral segment of the female has the margins straight and the posterior margin is broadly and roundingly emarginate almost one-half the distance to the base. Each lateral piece of the ovipositor has about twelve teeth or ridges of which the median six teeth are quite distinct.

Distribution: This species has been taken in six counties in the state as shown by the following map. The localities here given would indicate its distribution at least over the eastern two-thirds of the state. The records from Riley, Russell, and Ellis counties are those of the Kansas State Agricultural College. Van Duzee records its occurrence in Florida, Ohio, Kentucky and Texas, as well as in Kansas. Davis says it is a central United States species.



Tibicen dealbata (Davis).

(Pl. xx. figs. 1-2; pl. xxiv, fig. 10; pl. xxvi, fig. 3; pl. xxvii, fig. 17.)
Cicada marginata var. *dealbata* Davis, Jl. N. Y. Ent. Soc., xxiii, p. 162, 1915.
Tibicen dealbata Van D., Cat. Hemip. N. A., p. 493, 1917.

A large green and black species, some specimens, however, being yellowish-brown and black. Specimens at hand measure from 32 to 37.5 mm., most of them averaging about 35 mm.

Color: Head yellowish-green, with a black transverse band between the eyes which is broadened medially to touch the posterior margin and the base of the front, the latter being black but with a greenish elliptical spot on its upper portion. Pronotum greenish, with two irregular median lines usually running from the anterior margin to the collar and enclosing a broad median stripe. These black lines, however, are often reduced to mere spots at the anterior margin and just cephalad of the collar. Mesonotum greenish or brownish, marked with black as follows: Between the arms of the W, a long posteriorly tapering line on each side laterad of this which attains the posterior margin and is connected to the W by a black line at about its middle, a narrower lateral stripe on each side, and a large spot cephalad of the cruciform elevation which sends a median process cephalad between the median arms of the W. In the specimens at hand the lateral margins, the portion in front of the cruciform elevation, and three short narrow stripes at the tips of the arms of the W are pruinose. The abdominal terga are black with the posterior margins of the segments and frequently the sides of the terminal segments, yellowish or brownish. Usually there is a dorsal median row of pruinose spots and the sides are strongly pruinose. The wings have the veins greenish basally and brownish apically. The cross veins between R_3 and R_{4+5} and between the latter and M_1 are usually slightly darkened. The basal areoles of the fore wings are greenish and the flaps are brownish while the flaps of the hind wings are more grayish. Beneath the body is greenish and in fresh specimens is entirely pruinose. The legs are also greenish but with a tendency to become brown apically.

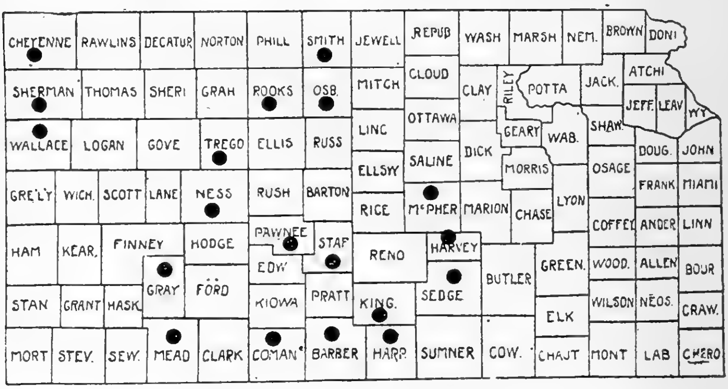
Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	32 to 37.5
Width of head	14.5 to 16.5
Expanse of fore wings	97 to 110
Greatest width of fore wing	17 to 18
Greatest width of operculum	6.5 to 7.5
Greatest length of operculum	9.5 to 10

The opercula are distinctly longer than broad if the extension beyond the coxal cavity be included. They overlap slightly for a short distance medially and the posterior margin is broadly rounded, the mesal portion distinctly longer and straighter than the outer part.

Genitalia: The supra-anal plate of the male is roundingly excavated apically and without a median tooth or with the bare suggestion of a very broad one. The uncus, viewed laterally, is regularly curved and narrowed to the obtuse apex. Viewed caudally it is distinctly triangular, the apex being quite pointed. The ventral piece has the arms deeply and rather narrowly divided to receive the apex of the uncus. The last ventral segment of the male is less than twice as wide as long and the apex is distinctly rounded. The pygofers of the female have a large but acute median spine which strongly exceeds the distinct lateral angles. The last ventral segment of the female is comparatively long, with the lateral margins distinctly sinuate and with the angular excavation of the posterior margin reaching slightly over one-third of the distance to the base. Each of the lateral pieces of the ovipositor bears three faint ridges followed by about ten teeth, the third to sixth of which are large and distinct.

Distribution: This species seems to be well distributed over the western two-thirds of the state as shown by the following map. Davis reports it from Colorado also.



Remarks: Davis originally described this species as a variety of *T. marginalis,* saying that he considered it as more of a mountainous form than the typical *marginalis.* Its recorded distribution in Kansas would seem to indicate the correctness of his view as to its ecological distribution.

Tibicen eugraphica (Davis).

(Pl. xxi, figs. 7-8; pl. xxv, fig. 2; pl. xxvi, fig. 7; pl. xxvii, fig. 2.)

Cicada eugraphica Davis, Jl. N. Y. Ent. Soc., xxiv, p. 52, pl. 5, fig. 3, 1916.
Tibicen eugraphica Van D., Cat. Hemip. N. A., p. 492, 1917.

A small black species marked with yellowish-orange. The specimens at hand measure from 18 to 24 mm., the average being about 22 mm.

Color: Head black, marked with yellowish-orange as follows: An elliptical spot on upper part of front, a spot on each side above antennæ and running along base of front, a spot on each side above the antennæ and between the latter and the eyes, and irregular spots laterad of lateral ocelli and running along posterior margin. Pronotum yellowish-orange, often with the two black median triangles entire though sometimes broken with orange, the grooves, humeral angles, and anterior margin of collar also irregularly black. Mesonotum yellowish-orange, marked with black as follows: Between the arms of the W, a pair of large spots laterad of these and extending to the posterior margin, small spots on the lateral margins, and caudad of the W a cross-shaped spot which, however, is often reduced to just the standard, on either side of which there are always two black dots. Abdominal terga usually black, sometimes dark brown, the posterior margins yellowish-brown. Fore wings with costal margins light to about the middle, beyond this, along with the rest of the veins, dark brown. Cross veins between R_3 and R_{4+5} and between the latter and M_1 are perfectly clear. The basal areoles of the fore wings are also clear, while the flaps of both wings are grayish. Beneath the insect is brownish, the opercula lighter, and in fresh specimens the whole surface is pruinose. The legs are yellowish-orange and streaked with testaceous.

Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	18 to 24
Width of head	8 to 9.25
Expanse of fore wings	62 to 69
Greatest width of fore wings	9 to 10
Greatest width of operculum	5
Greatest length of operculum	6

The opercula are distinctly wider than long excluding the extension beyond the coxal cavity. The mesal margins nearly or just touch, the lateral margins are sinuate, while the posterior margins are broadly and evenly rounded.

Gentalia: The supra-anal plate of the male has a broad rectangular notch apically in which is just the suggestion of a median tooth. Viewed laterally the lateral angles have a small but distinct anteriorly projecting tooth. The uncus, viewed laterally, appears stout, with a distinct backwardly-projecting knob at its central portion, and terminates in a stout but acutely-pointed claw which extends cephalo-ventrad. Viewed caudally it is wish-bone shaped, the arms strongly curving and rather well separated apically. The ventral piece has the arms separated by a broadly rounded incision so that they are pressed against the sides of the supra-anal plate. The last ventral segment of the male is about twice as wide as long, the lateral margins slightly sinuate, and the apex nearly truncate. The pygofers of the female have the lateral margins rounding to the acute median tooth. The last ventral segment of the female is a little over twice as wide as long, the angulate emargination of the posterior margin reaching about one-fourth of the distance to the base. The lateral pieces of the ovipositor each bear about nine rounded and quite distinct teeth cephalad of which there is an indistinct ridge.

Distribution: While there are a goodly number of specimens of this species in the Snow collection, an examination reveals that all our Kansas specimens were taken in Barber county. And this seems to be the only record for Kansas. Davis reports this species from Texas, Arizona and New Mexico. Thus it seems to be a distinctively southern form, and possibly reaches its northern limits in Kansas.

Remarks: Two of the specimens at hand are paratypes.

Tibicen vitripennis (Say).

(Pl. xxi, figs. 5-6; pl. xxv, fig. 3; pl. xxvi, fig. 6; pl. xxvii, fig. 4.)

Cicada vitripennis Say, Jl. Acad. Nat. Sci. Phila., ii, p. 236, 1830; Compl. Writ., ii, p. 372.

Cicada albipennis Woodw, Psyche, v, p. 68. 1888.

Cicada vitripennis Uhl., Trans. Md. Acad. Sci., i, p. 153, 1892.

Cicada vitripennis Macg., Can. Ent., xxxiii, p. 83, 1901.

Cicada vitripennis Snow, Kans. Univ. Sci. Bul., ii, p. 349, 1904.

Cicada erratica Osb., Ohio Nat., vi, p. 497, 1906.

Cicada erratica New., U. S. Dept. Agr., Div. Ent., Bul. 60, p. 52, 1906.

Cicada vitripennis Davis, Jl. N. Y. Ent. Soc., xxiv, p. 58, pl. 6, figs. 3-4, 1916.

Tibicen vitripennis Van D., Cat. Hemip. N. A., p. 497, 1917.

A rather small, usually greenish and black species which, however, varies to reddish-brown and black. Specimens at hand measure from 21 to 23 mm.

Color: Head black, with a broad, green band extending from the front along each side, along the antennal ledges to the eyes, and with large, green spots laterad of the lateral ocelli and extending along the posterior margin to the eyes. This leaves the black portion of the head in the form of a cross with a short and broad standard extending from the front to the posterior margin, and long and slender arms reaching to the eyes. Pronotum mostly green, with two black triangular spots on anterior portion which taper posteriorly and then widen just cephalad of the collar into triangular spots, the four enclosing an elongate median green mark. The furrows are also more or less blackened and the lateral angles bear black spots which sometimes extend in a narrow line along the anterior margin of the collar. Mesonotum green, strongly marked with black as follows: Between the arms of the W, large triangular spots laterad of these tapering to posterior margin, and just caudad of the W, a distinct cross with a short and stout standard and with the apices of the arms enlarged. The cruciform elevation is light. Abdominal terga are black, the posterior margins testaceaus, the first segment and sometimes also the second, with a distinct median testaceous line. The wings, as described by Say, are "vitreous immaculate," the cross veins being not at all darkened. The veins of the fore wing, with the exception of media, are green basally and testaceous apically. The basal areoles of the fore wings are entirely clear, while the flaps of both wings are gray. Beneath the body is entirely pruinose in fresh specimens, except for the median black stripe on the abdomen. The opercula are lighter than the rest of the under side. The legs are pale brown, with a distinct tendency to have ridged femora and greenish tibiæ.

Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	21	to	23
Width of head	9		
Expanse of fore wings	66		
Greatest width of fore wing	9	to	9.5
Greatest width of operculum	5.25	to	5.5
Greatest length of operculum	6.5	to	6.75

The opercula are broad and short, the inner margins strongly angled, with the points of the angles distinctly separated, and with the posterior margins broadly rounded.

Genitalia: Supra-anal plate of male broadly and deeply excised between the rounded but slightly toothed lateral angles. Uncus, viewed laterally, is stout basally, with a short inner tooth and an outer larger curving and acutely-pointed one. Viewed caudally it is wish-bone shaped, the arms gradually separating to the apices. They are not as widely separated or as curving as in *T. eugraphica*. The ventral piece is strongly U-shaped, the arms rather short and slender and widely separated, fitting against the sides of the supra-anal plate. The last ventral segment of the male is not quite twice as wide as long, the sides sinuately tapering to the well-rounded apex. The margins of the pygofers of the female curve evenly to the base of the well developed and acute median spine. The last ventral segment of the female has the sides roundingly narrowed to the deeply emarginate posterior margin, the emargination reaching nearly half way to the base and having its margins slightly but distinctly emarginate. Each of the lateral pieces of the ovipositor bears about eleven teeth or ridges, of which six are large enough to be very distinctly seen.

Distribution: The only counties in the state from which we have records of this species are Clark, Sumner and Barber.

These being in the extreme southern part of the state, indicate the southern distribution of this species. This is confirmed by the distribution given by Van Duzee, who records it from the following states: Florida, Louisiana, Indiana, Oklahoma, Texas, and Arizona. Davis reports it from Nebraska also.

Remarks: Davis quotes Prof. R. W. Harned as stating that this species is found only on low ground or in swampy places. In his article on Mississippi cicadas he makes *Cicada erratica* a synonym of this species.

Subfamily CICADINÆ Van D.

The members of this subfamily do not have the perfect tympanal coverings possessed by the males of the preceding subfamily, nor are these coverings entirely absent, as in the males of the following subfamily. Our species are medium sized or small forms.

The two genera of this subfamily represented in the state may be separated by the following key:

KEY TO GENERA.

A. Abdomen translucent; cross vein between A_3 and R_{4+5} strongly oblique; tympanal coverings of male large. *Cicada.*

AA. Abdomen not translucent; cross vein between R_3 and R_{4+5} perpendicular or very slightly oblique; tympanal coverings of male very small. *Proarna.*

Genus CICADA Linn.

The members of this genus that occur in the United States are rather small forms. They agree with the genus *Tibicen* in having the tympanal orifices concealed by tympanal coverings, but not perfectly, and yet much better than in the genus *Proarna.* They also have relatively much smaller heads than do the members of the genus *Tibicen.* The abdomen is very characteristic, being distinctly translucent. The opercula are quite small and are widely separated. They differ also from the genus *Proarna* by having the cross vein between R_3 and R_{4+5} strongly oblique instead of perpendicular, as in the latter.

A single member of the genus occurs in the state.

Cicada hieroglyphica Say.

(Pl. xxiii, figs. 1-2; pl. xxv, fig. 6; pl. xxvi, fig. 16; pl. xxvii, fig. 20.)

Cicada hieroglyphica Say, Jl. Acad. Nat. Sci. Phila., vi, p. 235, 1830; Compl. Writ., ii, p. 371.

Cicada characterea Germ., Thon, Ent. Archiv., ii, p. 40, 1830.

Cicada hieroglyphica Harris, Rept. Ins. Mass., p. 176, 1841.

Tettigia hieroglyphica Dist., Biol. Centr. Am., Homop., i, p. 11, pl. 3, fig. 2, 1881.

Tettigia hieroglyphica Uhl., Stand. Nat. Hist., ii, p. 227, 1884.
Tettigia hieroglyphica Macg., Can. Ent., xxxiii, p. 83, 1901.
Cicada hieroglyphica Van D., Bul. Buf. Soc. Nat. Sci., ix, p. 184, 1909.
Cicada hieroglyphica Davis. Jl. N. Y. Ent. Soc., p. 60, pl. 6, fig. 5; 1916.
Cicada hieroglyphica Van D., Cat. Hemip. N. A., p. 496, 1917.
Cicada hieroglyphica Davis, Jl. N. Y. Ent. Soc., xxvi, p. 152, 1918.

A rather small green and black species with the abdomen more yellowish-brown. Specimens at hand measure from 20 to 25 mm.

Color: Head yellowish-green, with two transverse black lines before the eyes and four black longitudinal lines, the outer ones short, running caudad from these. Just mesad and caudad of each eye there are also black spots. Pronotum greenish-yellow, marked with two black median triangular spots, enclosing between them a long light band, and uniting in two smaller triangular spots just cephalad of the collar. The grooves are also black and there are black spots on the humeral angles and small black spots are scattered here and there over the surface. Mesonotum yellowish-green, marked with black as follows: A longitudinal median line, spots between the arms of the W, a small triangular spot on each side at anterior margin laterad of these, and a large spot laterad of these small spots, and a black spot on each side of the median line just cephalad of the light cruciform elevation. The abdominal terga are yellowish-brown, the last segment and supra-anal plate being darker and the second segment has a median dorsal black line. The wings have the veins tawny to brown and all four cross veins are darkened, there also being small brown dots near the tip of each vein. The basal areoles of the fore wings are clear and the flaps of both wings are gray with a tawny tinge. Beneath the insect is a little lighter than above and fresh specimens are quite pruinose. The legs are of about the same color as the under side, striped with testaceous, and darkened apically.

Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	20	to	25
Width of head	7	to	8
Expanse of fore wings	56	to	60
Greatest width of fore wing	8	to	9
Greatest width of operculum	3.5		
Greatest length of operculum	3		

The opercula are very small, evenly curving from the antero-lateral corner to the point where the two opercula come nearest together, but even at this point they are far apart. In the male the sternites of the abdomen are distinctly keeled.

Genitalia: The supra-anal plate of the male is lightly chitinized dorsally at the apex and bears a small median process. The uncus, viewed laterally, is large, tapering ventrally, and ending in an obtuse apex which bears a small point extending cephalad. In the upper portion of its lateral aspect is a triangular membranous part which seems quite characteristic. Viewed caudally the uncus is narrow at the top, widest just below the middle, and its lower margin has a small median emargination. The last ventral segment of the male is nearly as long as broad, the margins are slightly sinuate and the apex is broadly rounded. The pygofers of the female bear a long median spine and the margins are distinctly and obtusely angulate. The last ventral segment of the female is of about equal length throughout, the posterior margin bearing two small lobes on either side of a small median triangular excavation. The lateral pieces of the ovipositor bear rather weak teeth of which only two or three on each side are prominent, the remaining four or five being very indistinct. Cephalad of the teeth is a very weak ridge on each side.

Distribution: The only record of the capture of this species in Kansas comes from Chautauqua county. Van Duzee records it from the following states: New Jersey, Pennsylvania, North Carolina, Georgia, Florida, Mississippi, Louisiana and Texas. Thus it would seem that Kansas forms the northwestern limit of this species.

Remarks: The males of this species seem to be much more common than the females. Mr. Davis kindly loaned me one of the latter and states that they are comparatively uncommon. He says they occur most commonly in the pine barrens, "where in June and July their songs constitute an almost continuous performance."

Genus PROARNA Stal.

The members of this genus are very small cicadas. The tympanal coverings are very imperfect, leaving most of the tympanal orifice exposed. The abdomen is not translucent and the cross vein of the fore wings between R_3 and R_{4+5} is very characteristically perpendicular instead of oblique. The opercula are small and do not approach each other very closely.

A single member of the genus occurs in Kansas.

Proarna venosa (Uhl.).

(Pl. xxiii, figs. 5-6; pl. xxv, fig. 8; pl. xxvi, fig. 20; pl. xxvii, fig. 8.)

Prunasis venosa Uhl., Ent. Am., iv, p. 82, 1888.
Prunasis venosa Macg., Can. Ent., xxxiii, p. 77, 1901.
Prunasis venosa Dist., Cat. Homop., Cicadidæ, p. 152, 1906.
Proarna venosa Dist., Ann. Mag. Nat. Hist., ser. 8, viii, p. 134, 1911.
Proarna venosa Dist., Genera Ins., fasc. 158, p. 16, 1914.
Proarna venosa Van D., Cat. Hemip. N. A., p. 497, 1917.

A very small pale green to straw-colored species. Specimens at hand measure from 11 to 13 mm.

Color: Head greenish or straw-colored, with a more or less continuous brownish transverse band between the eyes and extending backward medially to enclose the ocelli. The antennal ledges also are usually somewhat brown. Pronotum yellowish-green, immaculate, or with the humeral angles darkened, and sometimes the grooves slightly darkened also. Sometimes there is a suggestion of the two dark median triangles on the anterior margin. Mesonotum yellowish-green, marked with brown as follows: Between the arms of the W, a large posteriorly tapering spot on either side laterad of this, the tips of the anterior arms of the light cruciform elevation, and two faint dots just cephalad of these. Abdominal terga straw-colored, with the bases of the segments, especially laterally, more or less marked with fuscous. The wings have the veins straw-colored or greenish basally, becoming brownish apically. The cross veins between R_3 and R_{4+5}, between R_{4+5} and M_1, and between M_1 and M_2 are sometimes slightly, but usually distinctly darkened, and there is a tendency for all the veins to be slightly smoky apically. The basal areoles of the fore wings are clear and the flaps of both wings are milky-white to straw-colored. Beneath, the insect is straw-colored or yellowish-green, with the opercula lighter. The legs are straw-colored with the femora distinctly banded with fuscous.

Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	11	to	13
Width of head	3.75	to	4
Expanse of fore wings	29	to	32
Greatest width of fore wing	4	to	5
Greatest width of operculum	2	to	2.5
Greatest length of operculum	2.5	to	3

The opercula are distinctly wider than long excluding the extension beyond the coxal cavity. They are widely separated medially and are broadly rounded from the cephalo-lateral angle to the angulate meso-caudal angle which slightly overlaps the metasternum.

Genitalia: Supra-anal plate of male with a very wide emargination posteriorly. Viewed laterally there is a very strong and acute dorsal point. The uncus, viewed laterally, enlarges apically and is bifid. Viewed caudally it is narrowest basally, widest just below the middle, and ends in four rounded lobes. The ventral piece consists of two very widely separated arms which lie against the supra-anal plate. The last ventral segment of the male is about twice as broad as long and the truncate posterior margin is very slightly emarginate medially. The pygofers of the female have a small median tooth which does not exceed the sinuated posterior margins. The last ventral segment of the female is about three times as wide as long, the posterior margin being broadly emarginated about one-third of the distance to the base, the sides of the emargination themselves being slightly notched. The lateral pieces of the ovipositor each bear two or three indistinct ridges which are followed by four prominent teeth and these by three smaller and indistinct ones.

Distribution: The only counties from which this species seems to have been taken are Sumner and Barber. Van Duzee records it from Texas and New Mexico. Accordingly Kansas seems to be the northern limit of its range.

Subfamily TIBICININÆ (Dist.).

The members of this subfamily differ from those of the preceding in that the males do not have any tympanal coverings at all. In the main they are small to medium sized forms.

There are four genera of the *Tibicininæ* represented in our Kansas fauna. These may be separated by the following key:

KEY TO GENERA

A. Cells of median area of fore wings distinctly longer than marginal cells.
- B. Head about as broad as base of mesonotum. Opercula nearly touching medially. *Tibicina.*
- BB. Head distinctly narrower than base of mesonotum. Opercula widely separated.
  - C. Median transverse suture of elytra not very evident. *Okanagana.*
  - CC. Median transverse suture of elytra very evident. *Tibicinoides.*

AA. Cells of median area of fore wings not distinctly longer than marginal cells. *Melampsalta*

Genus TIBICINA Kol.

The tympanal coverings are entirely absent in this genus, in this respect agreeing with the following three genera. It differs from them, however, in having a relatively broader head which is as broad as the base of the mesonotum. Added to this is the characteristic of the opercula which nearly touch medially. As in the two following genera the cells of the median area of the fore wings are distinctly longer than the marginal cells.

The single member of the genus and its variety occur in the state. Only the 17-year race has been definitely recorded from within our borders though the 13-year race comes so close in Missouri that it would be surprising if it did not extend westward over into the state.

Tibicina septendecim (Linn.).

(Pl. xxiii, figs. 9-10; pl. xxv, fig. 5; pl. xxvi, fig. 14; pl. xxvii, fig. 19.)

Cicada septendecim Linn., Syst. Nat., edn. 10, i, p. 436, 1758; edn. 12, ii, p. 708, 1767.
Tettigonia septendecim Fabr., Syst. Ent., p. 679, 1775.
Tettigonia costalis Fabr., Ent. Syst., Suppl., p. 516, 1798.
Cicada septendecim Germ., Thon, Ent. Archiv., ii, p. 4, 1830.
Cicada septendecim Harris, Rept. Ins. Mass., p. 167, 1841.
Cicada septendecim Harris, Treat. Ins. Inj. Veg., edn. 2, p. 180, 1852.
Cicada septendecim Jag., Life of N. Am. Ins., p. 64, 1859.
Tibicen septendecim Stal, Ann. Soc. Ent. Fr., ser. 4, i, p. 618, 1861.
Cicada septendecim Harris, Treat. Ins. Inj. Veg., edn. 3, p. 206, 1862.
Cicada septendecim Ril., 1st Mo. Rept., p. 18, 1868.

Tibicen costalis Stal, Hemip. Fabr., ii, p. 116, 1869.
Tibicen septendecim Stal, Hemip. Fabr., ii, p. 116, 1869.
Cicada septendecim Uhl., Stand. Nat. Hist., ii, p. 227, 1884.
Cicada septendecim Lintn., 2nd Rept. N. Y. St. Ent., p. 167, 1885.
Cicada septendecim Ril., Rept. U. S. Dept. Agr. for 1885, p. 233.
Tibicen septendecim Uhl., Trans. Md. Acad. Sci., i, p. 160, 1892.
Cicada septendecim Marl., U. S. Dept. Agr., Div. Ent., Bul. n. s. 14, 1898.
Tibicen septendecim Felt, N. Y. St. Mus. Memoir, 8, i, p. 231, pl. 46, fig. 2, 1905.
Tibicina septendecim Dist., Cat. Homop., Cicadidæ, p. 125, 1906.
Cicada septendecim Marl., U. S. Dept. Agr., Div. Ent., Bul. 71, 1907.
Tibicina septendecim Van D., Cat. Hemip. N. A., p. 500, 1917.
Tibicina septendecim Davis, Jl. N. Y. Ent. Soc., xxvi, p. 152, 1918.

A medium sized black and orange species. Specimens at hand measure from 28 to 30 mm.

Color: Head entirely black except sometimes for a small orange median triangle at the posterior margin. The eyes are either black or orange in the dead specimens. Pronotum black except laterally, the inflexed portions being of an orange tinge. Sometimes the collar is faintly tinged with the same color. Mesonotum black except for narrow lateral orange stripes. Abdominal terga black, the conjunctivæ often appearing orange as does the posterior portion of the last segment in the male. The wings have the costal margin and the veins distinctly orange basally, but apically they become brown. The whole wing, especially basally and apically is more or less smoky. The W at the cross veins is quite prominent. The basal areoles of the fore wings are a very dark brown. The flaps are grayish, tinged with orange. Beneath, the insect is mostly black but with at least the posterior margins of the abdominal segments nearly orange and with the light color extending up the sides. Often the abdominal sternites are entirely brown. The legs are an orange-brown, striped with testaceous, the tarsi darker.

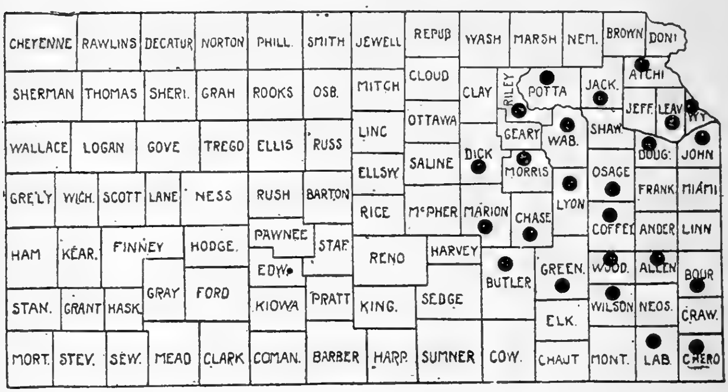
Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	28	to	30
Width of head	8.75	to	9.25
Expanse of fore wings	80	to	88
Greatest width of fore wings	12.5	to	13.5
Greatest width of operculum	3		
Greatest length of operculum	4.5		

The opercula are quite narrow, having the outer and posterior margins forming a semicircle, and their postero-mesal margins well separated.

Genitalia: The supra-anal plate of the male has a very large median projection. Viewed caudally its margins are inflexed below this median tooth, and each bears near its middle two curving, mesally projecting, finger-like processes and near the base a larger and more strongly haired one. The uncus, viewed laterally, has the form of a triangle with its apex bent strongly cephalad. Viewed caudally it has the form of two sclerites extending downward from the anal tube, encircling the penis, and widening below it into two triangular processes which taper to acute apices. The penis is usually strongly protruded from between the two parts of the uncus and possesses terminally two very characteristic little sclerites which meet dorsally and are wide apart ventrally and whose rounded margins are strongly serrate. The last ventral segment of the male is about twice as wide as long, the lateral margins sinuate to the rounded posterior margin. The pygofers of the female have the margins evenly rounding to the prominent median spine. The last ventral segment of the female has a very large incision posteriorly which reaches over one-half the distance to the base. The ovipositor is provided with about thirteen quite even and similar teeth on each side.

Distribution: According to Marlatt, only Broods I and IV are known to occur in Kansas. The former brood is recorded by him (Bul. 71, U. S. Dept. Agr., Div. Ent., 1907) from Leavenworth and Dickinson counties. Brood IV is our big brood and is recorded from the counties marked on the following map. In addition to Marlatt's record, specimens have been taken from Atchison, Butler and Riley counties and these, with the records of Brood I, are included in the map. None of these broods go further west than Kansas, and it is very likely that other broods of the 17-year race and some broods of the 13-year race occur in the state, but there seem to be no records of them.



Remarks: Marlatt gives the three different notes characteristic of the song of this species as follows:

1. At the height of the season, when many males are singing together, the most characteristic note is represented by the letters tsh-e-e-E-E-E-E-e-ou. Thus it was described by Fitch.

2. Early in the season when few males have emerged the Pha-r-r-r-aoh note is heard.

3. The clicking note "consisting of from 15 to 30 short, quick sounds, sometimes double, the whole lasting about five seconds."

Tibicina septendecim var. *cassinii* (Fish.).

Cicada cassinii Fish., Proc. Acad. Nat. Sci. Phila., v, p. 272, 1851.
Cicada septendecim var. *cassinii* Ril., 1st Mo. Rept., p. 21, 1868.
Cicada septendecim var. *cassinii* Van D., Cat. Hemip. N. A., p. 501, 1917.

This variety occurs along with typical *septendecim*. It differs from the latter in being distinctly smaller and in usually having the under side of the abdomen entirely black. Riley states that the genital hooks of the male (uncus) vary considerably in this variety whereas they are constant in typical *septendecim*. At any rate they are often just like those of the latter.

Genus OKANAGANA Dist.

This is a very large genus the members of which are most abundant in the western states. As in *Tibicina* the cells of the median area of the fore wings are distinctly longer than the marginal cells. The head is clearly narrower than the base of the mesonotum. The opercula are widely separated. The transverse suture of the fore wings is not as distinct as in the following genus.

Only two species belonging to this genus are known to occur in Kansas. They may be separated by the following key:

KEY TO SPECIES.

A. Species smaller, less than 20 mm.; black and honey-yellow in color. *synodica*.

AA. Species larger, over 20 mm.; black marked with reddish or orange. *bella*.

Okanagana synodica (Say).

(Pl. xxii, figs. 5-6; pl. xxv, fig. 11; pl. xxvi, fig. 19; pl. xxvii. fig. 15.)

Cicada synodica Say, Jl. Acad. Nat. Sci. Phila., iv, p. 334, 1825; Compl. Writ., ii, p. 253.
Cicada synodica Uhl., Bul. U. S. Geol. Geog. Surv., i, p. 341, 1876; iii, p. 455, 1877.
Tibicen synodica Woodw., Psyche, v, p. 68, 1888.
Tibicen synodica Macg., Can. Ent., xxxiii, p. 78, 1901.
Okanagana synodica Dist., Cat. Homop., Cicadidæ, p. 126, 1906.
Okanagana synodica Van D., Jl. N. Y. Ent. Soc., xxiii. pp. 27, 40, 1915.
Okanagana synodica Van D., Cat. Hemip. N. A., p. 503, 1917.

A small black and honey-yellow species. Specimens at hand measure from 15 to 18.5 mm.

Color: Head mostly black, with a transverse line across antennal ledges and base of front, three triangular spots on posterior margin and median line on front, honey-yellow. Pronotum with entire margin honey-yellow except for black spots on humeral angles. On either side of the pale median line are two large usually quadrate black spots, the grooves on either side of these are broadly black and parallel to the lateral margins, and extending on parallel to the adjacent portions of the posterior margins, are right-angled black marks on either side. The mesonotum is honey-yellow marked with black as follows: Between the arms of the W, a line extending back from these to the pale cruciform elevation with a dot on either side, and laterally two large triangular posteriorly tapering spots which reach the posterior margin. Abdominal terga black with the posterior margins honey-yellow, the terminal segments almost wholly light. The wings have the veins almost entirely honey-yellow but slightly darkening apically, and usually distinctly infuscated. The basal areoles of the fore wings are opaque and dark brown or brownish-yellow. The flaps are grayish tinged with yellowish or orange. Beneath the insect is almost wholly honey-yellow. The legs are of the same color but strongly marked with dark brown, the tarsi being dark.

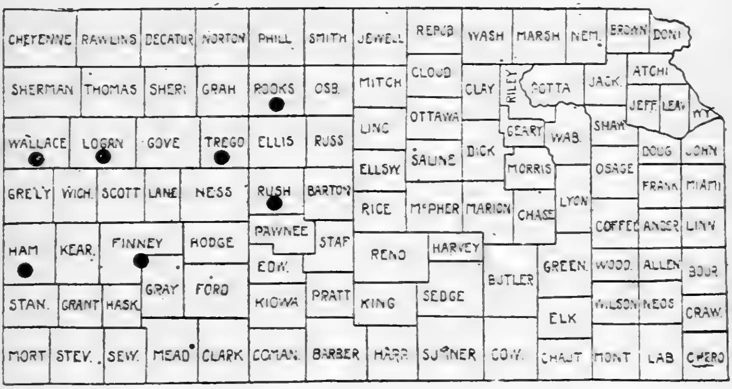
Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	15	to	18.5
Width of head	4.5	to	5.25
Expanse of fore wings..............	38	to	44
Greatest width of fore wing..........	5.75	to	6
Greatest width of operculum..........	1.25	to	2
Greatest length of operculum..........	2.5	to	2.75

The opercula are very small and narrow, strongly curved on both sides and ending in an obtusely pointed apex which points mesad and ends in about a line with the exterior margin of the coxa.

Genitalia: The supra-anal plate of the male is slightly but broadly emarginate on the posterior margin. The uncus, viewed laterally, is narrow basally, then widens to widest point and then tapers to rather obtuse apex. Viewed caudally it is broadly elliptical and slightly emarginate ventrally. The ventral piece has very stout arms which are deeply divided and whose apices suddenly narrow and turn slightly mesad. The last ventral segment of the male is distinctly less than twice as wide as long, the lateral margins are distinctly sinuate and the apex is truncate. The pygofers of the female have the posterior margins distinctly sinuate to the very small but distinct median tooth. The last ventral segment of the female has the lateral margins slightly sinuate and the posterior margin is broadly and deeply emarginate nearly three-fourths of the distance to the base. The ovipositor is stout and the lateral pieces are each supplied with about thirteen very regular ridges and teeth.

Distribution: This species occurs in the western part of the state as shown by the following map. The records from Wallace, Logan and Rooks counties are those of the Kansas State Agricultural College. Van Duzee records it from Colorado and New Mexico. Accordingly Kansas would seem to be the eastern limit of its range.



Okanagana bella Davis.

(Pl. xxii, figs. 3-4; pl. xxv, fig. 10; pl. xxvi, fig. 17; pl. xxvii, fig. 21.)

Okanagana bella Davis, Jl. N. Y. Ent. Soc., xxvii, p. 198, pl. 20, fig. 1, 1919.

A medium-sized black species, marked with reddish or orange. Specimens at hand measure from 21.5 to 22 mm.

Color: Head black, with antennal ledges, dash back of median ocellus, sometimes two spots at base of front and median line on upper portion of front, reddish-orange. Pronotum black, sometimes margined all around with orange, but always along the posterior margin. Mesonotum black, anterior arms of dark cruciform elevation spotted with orange and in front of them are two orange spots. The metanotum is black, the posterior margin being orange. Abdominal terga black, posterior margins narrowly orange dorsally, the orange band wider laterally. The wings have the costal margin orange to the end of the radial cell, the remainder of the veins being brown. The basal areole of the fore wing is dark brown, the flaps of both wings and parts of the bases of each wing being strongly orange. Beneath the insect is orange and black, the abdominal sternites with the posterior margins orange, the orange replacing the black more and more on the posterior segments. The legs are orange but strongly marked and striped with black.

Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	21.5	to 22
Width of head	7	to 7.25
Expanse of fore wings	60	to 65
Greatest width of fore wing	10	to 11
Greatest width of operculum	3	
Greatest length of operculum	4	
Length of valve	5	

The opercula are very small, widest basally, then suddenly narrowed due to a sudden incurving of the lateral margin. Then they slightly widen again before the lateral margin meets the mesal margin in an obtuse point which points mesad. The valve is quite elongate and acutely pointed apically.

Genitalia: The supra-anal plate of the male is very slightly emarginate apically. The uncus, viewed laterally, is narrow basally, then widened, the margins subparallel till near the very slightly hooked apex. Viewed caudally it is emarginate apically and the emargination appears slightly notched on each side. The ventral piece has the arms very widely separated and each is slightly notched apically. The last ventral segment of the male is nearly as long as wide, the lateral margins distinctly sinuate and the posterior margin truncate. The pygofers of the female have the posterior margins slightly sinuate on either side of the stout median terminal projection. The last ventral segment of the female has the lateral margins strongly narrowed and the posterior margin is angularly emarginate fully one-half the distance to the base. The ovipositor is stout, the lateral pieces each bearing about a dozen broad teeth.

Distribution: The only record of the occurrence of this species in Kansas is that given by Davis who states that there is a pair of specimens of this species from this state in the collection of the Academy of Natural Sciences, Philadelphia. Presumably it occurs in the western part of the state. The specimens examined are from Colorado, Arizona, Utah and Oregon. In addition Davis names the following states where this species is known to occur: New Mexico, Wyoming, Montana, Idaho, California and Washington, and it also occurs in Alberta and British Columbia.

Remarks: As Davis mentions, members of this species have in the past been confused with *Okanagana rimosa* (Say).

Genus TIBICINOIDES Dist.

The members of this genus are very like those belonging to the genus *Okanagana*. The chief difference lies in the very evident median transverse suture of the fore wings which is much less distinct in the members of the latter genus.

A single member of the genus occurs in Kansas.

Tibicinoides hesperius (Uhl.).

(Pl. xxiii, figs. 3-4; pl. xxv, fig. 9; pl. xxvi, fig. 18; pl. xxvii, fig. 14.)

Cicada hesperia Uhl., Bul. U. S. Geol. Geog. Surv., i, p. 342, 1876.
Tibicen hesperia Uhl., Trans. Md. Acad. Sci., i, p. 161, 1892.
Tibicina? hesperia Dist., Cat. Homop., Cicadidæ, p. 125, 1906.
Tibicinoides hesperius Van D., Jl. N. Y. Ent. Soc., xxiii, pp. 27, 43, 1915.
Tibicinoides hesperius Van D., Cat. Hemip. N. A., p. 504, 1917.
Okanagana hesperia Davis, Jl. N. Y. Ent. Soc., xxvii, p. 218, 1919.

A rather small honey-yellow and black species with the wings clouded basally and strongly marked with reddish or orange. The specimens at hand measure from 19 to 21 mm.

Color: Head black, marked with yellowish as follows: The antennal ledges, a large median elliptical spot on upper portion of front, often three spots at base of front, and a median line caudad of median ocellus. Pronotum black, bordered entirely with a narrow yellow collar, with yellowish markings in grooves and on lateral parts. Mesonotum black, marked with yellowish as follows: Tips of outer arms of W and its bases, the extreme lateral margins, and cephalad of the black-spotted anterior arms of the light cruciform elevation. The metanotum is mostly yellowish. Abdominal terga mostly yellowish, the first two segments darker and with median and lateral darker lines on all the segments. Sometimes the abdomen is entirely black with only the posterior margins yellowish. The wings have the costal margin yellowish up to the tip of the radial cell, otherwise the veins are brownish to black. Usually the veins are heavily infuscated up to the marginal cells, giving the basal portion a brownish color. The basal areoles of the fore wings are heavily clouded with brown. The flaps of both wings are reddish or orange as are other parts of the base of the hind wings. Beneath, the insect is honey-yellow, strongly marked with black, the abdomen being lighter than the other parts. The legs are so heavily marked with black as to appear nearly entirely dark.

Form: The following are the measurements in millimeters of the specimens at hand:

Length of body	19	to	21
Width of head	6.5	to	7.5
Expanse of fore wings	51	to	53
Greatest width of fore wing	7.5	to	9
Greatest width of operculum	3		
Greatest length of operculum	2.5		

The opercula are broader than long, widest at the base, then suddenly narrowed by the excavation of the lateral margin, the obtuse apex pointing mesad. The nodal furrow of the fore wings is very marked, forming a distinct transverse V with its arms widely separated.

Genitalia: The supra-anal plate of the male is very slightly but distinctly emarginate posteriorly. The uncus, viewed laterally, is widest near the base, the apex having a distinct downward hook due to a ventral preapical rounded incision. Viewed caudally it narrows apically and shows the lower margin to be distinctly emarginate. The ventral piece has its arms separated by a wide rounded incision and their apices are turned distinctly mesad. The last ventral segment of the male is considerably less than twice as wide as long, the lateral margins are strongly sinuate, and the broad truncate apex is broadly and clearly incised. The pygofers of the female have the margins regularly curving to the small but stout median tooth. The last ventral segment of the female is quite characteristic, the lateral margins being sinuate while the posterior margin is deeply and angularly excavated over one-half the distance to the base, the margins of the excavation being distinctly notched. The ovipositor is short and stout, the teeth on the lateral pieces being quite rounded and even, about a dozen on each side.

Distribution: This species has been taken in the three western counties of Trego, Ellis and Russell. The latter two records are those of the Kansas State Agricultural College. Van Duzee records it from Colorado, Nevada, and California. Davis mentions New Mexico, Arizona and Montana as states where it occurs. It is very evidently a western species which reaches its eastern limits in Kansas.

Remarks: There seems to be some doubt as to the proper generic disposition of this species. Davis places it in the genus *Okanagana* because the relative size of the marginal cells and those of the median area of the fore wing is about the same as in the members of that genus. On the other hand the coloring of the fore wings is that of the genus *Tibicinoides* as is also the very conspicuous nodal furrow.

Genus MELAMPSALTA Kol.

These are very small cicadas. The tympanal coverings are lacking, and the venation of the fore wings is very characteristic in that the marginal cells are of about the same size or even longer than the cells of the median area.

The single member of the genus occurs in Kansas.

Melampsalta calliope (Walk.).

(Pl. xxiii, figs. 7-8; pl. xxv, fig. 7; pl. xxvi, fig. 21; pl. xxvii, fig. 6.)

Cicada calliope Walk., List Homop., i, p. 212, 1850.
Cicada parvula Say, Jl. Acad. Nat. Sci. Phila., iv, p. 233, 1825; Compl. Writ., ii, p. 253.
Cicada pallescens Germ., Thon, Ent. Archiv., ii, p. 8, 1830.
Carineta parvula Uhl., Ent. Am., iv, p. 22, 1888.
Cicada parvula Uhl., Trans. Md. Acad. Sci., i, p. 165, 1892.
Cicada parvula Macg., Can. Ent., xxxiii, p. 76, 1901.
Cicada calliope Kirk., Can. Ent., xli, p. 390, 1909.
Melampsalta parvula Van D., Bul. Buf. Soc. Nat. Sci., ix, p. 184, 1909.
Melampsalta calliope Van D., Cat. Hemip. N. A., p. 506, 1917.
Melampsalta calliope Davis, Jl. N. Y. Ent. Soc., xxvi, p. 154, 1918.

A very small yellowish-brown to greenish species. Specimens at hand measure from 12.25 to 15.5 mm.

Color: Head in brown forms either practically unmarked or with an irregular broad transverse black band with a distinct dash projecting cephalad on each side of the base of the front which itself is basally dark except for the light median portion. Pronotum of brown forms either unmarked or the grooves irregularly marked with black. The mesonotum of the brown forms has two short median and two large lateral black lines. The abdominal terga of the brown forms may be unmarked or darkened basally and laterally. The wings of the brown forms have brownish veins, the basal areoles of the fore wings are clear and the flaps of both wings are grayish with a brownish tinge. Beneath, the body is nearly uniformly brown, the legs being marked with darker lines. The green forms at hand are uniformly green except for a transverse black band on the head cephalad of the eyes, black spots below the antennæ, and the rostrum and tips of tarsi blackish.

Form: The following are the measurements in millimeters of the specimens at hand:

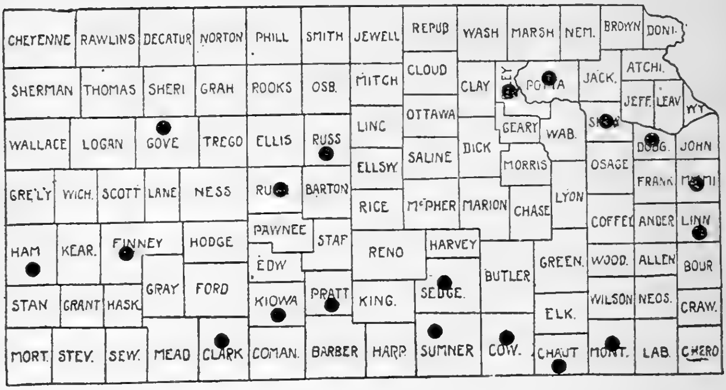
Length of body	12.25 to 15.5
Width of head	3.5 to 4.5
Expanse of fore wings	33 to 40
Greatest width of fore wing	5.5 to 7
Greatest width of operculum	3
Greatest length of operculum	3.25

The cells of the median area of the forewing are of about the same size or shorter than the marginal cells. This is most constant in regard to the relative length of cells 1st R_5 and 2nd R_5.

The opercula are quite small, about as broad as long, widely separated medially, and broadly rounding laterally and posteriorly.

Genitalia: The supra-anal plate of the male when viewed laterally is seen to be strongly pointed dorsally and to have a distinct caudally-projecting dorsal lobe on the posterior margin, just below which is a smaller rounded lobe. The uncus, viewed laterally, appears like a short, acute, curved process. Viewed caudally it consists of two diverging processes which taper to subacute apices. The last ventral segment of the male is triangular, about one-third wider than long, the lateral margins sinuately tapering to the obtuse apex. The pygofers of the female have the margins sinuate to the base of the large median spine. The last ventral segment of the female is very short and the posterior margin is broadly and triangularly emarginate nearly to the base. The ovipositor is equipped with about ten distinct and well rounded teeth on each side.

Distribution: This is a quite common species in the state. The records show it to be well distributed over Kansas as shown by the following map. The records from Riley and Russell counties are those of the Kansas State Agricultural College. Van Duzee records it from the following other states: New Jersey, North Carolina, Georgia, Florida, Tennessee, Louisiana, Arkansas, Illinois, Nebraska, Iowa, Colorado and Texas. Davis reports it from Mississippi also.



Explanation of Plates.

PLATE XVIII.

MALE GENITALIA—

1. Lateral view of *Tibicen linnei.*
2. Caudal view of *Tibicen linnei.*
3. Lateral view of *Tibicen pruinosa.*
4. Caudal view of *Tibicen pruinosa.*
5. Lateral view of *Tibicen lyricen.*
6. Caudal view of *Tibicen lyricen.*

PLATE XVIII.

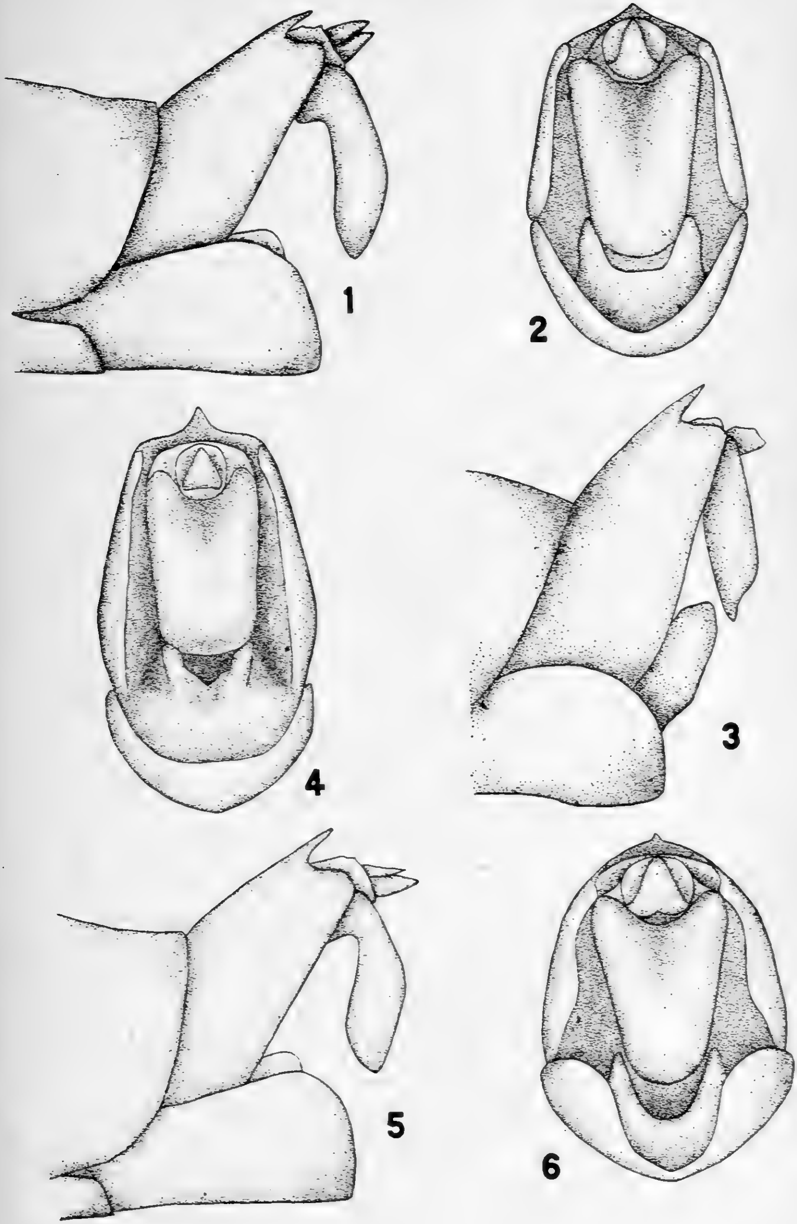


PLATE XIX.

MALE GENITALIA—

1. Lateral view of *Tibicen marginalis.*
2. Caudal view of *Tibicen marginalis.*
3. Caudal view of *Tibicen resonans.*
4. Lateral view of *Tibicen resonans.*
5. Caudal view of *Tibicen auletes.*
6. Lateral view of *Tibicen auletes.*

PLATE XIX.

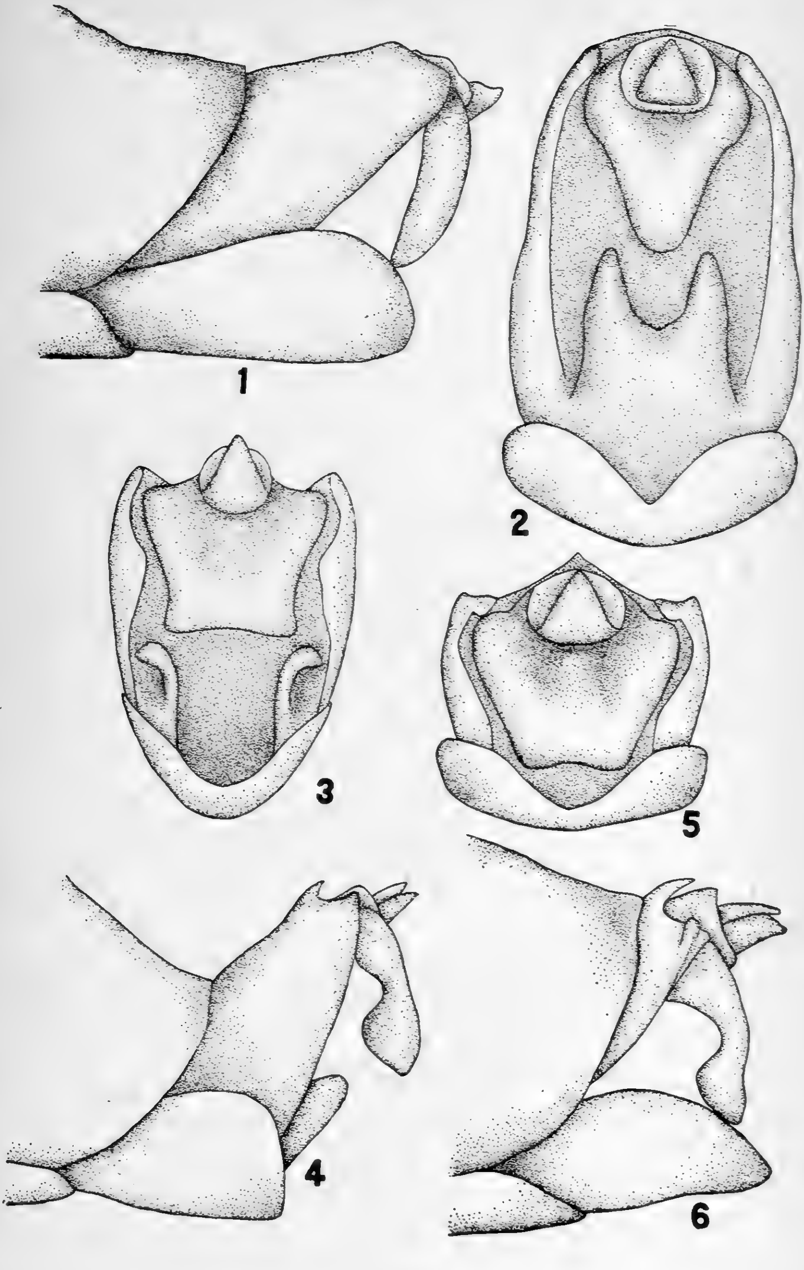


PLATE XX.

MALE GENITALIA—

1. Caudal view of *Tibicen dealbata.*
2. Lateral view of *Tibicen dealbata.*
3. Caudal view of *Tibicen resh.*
4. Lateral view of *Tibicen resh.*
5. Caudal view of *Tibicen dorsata.*
6. Lateral view of *Tibicen dorsata.*

PLATE XX.

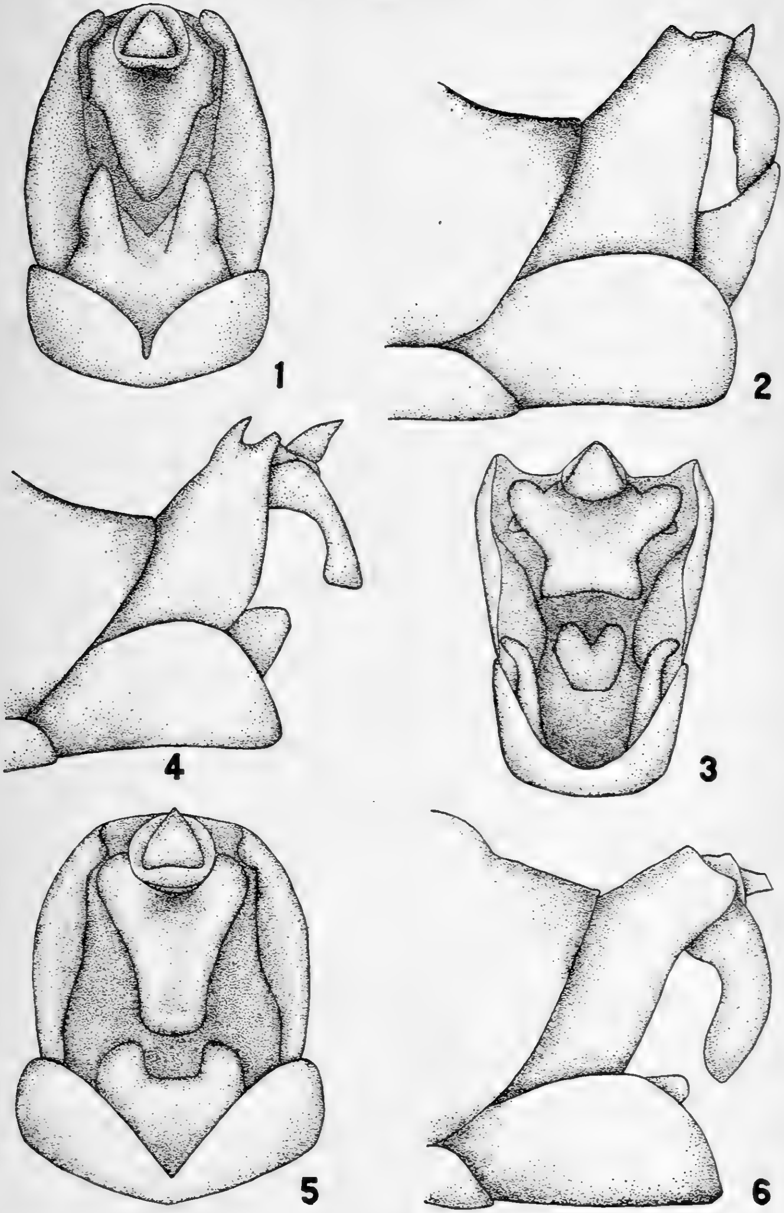


PLATE XXI.

MALE GENITALIA—

1. Lateral view of *Tibicen bifidus.*
2. Caudal view of *Tibicen bifidus.*
3. Lateral view of *Tibicen superba.*
4. Caudal view of *Tibicen superba.*
5. Caudal view of *Tibicen vitripennis.*
6. Lateral view of *Tibicen vitripennis.*
7. Caudal view of *Tibicen eugraphica.*
8. Lateral view of *Tibicen eugraphica.*

PLATE XXI

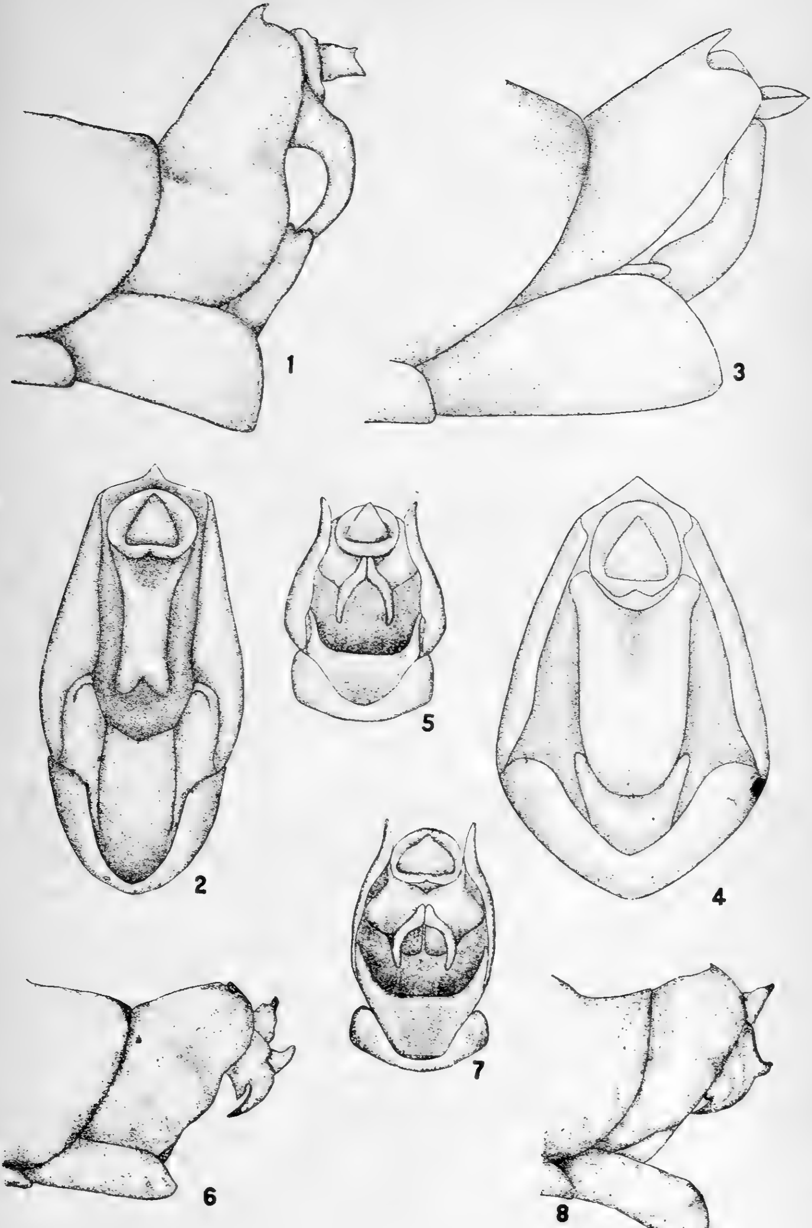


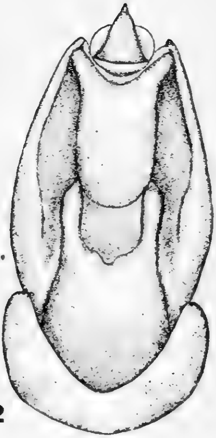
PLATE XXII.

Male Genitalia—

1. Lateral view of *Tibicen aurifera.*
2. Caudal view of *Tibicen aurifera.*
3. Caudal view of *Okanagana bella.*
4. Lateral view of *Okanagana bella.*
5. Lateral view of *Okanagana synodica.*
6. Caudal view of *Okanagana synodica*

PLATE XXII.

1



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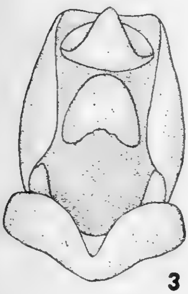

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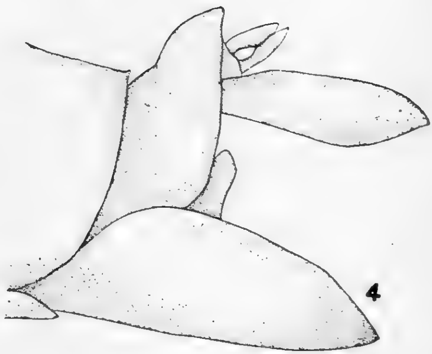

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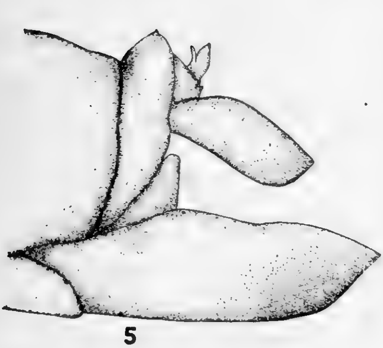

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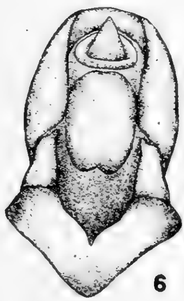


6

PLATE XXIII.

MALE GENITALIA—

1. Lateral view of *Cicada hieroglyphica.*
2. Caudal view of *Cicada hieroglyphica.*
3. Lateral view of *Tibicinoides hesperius.*
4. Caudal view of *Tibicinoides hesperius.*
5. Caudal view of *Proarna venosa.*
6. Lateral view of *Proarna venosa.*
7. Caudal view of *Melampsalta calliope.*
8. Lateral view of *Melampsalta calliope.*
9. Caudal view of *Tibicina septendecim* var. *cassinii.*
10. Lateral view of *Tibicina septendecim* var. *cassinii.*

PLATE XXIII.

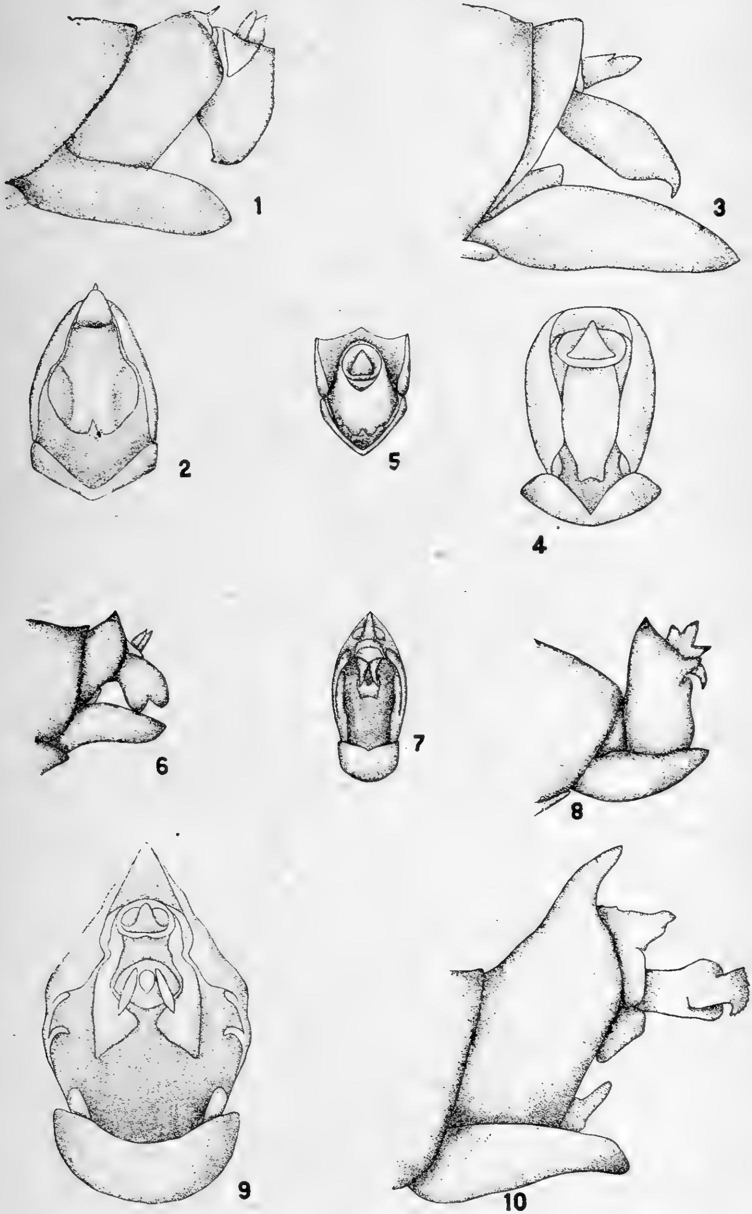


PLATE XXIV.

OVIPOSITORS—

1. *Tibicen lyricen.*
2. *Tibicen linnei.*
3. *Tibicen pruinosa.*
4. *Tibicen superba.*
5. *Tibicen aurifera.*
6. *Tibicen resonans.*
7. *Tibicen resh.*
8. *Tibicen dorsata.*
9. *Tibicen marginalis.*
10. *Tibicen dealbata.*

PLATE XXIV

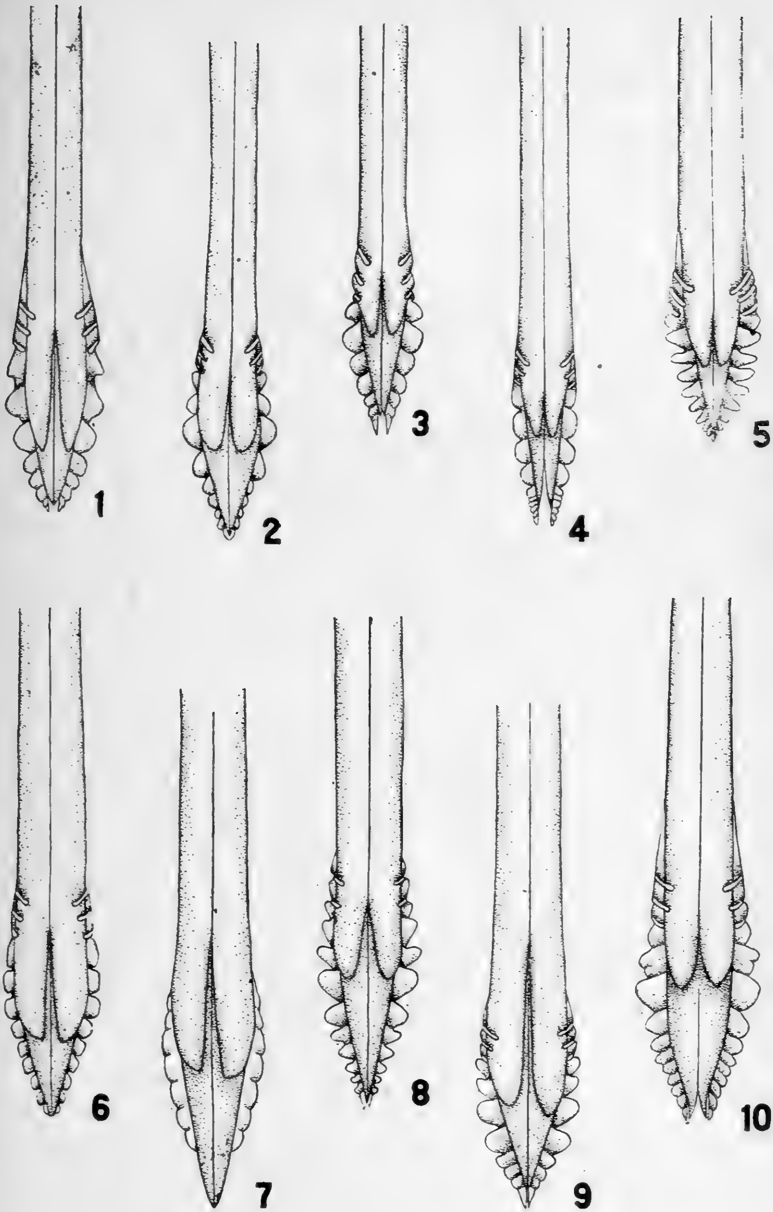


PLATE XXV.

Ovipositors—

1. *Tibicen auletes*
2. *Tibicen eugraphica.*
3. *Tibicen vitripennis.*
4. *Tibicen bifidus.*
5. *Tibicina septendecim.*
6. *Cicada hieroglyphica.*
7. *Melampsalta calliope.*
8. *Proarna venosa.*
9. *Tibicinoides hesperius.*
10. *Okanagana bella.*
11. *Okanagana synodica.*

PLATE XXV.

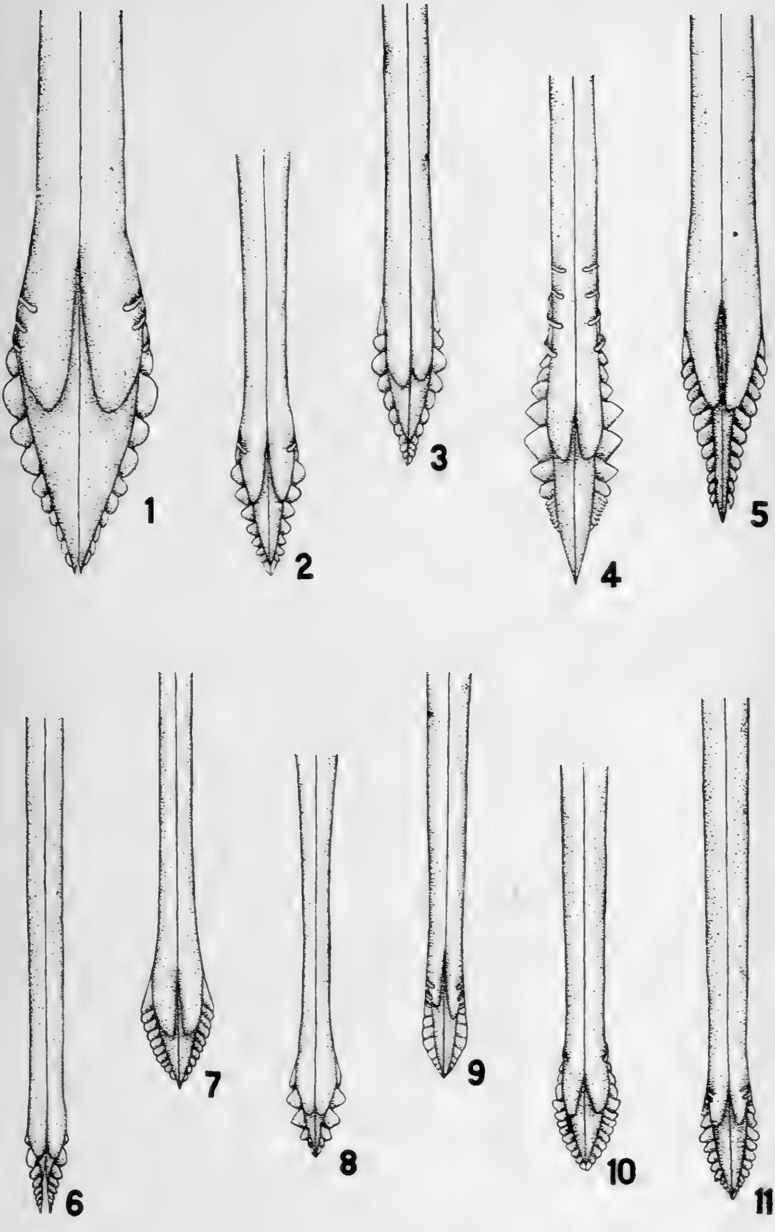


PLATE XXVI.

Last Ventral Segment of the Male—

1. *Tibicen auletes.*
2. *Tibicen resh.*
3. *Tibicen dealbata.*
4. *Tibicen dorsata.*
5. *Tibicen marginalis*
6. *Tibicen vitripennis*
7. *Tibicen eugraphica.*
8. *Tibicen lyricen.*
9. *Tibicen bifidus.*
10. *Tibicen pruinosa.*
11. *Tibicen linnei.*
12. *Tibicen superba*
13. *Tibicen resonans.*
14. *Tibicina septendecim.*
15. *Tibicen aurifera.*
16. *Cicada hieroglyphica.*
17. *Okanagana bella.*
18. *Tibicinoides hesperius.*
19. *Okanagana synodica*
20. *Proarna venosa.*
21. *Melampsalta calliope.*

PLATE XXVI.

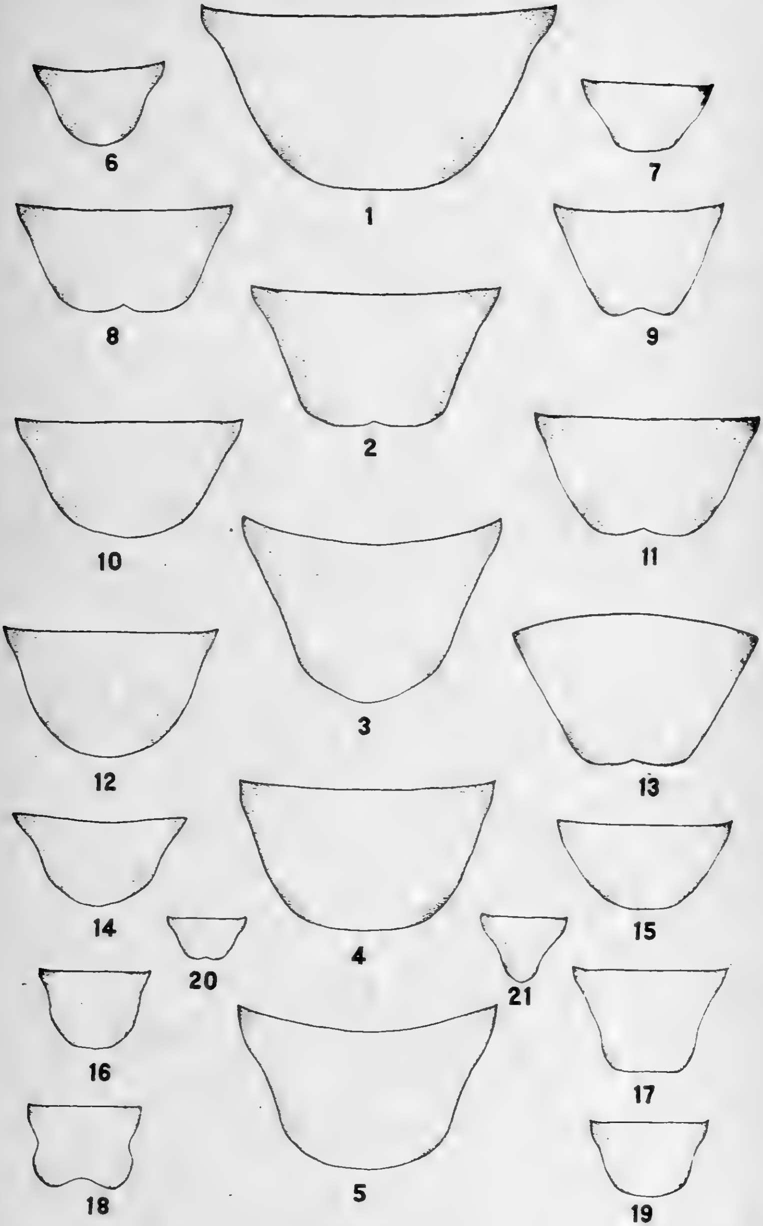
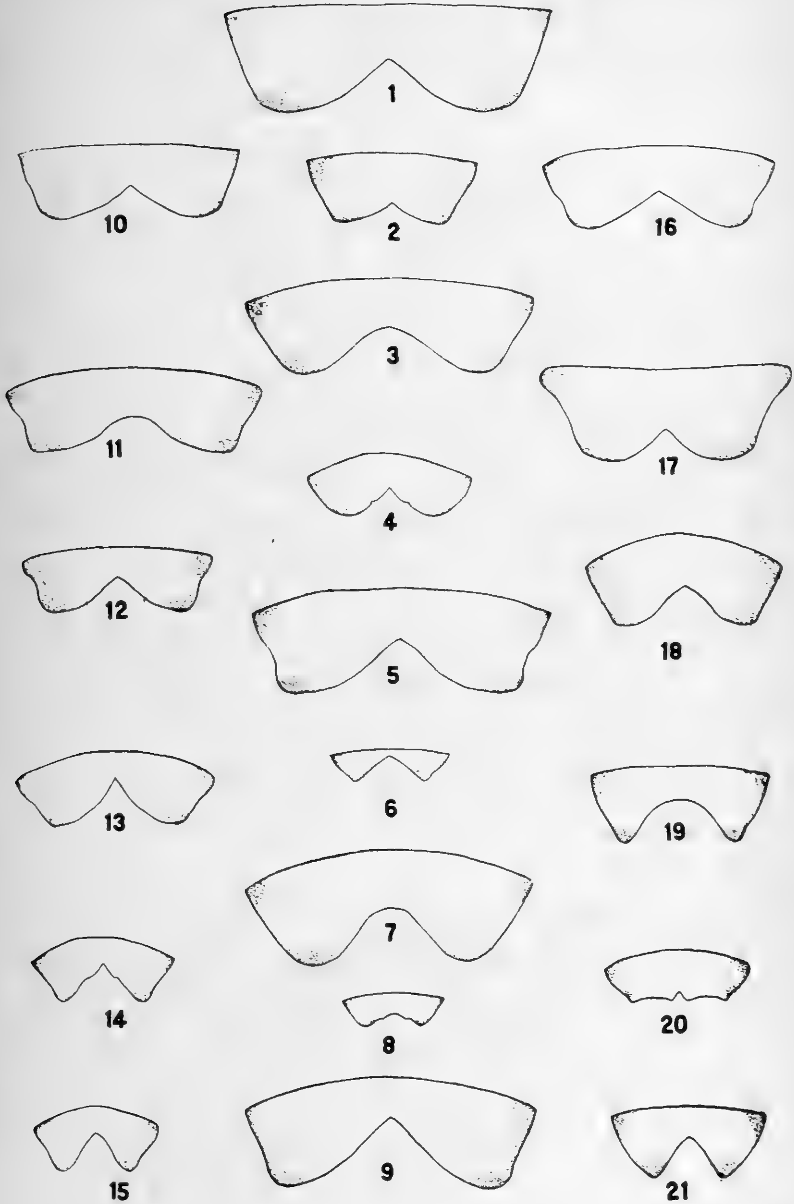


PLATE XXVII.

LAST VENTRAL SEGMENT OF THE FEMALE—

1. *Tibicen auletes*
2. *Tibicen eugraphicæ.*
3. *Tibicen marginalis.*
4. *Tibicen vitripennis.*
5. *Tibicen resh.*
6. *Melampsalta calliope.*
7. *Tibicen dorsata.*
8. *Proarna venosa.*
9. *Tibicen resonans.*
10. *Tibicen pruinosa.*
11. *Tibicen lyricen*
12. *Tibicen aurifera.*
13. *Tibicen bifidus.*
14. *Tibicinoides hesperius.*
15. *Okanagana synodica.*
16. *Tibicen linnei.*
17. *Tibicen dealbata.*
18. *Tibicen superba*
19. *Tibicina septendecim.*
20. *Cicada hieroglyphica.*
21. *Okanagana bella.*

PLATE XXVII.



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THE KANSAS UNIVERSITY SCIENCE BULLETIN

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BY MEMBERS OF THE UNIVERSITY OF KANSAS

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PART II. NOS. 10-15

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THE KANSAS UNIVERSITY SCIENCE BULLETIN.

VOL. XIII.] MAY, 1920. [No. 1.

Miocene Land Shells from Oregon.*

BY G. DALLAS HANNA,

Curator of Invertebrate Paleontology, California Academy of Sciences.

(Plate I.)

THE exposures of fossiliferous rocks in the valley of the John Day river in Oregon have been known as a collecting ground for mammalian remains since 1861. Many expeditions have worked there and an extensive literature exists in which numerous types have been described. Fossil mollusks were obtained by the earliest collectors and subsequently and several papers have been written about them since 1870.

In 1907 an expedition was led into the region by Mr. H. T. Martin, curator of paleontology of the University of Kansas. Numerous specimens of vertebrate animals were secured and Mr. Martin also collected the land shells which form the basis of this report. Sixteen specimens belonging to eight species were found at Cove Inlet of John Day river. Four species appear to be new and are named and described herein.

Altogether thirteen species of mollusks have been collected in the John Day deposits, eleven being land pulmonates, one a fresh-water pulmonate and a fresh-water mussel. All are species not now known to exist but no genus has been considered to be new. The preponderance of the land forms has an interesting bearing upon the question of the lacustrine, fluviatile or æolian method of deposition of the strata.†

* Received for publication on February 2, 1920.

† For a full account of the geological, stratigraphical, and paleontological features of the region see, Merriam, "A Contribution to the Geology of the John Day Basin," University of California publications, Bulletin of the Department of Geology, vol. 2, No. 9, pp. 269-314, April, 1901. Also, same author and series, vol. 5, No. 1, pp. 1-64; December, 1906. Also, vol. 5, No. 11; Merriam and Sinclair for fairly complete bibliography, etc.; October, 1907.

The age of the beds is believed to be Miocene, a conclusion reached from a study of the fossil mammals and plants, and other geological features. A sufficient number of land and fresh-water shells has not been collected to have an important bearing on the subject. However, the long geological life of the molluscan genera found in these strata as compared with the disappearance of families and perhaps orders of mammals is a valuable commentary on the correlation of deposits elsewhere by the two classes of fossils when they are found singly. Not only have the mollusks passed through epochs of intense climatic change but they have withstood one of the most violent outflows of lava visible on the surface of the earth. Yet the genera found in the John Day and Mascall beds are represented in and near the same region to-day with closely allied species.

Ammonitella lunata Conrad.

Planorbis (*Spirorbis?*) *lunatus* Conrad, Am. Journ. Conch., vol. VI; p. 315, pl. XIII, fig. 8, 1870. Condon collection. Bridge Cr., Ore.

Planorbis (*Spirorbis?*) *lunatus* White, 3d. Ann. Rep. U. S. Geol. Surv., p. 448, pl. XXXII, figs. 24, 25, 1880-'81. Published, 1883.

Gonostoma yatesi Cooper. Stearns (in White), Bul. 18, U. S. Geol. Surv., p. 16, pl. III, figs. 8-12, 1885. Cope and Condon Coll.

Ammonitella yatesi præcursor Stearns, Proc. Wash. Acad. Sci., vol. II, p. 656, pl. XXXV, figs. 8-12, 1900. Same figures reproduced as in Bul. 18, U. S. Geol. Surv., cited above.

Ammonitella yatesi·præcursor Stearns, Science, New Series, vol. XV, p. 153, 1902. University of California Collection.

Ammonitella yatesi præcursor Stearns, Univ. of Calif. Pub. Geol., vol. V, No. 3, p. 67, 1906.

Although Conrad's description is very meager, taking it together with his figures leaves no doubt that he first described the shell which seems to have been collected by many exploring parties into the John Day region. His specimens were collected by Thomas Condon, the pioneer in the field and it is stated that they came from "Bridge Creek, Oregon." The error in considering it to be a species of the fresh-water genus *Planorbis* is not strange since Cooper says of *Ammonitella yatesi* (*Am. Jour. Conch., IV, 210, 1868*): "It would have been supposed to be a *Planorbis* if found near water, and if the streams of that country (Calaveras county, California) had not been thoroughly searched by many collectors."

Stearns first identified the fossils as *A. yatesi* Cooper but later reconsidered the matter and made them a new subspecies based chiefly on size. He says: "Though the fossil specimens are considerably larger than any of the recent ones, I am unable to detect any other difference." (*Proc. Wash. Acad. Sci., vol. II, p. 657, 1900.*)

The University of Kansas expedition secured two specimens of this interesting form and although they are not perfect I am able to point out specific differences which are of sufficient importance to continue the separation of the fossil from the living form. Comparison has been made with several fossil specimens in the collection of the University of California; also with 16 excellent specimens of *Ammonitella yatesi* Cooper from the Hemphill collection which now forms a part of the museum of the California Academy of Sciences. The recent shells came from "near Murphys, California," and were collected by Henry Hemphill.

One important difference is in size. The largest *yatesi* is but 9 mm. in greatest diameter, whereas the largest *lunata* (and it is imperfect) is 15 mm. The former also has eight whorls while the latter has nine. The umbilicus of *lunata* is proportionately wider and the apex is a hollow cone. The apex of *yatesi* is truncated inside and therefore shallower. On the ventral side of *yatesi* the last whorl swings out over the one preceding, but this is not true in the best specimen of *lunata*, although figure 1 of Stearns (White) indicates that there may be some variation in this respect in the fossil species.

MEASUREMENTS.

(All measurements are in millimeters.)

	A. yatesi.	*A. lunata.*	
Greatest diameter	9.00	15.00	12.50
Least diameter	8.00	13.50	11.00
Greatest altitude	4.50	7.50	6.50

No measurements of the fossils studied by Conrad, Stearns and White have been published. Their figures show that the shell substance of the body whorl has been lost, a condition which is almost always the case. The University of Kansas specimens are in that condition, but through the kindness of Prof. Bruce L. Clark, I was permitted to examine well-preserved material in the University of California. It was learned that the shells are smooth and shining as in the recent species, with growth wrinkles barely showing on the latter part of the body whorl.

Gastrodonta imperforata Hanna. New species.

(Plate I; figures 1, 2, 3.)

Whorls six; spire high and dome-shaped; sutures moderately impressed; apex marked with fine regular growth lines; growth lines on the body whorl slightly uneven but without an approach to a ribbed condition; last whorl slightly descending at the aperture; peristome thin and acute, slightly expanded on the basal portion; umbilical region deeply impressed, the perforation being minute. Greatest diameter, 17.50. Least diameter, 16. Altitude, 13.

Type in the University of Kansas from Cove Inlet, John Day river, Oregon, collected by H. T. Martin in 1907.

A single specimen was obtained. The dome-shaped shell and thin, acute peristome prevents its being classed as *Polygyra dalli,* the species with which it is most apt to be confused. Its correct generic position cannot be stated because of minor shell differences which separate many of the groups of recent pulmonates. It resembles in general shape some of the *Gastrodontas* as *intertexta,* for instance. The fact that the lip is slightly expanded below is the chief character which casts some doubt upon its being a *Gastrodonta.* This condition is met with in *Oreohelix* and our shell resembles in form and size some of the dome-shaped varieties of *O. cooperi,* as, for instance, *apiarium* Berry. It might be placed directly in this genus were it not for the differentiating characters of the umbilicus.

The specimen is slightly defective as shown by the photographs but it is sufficiently intact it seems to make the species easily recognizable in the future.

There is a second specimen in the collection of the University of California which is similar in all respects to the type, except perhaps it is a little better preserved.

Pyramidula mascallensis Hanna. New species.

(Plate I; figures 4, 5, 6.)

Whorls six and three-fourths, rounded below and flat above; spire not greatly elevated; suture apparently channeled; last whorl carinated through the first two-thirds, the carina gradually disappearing; latter part of last whorl depressed below the carina of the one preceding; the shell substance of the apical whorls is preserved but sculpture is absent; the body whorl is an internal cast but shows on the upper side some coarse uneven growth ridges; umbilicus widely open. Greatest diameter, 33.50. Least diameter, 30.25. Altitude, 28.

Type in the University of Kansas from Cove Inlet, John Day river, Oregon, collected by H. T. Martin in 1907.

Only the type specimen was secured so that a statement of variation cannot be given. The flattened upper whorls and the apparently deeply channeled suture distinguish this shell from other species. It may represent a new generic type, but the genera of land shells were so often based upon anatomical and minor shell characters that it seems best for the present to include this under *Pyramidula,* the genus which it most resembles. Perhaps better material will eventually be secured and enable the correct genus to be determined. The specimen is not perfect. The aperture has been lost, together with the shell substance of the last two whorls. It has also been crushed but not in such a manner as to distort the shape. The original shell had over seven whorls and was considerably more elevated than the measurements given show. But the diameter was but little if any greater on account of the last whorl growing in beneath the one preceding. Also when the shell was complete the last whorl was but little angulated on the periphery, this seeming to be a character which applies only to the whorls up to and including the sixth.

It is named for the Mascall, one of the subdivisions of the John Day series.

At first it was believed that this specimen was Conrad's *Helix* (*Zonites*) *marginicola* because it was the only form found with the "spire scarcely raised above the margin of the last volution." However, he states that his shell had six whorls and was narrowly umbilicate. He gave no measurements, but his figure shows that he had a young specimen. He states further that his shell was narrowly umbilicate, a condition which would not be true in the young of *mascallensis.* There is, in my opinion, little doubt that one of the species subsequently described under another name is *marginicola,* but this cannot be recognized because of the inadequate original description. It is to be hoped that if the type specimen is in existence it will some day be fully described.

Polygyra dalli Stearns.

Helix (*Monodon*) [*error for Mesodon*] *dalli* Stearns. In White, Bul. 18, U. S. Geol. Surv., p. 14, pl. III, figs. 4-6, 1885.

Polygyra dalli Stearns, Proc. Wash. Ac. Sci., vol. II, p. 655, pl. XXXV, figs. 4-6, 1900. Same figures as above reproduced.

Polygyra dalli Stearns, Science, new series, vol. XV, p. 153, 1902.

Polygyra dalli Stearns, Univ. of Calif. Pub. Geol., vol. V, No. 3, p. 67, 1906.

One almost perfect specimen and four young and broken ones were obtained at Cove Inlet, John Day river, by Mr. Martin. A large number of specimens in the University of California indicates that this is probably the most abundant species in the region. As Stearns has shown, it is very closely related to *Polygyra columbiana* Gould, which is common in the

Pacific coast states to-day. The latter, however, is smaller; some specimens of *dalli* are almost as large as *thyroides* of Kansas and Missouri. The umbilicus of the fossil species is covered by the narrowly reflected peristome and its junction with the body whorl is deeply seated. There appears to be no tendency for the peristome to descend more or less abruptly near its outer termination with the body whorl.

Polygyra expansa Hanna. New species.

(Plate I; figures 7, 8, 9.)

Whorls about seven, somewhat flattened above and below; sutures not deeply impressed; lines of growth apparently uneven on the last whorl and broken into ridges parallel thereto; the last whorl of the type is subcarinate at its beginning due to pressure, but is flattened naturally on the lower side; axis imperforate and covered with heavy shell substance; the junction of the peristome with the body whorl in the umbilical region is marked with a distinct angular depression; it is not a gently concave depression as found in such recent *Polygyras* as *albolabris*. Greatest diameter, 32. Least diameter, 28.50. Altitude, 17.

Type in the University of Kansas from Cove Inlet, John Day river, Oregon, collected by Mr. H. T. Martin.

A single specimen was secured and it is not in as good condition as would be desired. Its characters are so distinct, however, that it cannot be referred to any known form. The imperforate axis covered with heavy callus places it in *Polygyra* rather than in *Epiphragmophora*. However, it is flattened on the base and has a tendency to be slightly carinated as some forms of *fidelis* Gray of the latter genus.

A single, and better preserved specimen in the University of California shows, in addition to the above characters, that the outer lip abruptly descends at its junction with the body whorl for a distance of 4 mm.

Polygyra martini Hanna. New species.

(Plate I; figures 10, 11, 12.)

Whorls five, well rounded, the last being conspicuously enlarged vertically; sutures moderately impressed; lines of growth very fine for a shell of this size and very regular, crossed by less impressed revolving striæ which are most noticeable on the body whorl; umbilical region deeply impressed; lip thickened by callus and reflected over almost the entire umbilicus; no indication of a noticeable deflection of the peristome at its junction with the body whorl. Greatest diameter, 34.50. Least diameter, 25. Height of body whorl, 19. Altitude without body whorl, 18. Altitude (total), 28.

Type in the University of Kansas from Cove Inlet, John Day river, Oregon, collected by Mr. H. T. Martin in 1907.

A single well-preserved specimen was secured. While it resembles in general shape some of the old world species, as *Pomatia aspera* for instance, it is believed to be more closely related to the *albolabris* group of *Polygyra*. It must be stated, however, that important differences exist. The shell is more globose than other species of this genus and the umbilical region is more deeply impressed. While most of the margin is broken away, enough remains to show that it was folded back upon itself in the basal region and the body whorl was obtusely keeled in this region.

The shell resembles in some respects the *Helix leidyi* of Hall and Meek (*White, 3d. Ann. Rep. U. S. Geol. Surv., p. 455, pl. XXXII, figs. 32, 33, 1881-'82*), but it is proportionately more elevated and the body whorl is deeper in a vertical direction. The two species belong to the same section of the genus which may be defined by the form of the lower apertural margin and the angular body whorl in the umbilical region.

The species is named in honor of Mr. Martin, an indefatigable collector of fossils.

Epiphragmophora dubiosa Stearns.

Epiphragmophora dubiosa Stearns, Science, new series, vol. XV, p. 153, 1902. (Original description.)

Epiphragmophora dubiosa Stearns, Univ. of Calif. Pub. Geol., vol. V, p. 69, figs. 3, 4, 1906. Original description repeated and figures provided.

Only one specimen of this interesting species was found. The shell is imperfect, as was the type, but enough remains to show that it is narrowly umbilicated; very flat below and spire but little elevated; whorls flattened above and sutures but little impressed; the pitting on the apex mentioned by Stearns cannot be seen, but this may be due to the worn condition of the shell substance; for the same reason the growth striæ are not well preserved. Greatest diameter, 23. Altitude, 12. Whorls, five and three-fourths.

It is not certain that the form is placed in the correct genus, but without better preserved material for study it would be useless to attempt any other disposition. Doctor Stearns states and shows in his figure that the sutures are deeply impressed. It is believed, however, that this is not natural, as the Kansas University specimen and four others seen in the University of California did not show them noticeably deepened. Snails of this group are known to be subject to considerable variation in this respect so that it would not seem to be justifiable to consider them distinct on this character when otherwise all which have been seen agree with the description and figures. Unfortunately the formation of the aperture in the species cannot be determined.

Epiphragmophora antecedens Stearns.

Helix (Aglaia) fidelis Gray. Stearns (in White) Bul. 18, U. S. G. S., p. 14, pl. III, figs. 1-3, 1885.

Epiphragmophora fidelis antecedens Stearns, Proc. Wash. Acad. Sci., vol. II, p. 653, pl. XXXV, figs. 1-3, 1900.

Epiphragmophora fidelis antecedens Stearns, Science, new series, vol. XV, p. 153, 1902.

Epiphragmophora fidelis antecedens Stearns, Univ. of Calif. Pub. Geol., vol. V, p. 67, 1906.

Four specimens which clearly belong to this species were found. One is fully grown. It shows that the umbilicus was normally completely closed and thickened with callus, a condition which does not obtain in *E. fidelis*. The umbilicus, however, is of the general form found in *Epiphragmophora* and not that which is common in *Polygyra*. The best specimen Stearns had was imperforate, but it seemed to have been caused by crushing. This is now known to be normal.

In order to complete the record the other species of mollusks known from the John Day Miocene will be mentioned. The original generic terms ascribed to them are retained. No object would seem to be gained by attempting a rearrangement at this time. The full synonomy of *Unio condoni* White has not been searched for.

1. *Unio condoni* White, Bul. 18, U. S. Geol. Surv., p. 13, pl. II, figs. 1-3, 1885.
2. *Limnæa maxima* Stearns, Science, new series, vol. XV, p. 154, 1902.
   Limnæa maxima Stearns, Univ. of Calif. Pub. Geol., vol. V, p. 70, fig. 1, 1906.
   Limnæa stearnsi Hannibal (in Baker) *Limnæidæ* of N. and Mid. Am., p. 102, pl. XVII, fig. 11, 1911. New name for *L. maxima* above, preoccupied by Collin, Ann. Soc. Mal. Belg., VII, p. 94, 1872.
3. *Helix (Zonites) marginicola* Conrad, Am. Jour. Conch., vol. VI, p. 315, pl. XIII, fig. 9, 1870. Bridge creek, Oregon. Condon, Coll.
   Helix (Zonites) marginicola White, 3d Ann. Rep. U. S. Geol. Surv., p. 453, pl 32, fig. 34, 1880-'81.
4. *Helix (Patula) perspectiva* Say. Stearns, Bul. 18, U. S. Geol. Surv., p. 14, pl. III, fig. 7, 1885.
   Pyramidula perspectiva simillima Stearns, Proc. Wash. Acad. Sci., vol. II, p. 657, pl. XXXV, fig. 7, 1900.
   Pyramidula perspectiva simillima Stearns, Science, new series, vol. XV, p. 153, 1902.
   Pyramidula perspectiva simillima Stearns, Univ. of Calif. Pub. Geol., vol. V, p. 67, 1906.
5. *Pyramidula lecontei* Stearns, Science, new series, vol. XV, p. 154, 1902.
   Pyramidula lecontei Stearns, Univ. of Calif. Pub. Geol., vol. V, p. 68, fig. 2, 1906.

The reader is referred to a paper by Harold Hannibal (*A Synopsis of the Recent and Tertiary Mollusca of the Cali-*

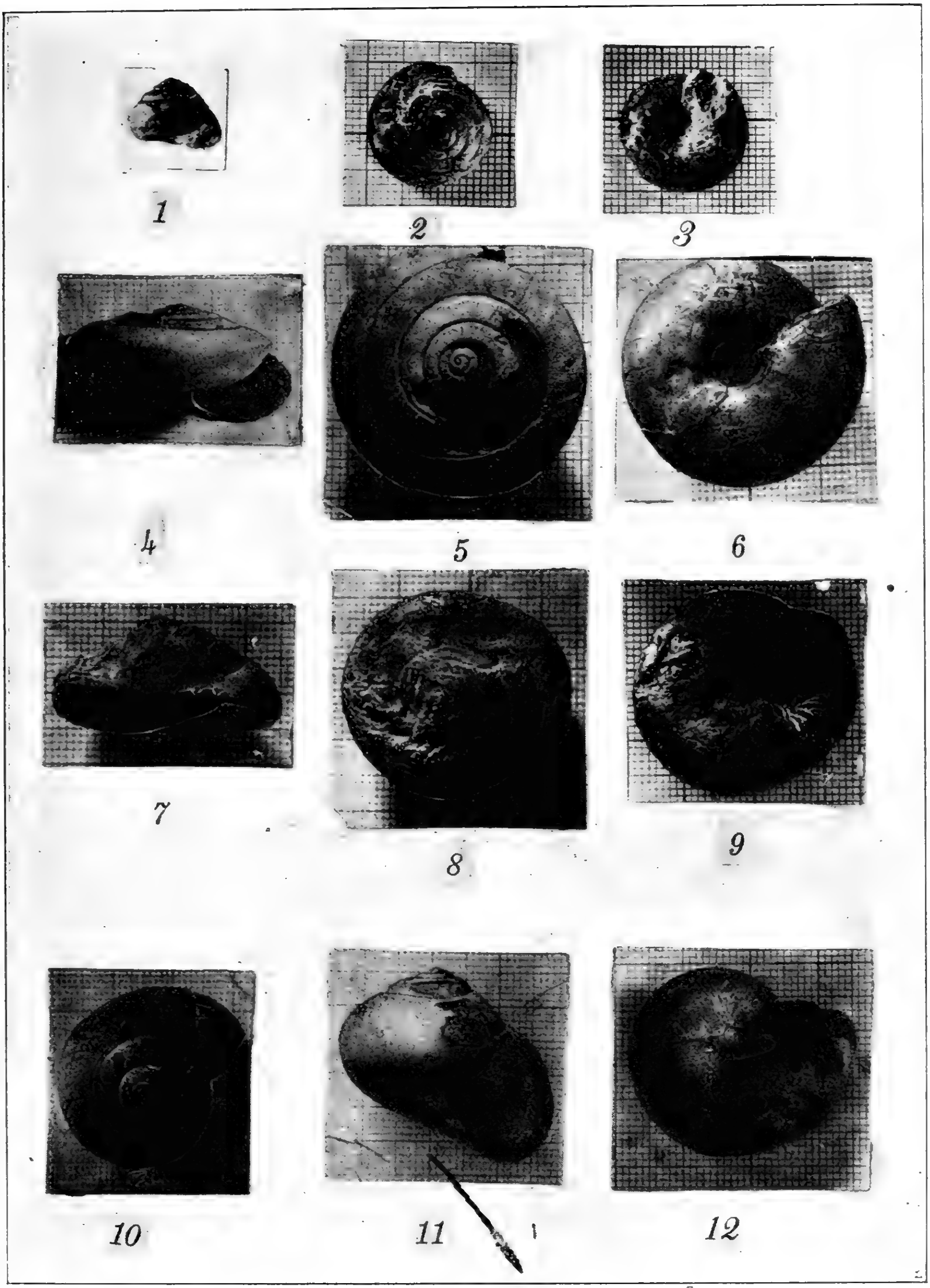
fornian Province; Proc. Mal. Soc. London, vol. X, pp. 112-211, 1912) which may perhaps have references to the John Day fauna. The paper has not been favorably reviewed. (*Pilsbry, Nautilus, XXVI, 71, 1912.*) I have not seen it and cannot comment on what it contains, but apparently Hannibal, in working over the John Day material in the University of California, combined at least four species under the name *Helix marginicola* Conrad. Some of them bore Stearns' labels and probably some of them were his types.

EXPLANATION OF PLATE I.

The figures are from photographs which have been retouched. The photographs were taken with millimeter cross-section paper for a background and the scale can be obtained from this. Figure 1 is less enlarged than figures 2 and 3.

Figures 1, 2 and 3. *Gastrodonta imperforata* new species.
Figures 4, 5 and 6. *Pyramidula mascallensis* new species.
Figures 7, 8 and 9. *Polygyra expansa* new species.
Figures 10, 11 and 12. *Polygyra martini* new species.

PLATE I.



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THE KANSAS UNIVERSITY SCIENCE BULLETIN.

VOL. XIII.] MAY, 1920. [No. 2.

Pleistocene Mollusks from Wallace County, Kansas.*

BY G. DALLAS HANNA.

Curator of Invertebrate Paleontology, California Academy of Sciences.

ONE of Mr. H. T. Martin's numerous fossil hunting expeditions for the University of Kansas took him to the Miocene mammal beds of Wallace county of that state. Here, in one locality he found some ant hills about which were numerous shells the indefatigable insects had collected. A small quantity of the general debris about the nests was preserved and the mollusks have come to me for study.

The collection, although small, is valuable because it throws more definite light upon the size and duration of the Pleistocene Kansas lake which Prof. J. E. Todd has aptly named "Kaw Lake." Some of the species of mollusks found inhabit lakes solely and since there are none of these bodies of water within a long distance of the locality at the present time, practically conclusive proof is offered of the existence of Kaw Lake before the present epoch. And since many of the species now live in northern cold waters it seems justifiable to conclude that this body of water was coexistent with the great glaciers. Probably its inhabitants lived during the deposition of the Aftonian gravels; that is, prior to the descent of the Kansan ice sheet. It seems likely that the lake was formed by the pre-Kansan ice sheets, continued through the Aftonian period and that its dam was broken by the Kansan sheet.

Kaw Lake probably existed for several hundred years. This is indicated by the presence in it of a large molluscan population which would require a very considerable number of years

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for dispersal. A cool, moist climate similar to that of northern United States or southern Canada must have accompanied it. This is shown by the land-shell species found associated with the fresh water. This was also shown by the shells found in the Phillips county Pleistocene which has been reported upon. (*Hanna and Johnson, Kan. Univ. Sci. Bul., vol. VII, No. 3, 1913.*)

That radical change took place in the climate, fauna and flora of western Kansas after the disappearance of Kaw Lake is evident from the almost complete disappearance of the land and fresh-water mollusks. A considerable number of species and at least two genera are not known from Kansas as yet except from Pleistocene fossils. Neither streams nor uplands are fitted for their existence and search must be made for them far to the north before they are located.

The ants were not particular in choosing material for their "hills." Besides the fossil shells dug from the light buff material forming the lake deposit they collected a few recent species, probably found living near at hand. There were also sand grains of large size and plant stems, seeds and roots.

LIST OF SPECIES.

Sphærium. What appear to be two species were secured. Any attempt at specific determination in this group of shells at this time would merely add to the already almost inextricable confusion.

Valvata tricarinata Say. Four specimens. I know of no published records of this species from Kansas, either living or fossil. Mr. E. C. Johnston collected a dead shell, but not a fossil, at Cameron's Bluff, above Lawrence, Kan., in 1916. No other records are available for the state.

Lymnæa humilis rustica Lea. One specimen. This form is recorded from Douglas county, Kansas, by Baker (*Lymnæidæ of N. Am., p. 269, 1911*), and is probably the same as was recorded from the Phillips county Pleistocene as *L. humilis.*

Lymnæa parva Lea. Thirteen specimens. Previously known from the marl beds of Long Island, Phillips county, and from Douglas county river debris.

Planorbis antrosus Conrad. Seven specimens.

Planorbis deflectus Say. Two specimens. Both are small and apparently not full grown. The species lives in Lake View, Douglas county and has been found in the Pleistocene of Phillips county. Baker (*Naut., XXIII, p. 93, 1909*) records it from Anthony, Kan.

Succinea avara Say. Abundant.

Succinea stretchiana Bland. Two specimens. This species lives on the plains at the present time and the two shells secured are plainly not fossils.

Vallonia pulchella Müller. Fifteen specimens. This is an addition to the list of Kansas Mollusca and since it inhabits cool, moist timbered areas it emphasizes that this was the condition in western Kansas in Pleistocene time.

Zonitoides singleyanus Pilsbry. Two specimens, not fossils.

Pupilla muscorum Linnæus. Abundant. In Pleistocene time this was a very common snail in western Kansas.

Pupoides marginatus Say. Six living shells.

Gastrocopta armifera Say. One living shell. Both this and the preceding species live in the region at the present time.

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THE KANSAS UNIVERSITY SCIENCE BULLETIN.

VOL. XIII.] MAY, 1920. [NO. 3.

Moisture Requirements of Germinating Seeds.*

BY RUPERT PETERS.

INTRODUCTION.

IT HAS long been recognized that a close relation exists between plant life and soil moisture. Common observation showed our ancestors that wilting occurred when the moisture content of the soil was markedly lowered and that death followed when it was long continued, but it remained for the twentieth century investigators to attempt the discovery of the moisture conditions under which plants could best flourish and those under which they wilted and died, as well as to point out definitely the boundaries between these. But, even yet, very little is to be found in the literature concerning the lower limits of soil moisture in connection with plant growth.

This paper is the record of an attempt to aid in the location of the lowest boundary at which plants may be active, and is concerned particularly with the relation of the wilting coefficient of the soil to the germination of seeds. An attempt has been made to answer the question whether seeds can germinate when the amount of soil moisture is so low that plants growing in it wilt and die.

The work was suggested by Dr. Charles A. Shull, then of the plant physiology laboratory of the University of Kansas, now of the University of Kentucky. Most of the actual work was done in the botany laboratory of the Northeast High School, Kansas City, Mo., near enough to be in frequent consultation with Doctor Shull. It is but fitting that an appreciation of his deep interest and kind suggestions be made here. Thanks

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are also due Prof. W. C. Stevens for suggestions and criticisms in the preparation of this paper.

HISTORICAL.

Although Sachs (7) recognized a wide range, from 1.5 per cent in coarse sand to 12.3 per cent in a mixture of sand and humus, in the moisture content of various soils when plants wilted, he made his tests with a single plant species (the tobacco), drew his conclusions, and then dropped this line of investigation. Few have taken it up since. Hedgecock (4) found that entire turgid plants of the same species had, at any given age, approximately the same water content, regardless of the differences in the soil or in the conditions under which they were grown. On the contrary, the water content of plants beginning to wilt varies with the soil, being always greater in clay, loess, and saline soils than in loam, humus, or sand. He also found that xerophytes could remove more water from the soil than could mesophytes or hydrophytes; the former removing all but 3 per cent, while the second named left in the same soil under the same ærial conditions at least 5 per cent. Clements (3), independently, arrived at similar conclusions.

These were the chief contributions until Briggs and Shantz (1) brought out their work on the "wilting coefficient." They proposed the term and defined it as the percentage of water (based upon the dry weight of the soil) remaining in this when wilting had progressed to such an extent that recovery by the plant was impossible even in an approximately saturated atmosphere, without the previous addition of water to the soil. In working out their results they maintained practically uniform conditions; their greenhouse had an average temperature of about 70° F. and the relative humidity was maintained at 85 per cent. Such changes as did occur in these factors were slight and gradual. A constant temperature for the soils being examined was maintained by a specially-devised water bath in which the containers were set. About twenty different soils were examined, differing widely in all characters, and giving results ranging from 1 per cent in coarse dune sand to over 30 per cent in the heaviest types of clay. For plants, over a hundred species and varieties were tried out, so selected as to give a range from extreme xerophytes to hydrophytes. In general, the amount of water remaining in any one of these soils when the plants growing in it had fully wilted, was practically constant. It made no difference as to the plants used, being a fixed quantity for that soil. Furthermore, they worked out formulæ by which this wilting coefficient for any soil could be calculated from either of four factors: its moisture equivalent, its hygroscopic coefficient, its moisture-holding capacity, or its texture as determined by mechanical analysis. Their wilting coefficient was the standard when this work was begun. Since then, the work of Caldwell (2) has come to hand. He carried on his experiments at the desert laboratory of the Carnegie Institution at Tucson, Arizona. Here, transpiration was excessive as the result of the heat, low humidity, and the hot, dry winds. When he produced conditions similar to those of Briggs and Shantz, his results tallied with theirs. When conditions were natural for his location, he found the wilting coefficient always higher (even 30 to 40 per cent) than theirs or than that calculated from their formulæ. Further, "under any set of aërial conditions the observed soil moisture content at permanent wilting is approximately a constant for each of the soils used, and its value increases with the increase in the rate of transpiration, being greater under conditions of high evaporation intensity and declining with the decrease of the evaporating power of the air. For a series of plants grown in any soil, and wilted under different aërial conditions, all with relatively high evaporation rates, as many different soil moisture contents at permanent wilting are obtained as there are sets of conditions."

Russell (6) has shown that the rate of supply of soil water is simply the speed at which water can move in the soil, and this depends upon the amount of clay and colloidal matter present. Livingstone (5) calls attention to another factor which complicates the problem still more. In a set of experiments carried on in the Johns Hopkins' greenhouses where he had plants grown with their roots in vessels of water and subjected to varying aërial conditions, he found that with the "back pull" of the soil thus cut out, temporary and even permanent wilting occurred. His conclusion is that the trouble is internal, the absorbing power of the roots is inadequate to supply moisture as fast as it is lost by evaporation. Hence, he thinks permanent wilting need not depend upon soil moisture conditions necessarily, although it frequently does. Caldwell's higher results are thus evidently due to the rapid transpiration of water from the leaves, associated with the slowness of the water movement in the soil, especially when the amount present was quite low; in other words, the water was evaporated from the leaves more rapidly than it could be absorbed from the soil, and wilting followed as the result of this back pull before the amount of water in the soil was lowered to the point reached in the corresponding tests of Briggs and Shantz.

METHODS.

Since the purpose of this investigation is to determine if germination can occur with far less moisture than is commonly thought necessary, since transpiration is not a factor in the tests (thus making them somewhat similar to those of Briggs and Shantz in that they had always a high humidity present in theirs), and since the Briggs and Shantz' figures are lower than Caldwell's, they are retained as the standard for this test. Nevertheless, it is recognized that this may not be a fixed standard for all conditions but may vary with differing atmospheric conditions whenever transpiration is a factor.

Because quartz sand and its data were available, it was used. It is designated as No. 2/o by its manufacturers, the Wausau Quartz Company, and passes over a 147-mesh screen but through a 124-mesh one, thus making the average diameter of the particles about .10 mm. It contains by analysis:

	Per cent.
Silicon dioxide	99.07
Iron oxide	0.17
Aluminum oxide	0.52
Hygroscopic moisture	0.06
Undetermined	0.18
	100.00

Its wilting coefficient, as determined at the biophysical laboratory of the bureau of plant industry, Washington, D. C., of which Mr. Briggs is director, is 1.31 per cent (8).

Two hundred grams of this sand, roughly weighed, was chosen as the unit, merely because it lacked about three centimeters of filling the common heavy glass tumblers used. The unit of sand was spread upon a glass plate and water to produce the desired percentage of moisture was added from a burette, and *thoroughly* mixed in with a spatula. Owing to varying humidity conditions in the air during mixing at different times, accuracy was approximate only, but as a rule about twenty per cent more water had to be added than was desired when mixing was complete. The wet sand was placed in the tumbler, the seeds were spaced more or less evenly about four centimeters below the surface, and the sand was settled by jarring the tumbler against the table. Enough of the melted paraffin-vaseline mixture (20 per cent vaseline in paraffin having a melting point of 45° C.) was poured over the surface to seal it effectively, and the labelled tumbler was set aside at room temperature for two weeks. As sufficient growth did not occur for photosynthesis to become a factor, light was disregarded.

In this connection, it should be stated that the first series of tests, some thirty, failed because the seeds were planted about a centimeter only below the surface of the sand. The clue was found when a sample was taken from the top and another from the bottom of the sand at the close of one of these tests, run for moisture content, and compared. That from the bottom showed a higher moisture content than the upper one, where the seeds were. A series was then run upon a tumbler machine (the one described by Shull, Bot. Gaz., 62:10-11). The bottles were half filled with the wet sand, the seeds were added, heavily shellacked corks were sealed in place, and the bottles fixed upon the wheel of the machine so that they had fifteen complete rotations a minute. This so mixed the contents of the bottles that there could be no question as to the moisture content in the various parts of the soil mass. The results were checked with another series in which the seeds were placed near the center of the sand mass, the tumblers sealed as usual, and set aside for the regular time. As results corresponded closely, the more troublesome machine method was not further used.

While filling the tumblers a carefully chosen sample of the sand was placed in a tared weighing bottle and this was immediately covered. Although this sample was taken when the tumbler was half filled, and although all speed commensurate with careful work was used, yet on dry days considerable loss of water must have occurred from the sand not yet in the tumbler and from the surface of that already in it. This sample was carefully weighed upon a standard balance sensitive to .0001 gram and was then placed with cover removed in a drying oven at 100° to 104° C. until a constant weight was obtained. Another source of error is to be noted here. The particles of dry sand were so light that unless extreme care was used in covering and uncovering the bottles, some of these particles would be carried out on air currents and so give false results upon subsequent weighings. From the two figures obtained by these weighings, the per cent of moisture in the corresponding sand was secured.

At the end of the two-week period the seal was broken and the contents of the tumbler were dumped upon a glass plate. A sample was taken quickly for determining the moisture content. Germination was noted and the seeds were separated from adhering sand grains by being gently brushed with a camel's hair brush, were at once dropped into a weighing bottle, and their loss of moisture then determined by weighing and drying to a constant weight.

Seeds were considered to have germinated when .5 cm. of the rootlet extended through the seedcoat, and to be "incipient" when a shorter length was to be seen. This is another arbitrary standard, but some such point had to be chosen.

It is realized that with no means available for controlling the soil temperatures during the tests, considerable error may have crept in, but with all allowance for such in the results following, it is felt that it would not alter the conclusions drawn.

PRELIMINARY TESTS.

An early step taken as a guide to the amount of absorption to be expected was to determine the approximate curve of water absorption of various seeds when conditions were favorable for germination. It was thought this might be used in comparison with results obtained in the tests as an indicator, suggesting nearness of approach to necessary amounts of water to be furnished. Although of little assistance in the way planned, the results later obtained tallied fairly closely. To get these, ten weighed seeds were placed upon wet sand, or on or between pads of wet cotton, in Petri dishes at room temperature (averaging 19.5° C.) and weighed at intervals until germination had taken place.

The results are shown in the following tables:

TABLE 1. Water Absorption of Corn.

Test No.	1		2		3		4	
Dry wt.	3.6270		3.7286		3.6565		3.5170	
Time in hours.	Gain.		Gain.		Gain.		Gain.	
	Grams.	Per cent.	Grams.	Per cent.	Grams.	Per cent.	Grams.	Per cent.
1	.2731	7.52	....	....	....	....	...	...
2	....	....	....	....	.2690	7.3	...	...
3	.3991	11.00	....	....	....	....	...	...
4	....	....	.7215	19.3	....	....	.2466	7.0
5	.4926	13.58	....	....	....	....	...	...
7	.5903	16.27	....	....	.5757	15.7	...	...
8	....	....	.9848	26.4	....	....	.4146	11.2
9	.6585	18.15	....	....	....	....	...	...
24	1.0115	27.89	1.4465	38.8	1.0834	29.9	.7241	20.5
28	1.9495	28.93	1.5142	40.0	1.1766	32.1	....	....
32	1.1109	30.62	1.5652	41.1	1.2342	33.7	.8809	25.0
48	1.2587	34.70	1.8168	48.7	1.4037	38.3	1.0030	28.5
52	1.3111	36.14	....	....	1.4264	39.0	....	....
56	1.3137	36.22	...		1.4548	39.7	....	....
72	1.4735	40.7			1.5937	43.5	1.1198	31.8
96	2.0045	55.2			1.7588	48.1	1.2073	34.3
120	....	...			....	....	1.4661	41.1

Germination.—No. 1, all ten, rootlets averaged 2 cm.; No. 2, the same; No. 3, nine with 1.8 cm. rootlets, secondary rootlets and shoots appearing, one rot; No. 4, eight with rootlets from 1 to 3.5 cm., shoots appearing, one incipient, one rot. No. 4 was checked by setting up another test under the same conditions and taking but the initial and the final readings. Germination was complete and the per cent of gain was 41.5.

TABLE 2. Water Absorption of Legumes.

	Peas.		Navy beans.		Soy beans.	
Dry weight.	3.3909		2.7181		4.0166	
Time in hours.	Gain.		Gain.		Gain.	
	Grams.	Per cent.	Grams.	Per cent.	Grams.	Per cent.
1	....	....	1.0070	40.49	.4811	11.97
3	....	....	1.6225	59.69	.8870	22.08
4	2.8367	83.6	....	....	....	....
5	....	....	1.9493	71.71	1.2667	31.53
7	....	....	2.1184	77.93	1.6510	41.10
8	3.9282	115.8	....	....	....	....
9	....	....	....	....	1.9613	48.80
24	5.1386	151.5	2.5903	95.29	3.8499	95.84
27	....	....	2.6135	96.15	....	....
28	5.2918	153.1	....	....	4.2329	105.38
30	....	....	2.6394	97.10	4.4170	109.96
32	5.3788	158.6	....	....	4.5323	112.83
48	....	....	2.8475	104.76	4.7940	119.35
52	....	....	....	....	4.8430	120.57
54	....	....	2.9528	108.62	....	....
56	....	....	....	....	4.8823	121.55

Germination.—All peas and the navy beans had rootlets averaging 0.9 cm. One soy bean rotted, the others had 0.5 to 1.0 cm. rootlets.

The results shown in these tables are shown graphically in figure 1. They were checked by running a series of five sets each. The above are characteristic and the data for the others is omitted. The averages, however, were: Corn, 46.4 per cent; peas, 149 per cent; navy beans, 108.3 per cent; and a series of tests with wheat, 69.1 per cent.

Widtsoe (10) gives the following as the percentages of moisture contained by seeds at saturation. Wheat, 52 to 57; corn, 44 to 57; peas, 93; beans, 88 to 95. The differences between those given above and those of Widtsoe are probably due to differing end-points, or the different varieties of seeds may differ in their saturation percentages. The original papers to which he refers are not available. The results reached here will be used as the same end-point and as seeds from the same lots were used as in the tests following.

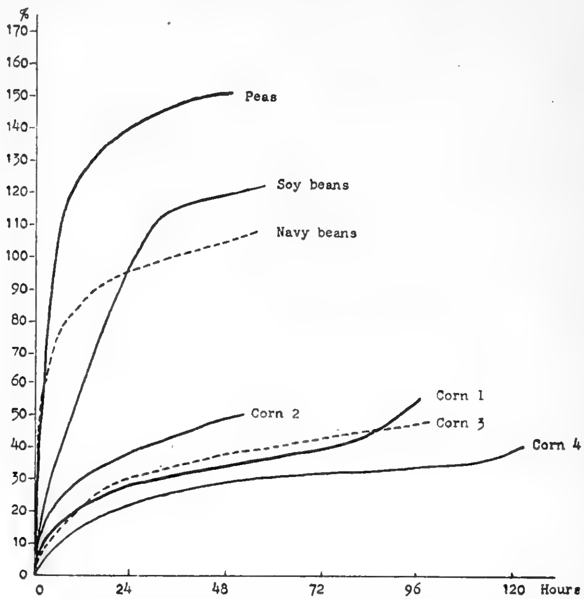

FIG. 1. Water absorption of various germinating seeds. Corn 1, navy beans and soy beans on wet cotton; peas and corn 2, between pads of wet cotton; corn 3, on sand wet with 10 per cent water; corn 4, on sand wet with 5 per cent water.

RESULTS.

At the same time this preliminary test was run, careful germination tests were made of different lots of seeds and only those were chosen for use which gave a high percentage of vitality. Corn was the first used, Boone County White, as to variety. With no arrangement to keep temperatures down, and working at first in July in a room where it at times became exceedingly warm, a number of the early tests failed because the vapor caused the seal to buckle and loss of moisture resulted. The unnoticed loss of sand particles in removing covers when placing bottles in the oven, caused on one series alone some seventy useless weighings in the endeavor to secure constant weights. But when the difficulties had been overcome, results were secured as shown in table 3, the first ones naturally being too high.

Only those tests are quoted which may be of assistance in reaching conclusions. By "weight of bottle" is meant the tare of the weighing bottle in which the particular sand sample was placed for drying. "Weight with wet sample" is the weight of this bottle and the wet sand sample before going into the oven. "Weight with dry sample" means the weight of this bottle and the sand when a constant weight had been secured by drying. "Loss of water" is the difference between the two just given. "Weight of dry sample" is the net weight of the sand sample after drying. "Per cent of water" $= \frac{\text{Loss of water}}{\text{Weight of dry sample}}$. The upper line of figures in each test is the record of the sample taken at the beginning of the test; the lower one, that at the close of it.

TABLE 3. Results of tests with corn.

No.	Weight of bottle.	Weight with wet sample.	Weight with dry sample.	Loss of water.	Weight of dry sample.	Per cent of water.	Germination.
22	15.1972 14.9436	27.2665 24.4012	27.0445 24.3547	0.2220 0.0465	11.8473 9.4111	1.87 0.48	All sprouted; tumbler filled with tangle of roots; two shoots through seal.
23	14.9436 13.1033	26.2905 22.4946	26.1013 22.4467	0.1892 0.0479	11.1577 9.3434	1.69 0.51	Four growing vigorously, 25 cm.; roots freely branched, no shoots; one rotted.
24	13.4485 11.2461	22.8234 21.7644	22.6711 21.6932	0.1523 0.0712	9.2226 10.4471	1.65 0.68	Four germinated, one incipient.
25	11.2461 13.4485	19.7670 22.9802	19.5860 22.9190	0.1810 0.0612	8.3399 9.4705	2.17 0.64	All growing freely; shoots appearing.
28	14.9436 11.2461	27.1611 20.6403	26.9926 20.5776	0.1685 0.0627	12.0490 9.3315	1.39 0.67	All germinated, roots 0.5 to 3cm., shoots forming.
29	15.7069 13.1033	28.8811 21.4845	27.7170 21.4264	0.1641 0.0581	12.0101 8.3231	1.36 0.69	All with branched roots, 5-12 cm., and with 1-3 cm. shoots.
30	15.1972 13.4485	26.4334 23.1298	26.2708 23.0806	0.1626 0.0492	11.0736 9.6321	1.46 0.51	Four with 1 cm. rootlets, 1 incipient.
33	14.9436 12.7311	27.2533 21.9564	27.0783 21.8662	0.1750 0.0902	12.1347 9.1352	1.44 0.98	All with 1 cm. rootlets.
34	15.7069 11.2461	27.4449 21.7802	27.2634 21.6694	0.1815 0.1108	11.5565 10.4233	1.59 1.06	All with 4-7 cm. roots, shoot just showing.
36	15.1972 13.1033	26.6290 22.6704	26.5158 22.6056	0.1182 0.0648	11.3186 9.5023	1.00 0.68	One with 2 cm. rootlet and with shoot showing, 4 with 1 cm. rootlets.
38	15.7069 15.7069	27.0591 27.1975	26.9420 27.1318	0.1171 0.0657	11.2351 11.4249	1.04 0.57	One fully germinated, 4 incipient.
39	12.7311 12.7311	23.0582 22.4594	22.9908 22.4195	0.0647 0.0399	10.2597 9.6884	0.65 0.41	All swollen.
41	14.9436 13.4485	28.0634 23.8692	27.9723 23.8295	0.0911 0.0397	13.0287 10.3810	0.69 0.38	One with 2 cm. rootlet; 1 incipient; 3 swollen.
42	15.1972 13.1033	26.2167 21.9365	26.1267 21.8895	0.0900 0.0470	10.9295 8.7862	0.82 0.53	Two with 1 cm. rootlets; 1 incipient, 2 swollen.
43	15.1972 13.4485	27.2890 22.8073	27.2100 22.7795	0.0790 0.0278	12.0128 9.3310	0.65 0.29	All swollen.
46	11.2461 12.7311	21.7230 22.8293	21.6416 22.8028	0.0814 0.0265	10.3955 10.0717	0.78 0.26	One with 1 cm. rootlet, the others swollen.

Navy beans were next tested. Because of their larger size and because they absorb at least their own weight of water in germinating (table 1 and fig. 1), but two seeds were used for each test lest the necessary moisture demands for germination should so exceed the amount furnished in the sand that germination would be impossible.

TABLE 4. Results of tests with navy beans.

No.	Weight of bottle.	Weight with wet sample.	Weight with dry sample.	Loss of water.	Weight of dry sample.	Per cent of water.	Germination.
58	12.7311 15.1972	21.7195 27.7559	21.6582 27.7136	0.0613 0.0423	8.9271 12.5160	0.68 0.33	One somewhat swollen, one with 2 cm. rootlet.
59	14.9436 13.1033	26.5169 22.0372	26.4262 22.0058	0.0907 0.0314	11.4826 8.9025	0.79 0.35	One with 1 cm. rootlet, one with 0.4 cm. rootlet.
60	15.1972 12.7311	27.1102 22.0474	26.9874 21.9928	0.1228 0.0546	11.7902 9.2617	1.04 0.58	One with 2.4 cm. rootlet, one with 0.2 cm. rootlet.
61	15.7069 13.4485	27.1330 24.1932	26.9881 24.1025	0.1449 0.0907	11.2812 10.6540	1.28 0.85	One with 3 cm. rootlet, one dry and unswollen.

Numbers 59 and 60 are particularly interesting as they show germination of both seeds with amounts of water supplied well below the wilting coefficient of the sand. Number 61 unfortunately had a dead seed. As a further check in this series, the beans were weighed when selected, again when the test was complete, and were then dried and the loss of water determined. In the following table "calculated absorption" is based upon the results shown in table 1 above. The actual loss of weight is in every case below the calculated absorption, even though it includes the water originally present in the seeds. This either indicates that germination can take place with less water than the amounts indicated there, or illustrates the difficulty of making transfers without the loss of water, probably the latter, although corn 4 compared with corn 3 in table 1, given originally 5 per cent and 10 per cent of water in the sand, seem to bear out the former idea, since the absorption was 4 per cent and 48 per cent, respectively.

TABLE 5. Loss of water in drying germinated beans.

No.	Original weight.	Sprouted seeds.	Dried seeds.	Loss of weight.	Calculated absorption.
58	0.5082	0.8624	0.4200	0.4424	0.5448
59	0.5618	0.9484	0.4622	0.4862	0.6067
60	0.5440	1.0178	0.4356	0.5822	0.5875
61	0.5257	0.8092	0.4634	0.3458	0.5677

The final series upon which a report can be made was run with wheat, ten grains to the test. Results follow:

TABLE 6. Result of tests with wheat.

No.	Weight of bottle.	Weight with wet sample.	Weight with dry sample.	Loss of water.	Weight of dry sample.	Per cent of water.	Germination.
101	14.9436	28.5618	28.4282	0.1336	13.4846	0.99	5 with 0.5-1.2 cm. rootlets, 4 incipient, 1 dead.
	14.9436	25.8592	25.7821	0.0771	10.8385	0.71	
102	11.2461	21.2021	21.0792	0.1229	9.8331	1.25	6 incipient, 4 unchanged.
	15.7069	27.1988	27.1070	0.0918	11.4001	0.80	
103	12.7311	24.2885	24.1628	0.1257	11.4317	1.09	7 with 5-7 cm. rootlets, 3 incipient.
	12.7311	22.9414	22.8613	0.0801	10.1302	0.79	
104	15.5137	24.7871	24.6767	0.1104	9.1630	1.20	2 with 0.5-1.2 cm. rootlets, 7 incipient, 1 dead.
	15.1972	25.9985	25.8904	0.1081	10.6932	1.01	

Of these, No. 103 gives illuminating results with Nos. 101 and 104 close seconds.

DISCUSSION.

Some interesting things are shown in these tables. Numbers 22-35 started with moisture contents above that of the wilting coefficient of this sand, 1.31 per cent; the remaining ones quoted were below it. Numbers 36, 38, 59, 60 and 103 showed satisfactory germination in a soil given less than the wilting coefficient of moisture. Others are very close, not listed simply because fewer of the seeds germinated. Some are very suggestive: Numbers 28 and 29, for example, fully germinated and with original moisture content but 0.08 and 0.05 per cent, respectively, above the limit. There seems abundant evidence in the results shown here to indicate that seeds can germinate at or below the wilting coefficient of the soil.

Why germination did not take place in some instances is still a problem. For example, in number 4, with 1.55 per cent of moisture on the start, the seeds became slightly swollen with one rotted, and 1.30 per cent of moisture remained in the sand at the close of the test. In the light of the other tests, it hardly seems that five infertile seeds were selected for this particular one.

Further, germinating seeds pull the moisture content down to surprisingly low figures, the average, as already given, being 0.584 per cent for corn, 0.42 per cent for beans, and 0.83 per cent for wheat. This evidently depends considerably upon the rapidity with which water moves through the soil, as referred to above. In this connection, while Briggs and Shantz found the same amount of moisture remaining in the soil at permanent wilting regardless of the kind of plants grown in it, results here show quite the contrary, as just pointed out. Of course their plants had root systems distributed through the soil and with very short distances, comparatively, to pull the water; transpiration was going on; and wilting gave a more or less definite end-point; while here, there were practically no roots, just as many absorbing centers as there were seeds. There was no transpiration to be a factor, and the end-point was not even approximately fixed, making this problem really in no way comparable to theirs. Yet, in a series from the corn tests where the moisture supplied was above the wilting coefficient, there remained at the close of the tests, 0.48, 0.51, 0.68, 0.67, 0.69, and 0.51 per cent, respectively, and with the crude apparatus used, with the lack of soil temperature control, and with the variations in the end-points reached, these do not really differ a great deal.

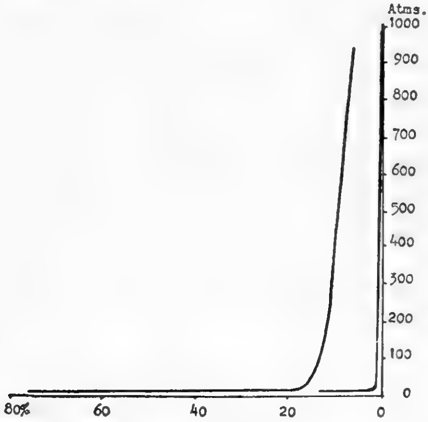

FIG. 2. Curves showing increase in the surface forces of soils as drying proceeds; to the left, for subsoil of the Oswego silt loam; to the right, for No. 2/0 sand.

But, in contrast, in those tests which started with just about this amount of water, the corn grains showed absorptive power sufficient to pull the water down to 0.29, 0.38, and 0.41 per cent, respectively. Dead plants, as shown by Briggs and Shantz (1), would have done this, or more, if extending through the seal, but here it went into the seeds. This is especially interesting in view of the fact shown by Shull (8) in his graph reproduced here, that the soil forces tending to retain moisture increase enormously as the soil becomes drier and drier, especially when approaching air-dry conditions. In these three instances there is shown a tremendous absorptive power which is evidently not present in the six cases given above, or they would have pulled more moisture from the sand.

But Shull (9) also found that air-dry seeds of the cocklebur (hygroscopic moisture, 7 per cent) had an internal attractive force for water of 965 atmospheres, or over 14,000 pounds per square inch, and that when these seeds had absorbed an additional 7 per cent of water this force had dropped to less than 400 atmospheres. The absorptive power shown by the three instances referred to in the paragraph above seems to bear out his findings. In the case of the other six, there was evidently sufficient water in the sand to allow an equilibrium to be reached between the opposing external and internal forces before the percentage of water present was pulled to the low figure reached by the other set.

Another way of looking at the results mentioned above, numbers 39, 41, and 43 were given about the same amount of water each, practically half that required for the wilting coefficient of this sand, and the results are practically the same. By calculation, disregarding that removed in sampling, each tumbler contained a total water content of about 1.3 grams. Of this, the seeds absorbed about half, 0.48, 0.62, and 0.72 grams, respectively. According to table 1, 41 per cent of the weight of the corn seed is the minimum for fair germination when conditions are favorable. Forty-one per cent here is 0.73 gram. The maximum used as shown in the table is 55 per cent, or, that would be here, 1 gram. With 0.48 to 0.72 gram of water used here, with 0.73 to 1 gram used when conditions are favorable for absorption, with the weight of the seeds practically the same, and with the moisture content of the soil pulled down to 0.29-0.41 per cent, it would seem that when the lower limit of possible water absorption from the surrounding soil was reached by these seeds in the cases quoted, they had been unable to secure water enough for germination. The lower limit is probably somewhere about 0.75 to 0.85 per cent.

In comparison, number 36 used but about 0.64 gram of water for complete germination, and when this was complete, as much water remained in the sand as each of the three mentioned had to start with. But why should number 36 germinate when it had absorbed 0.64 gram of water and number 43 fail to do so when it absorbed 0.72 gram? Has the rate of absorption or the amount remaining in the soil anything to do with it?

CONCLUSIONS.

1. Seeds can germinate when supplied with amounts of water which are below the wilting coefficient for the particular soil used.

2. A uniform water content remaining in the soil when permanent wilting occurs in the plants growing in it, regardless of species, does not hold true for seeds germinating in such a soil even when the amount supplied could have been used in germination.

3. While the amount of water used by seeds for germination may be more or less constant when moisture is abundant, they may germinate with far smaller quantities when the supply is scanty.

4. When the supply of moisture is scanty, the time required for germination is correspondingly lengthened.

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Army service interrupted this work and it is not now convenient to resume it. Its imperfections are realized, but it is hoped that it adds something to our knowledge in this field and that it may suggest further investigation.

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A Special Riemann Surface.*

BY H. H. CONWELL.

(Plates II to V.)

THE purpose of this paper is to consider in detail, for elliptic functions and briefly for hyper-elliptic functions, a special Riemann surface in three space obtained as the projection of the intersection of two hyper-surfaces in four space.

It will be seen that the surface investigated here is of advantage in the fact that it can be easily identified, from the point of view of analysis situs, with a double-faced disk having p holes; where $p = \left[\frac{n-1}{2}\right]$†, n being the degree of the function. In Riemann's real representation this is obtained only after an artificial and somewhat complicated dissection of the surface, in which the determination of the branch points is a very important factor. In a sense this difficulty may be said in our case to have been merely shifted from such a dissection to the construction of a certain real surface from its equation in three space. This construction can, however, be made very simple. In the ordinary Riemann surface the actual location of the branch points is difficult at best, and is useless so far as the investigations bearing on the surface are concerned. The actual construction of the surface under consideration will be avoided except in the simplest case, and then only as much of its outline as is necessary will be obtained. This construction will be found to be comparatively simple.

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* Received for publication on April 29, 1920.

† $\left[\frac{n-1}{2}\right]$ is understood to mean the greatest integer in $\frac{n-1}{2}$.

Let $f(w, z) = O$ be an irreducible polynomial in the two complex variables w and z, with either real or imaginary constant coefficients. Substituting $w = u + iv$ and $z = x + iy$ in the above relation we obtain the equation,

$$P\ (x, y, u, v) + iQ\ (x, y, u, v) = 0 \quad \ldots\ldots\ldots\ldots \quad (1)$$

Whence,

$$P\ (x, y, u, v) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$Q\ (x, y, u, v) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

The last two equations represent real three dimensional manifolds in the real four space (x, y, u, v). Their intersection in four space will be the surface Φ. Assume that $w = w_0$ when $z = z_0$. It is then possible, in the neighborhood z_0, w_0, to expand $(w - w_0)$ in powers of $(z - z_0)$ and by analytical continuation to go from the neighborhood of z_0 to the neighborhood of z_1. As z changes from z_0 to z_1, w will change from w_0 into one of the values w_1 corresponding to z_1. If this process be continued until z by a continuous succession of values returns to z_0, w may or may not return to w_0. In the first case the representative point on Φ corresponding to a pair of values (w, z) will describe a closed path, while in the second case the path will be open. The obvious one to one correspondence between points of the surface Φ and sets of values (w, z) shows that this surface can play the same role as the ordinary Riemann surface.

If between equations (2) and (3) v is eliminated there arises the relation,

$$F\ (x, y, u) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

which represents in the three space (x, y, u), a surface F, viz., the projection of Φ in that space. This surface F, as well as Φ, can be used as a Riemann image, this being the configuration to be investigated in this paper. We shall limit ourselves, as before stated, to the hyper-elliptic case. It is evident that the x, y or u projection of Φ would serve the same purpose as F.

Before proceeding with the general cubic a special cubic will be considered in detail, and enough of the resulting surface constructed to show its properties as a Riemann image. (This special cubic is chosen on account of its adaptability to cross-section representation.)

Consider the equation

$$w^2 = z^3 - 31z - 30 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

from which

$$P \equiv u^2 - v^2 - (x^3 - 3xy^2 - 31x - 30) = 0 \quad .. \quad (6)$$

and

$$Q \equiv 2uv - (3x^2y - y^3 - 31y) = 0 \ldots\ldots\ldots\ldots \quad (7)$$

The intersection of $P = 0$ and $Q = 0$ in four space is the surface Φ. The v projection of Φ in three space has for its equation

$$F\ (x, y, u) = 4u^4 - 4u^2\ (x^3 - 3xy^2 - 31x - 30) - (3x^2y - y^3 - 31y)^2 = 0 \ldots. \quad (8)$$

This surface is symmetric to both the XU and XY planes. The trace on the XU plane is the XX axis and the real curve

$$u^2 = x^3 - 31x - 30 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

representing all the real pairs (w, z) satisfying the original equation. The curve represented by (9) consists of an infinite branch and an oval (see fig. I). The XY trace consists of the XX axis and the hyperbola (see fig. II).

$$3x^2 - y^2 = 31 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

This hyperbola and the XX axis are the only double curves of the surface.

From equation (4) we obtain,

$$u = \pm \sqrt{\tfrac{2}{2}}\left[S + (S^2 + T^2)^{1/2}\right]^{1/2} \ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

where

$$S = x^3 - 3xy^2 - 31x - 30 \ldots\ldots\ldots\ldots\ldots \quad (12)$$

and

$$T = 3x^2y - y^3 - 31y \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (13)$$

In this expression for u only positive values of the inner radical are considered as only real points on the surface F are to be investigated. Investigations of (11) show that when $y = 0, \dfrac{\delta u}{\delta y} = 0$ for all values of x except 6, -1 and -5, where it is infinite. For values of $x \leqq \sqrt{\dfrac{31}{3}}$ and $y > 0$, $\dfrac{\delta u}{\delta y}$ is positive or negative according to whether u is positive or negative, while for negative values of y it is positive or negative according to whether u is negative or positive. Hence for all sections of the surface parallel to the $Y U$ plane, where $x \leqq \sqrt{\frac{31}{3}}$ there will be either both a maximum and minimum point, or a double point, for y equal zero and for no other finite value of y. For $x > \sqrt{\frac{31}{3}}$, there are other maximum and minimum points and double points, and the curves all pierce the $X Y$ plane along the curve represented by equation (10). From the preceding discussion and an inspection of equation (9) and figure I it is evident that the orthogonal projection of F upon the $X U$ plane will be nowhere within the oval, and hence that there is a hole in F for which the oval is the central section.

It is obvious that the surface F is composed of two sheets (see figs. I-VII) which hang together along the XX axis from $-\infty$ to -5, from -1 to $+6$ and pass through each other along the branch of the double curve $T = 0$ which lies to the right of the YY axis.

Sections parallel to the XU plane give curves composed of two branches which cut each other in points on one branch of the double curve $T = 0$ and nowhere else. Each branch continues to infinity and there unites parabolically with the other. The YU sections also unite parabolically at infinity, and hence the two sheets of the surface F merge into each other everywhere at infinity.

The surface F may be reduced to a double-faced disk with one hole as follows: For all values of $x > \sqrt{\frac{31}{3}}$ deform the surface by pulling the sheets through each other in such a way that instead of cutting in two distinct points on $T = 0$ for each value of x they will cut each other in two coincident points. This deformation will be continuous and approach zero in magnitude as x approaches $\sqrt{\frac{31}{3}}$ and will nowhere produce a tear in the surface. Having made this deformation, project the surface upon the XU plane and the result will be a double-faced disk with one hole.

Starting at a point P in sheet I and continuing in any direction on the surface F we can always return to P. This closed path may be all in sheet *I* or in both sheets *I* and *II*. It may or may not pass through or around the oval. In the latter case the circuit can always be reduced to zero while in the former it cannot be so reduced, unless there be an even number of such passages and they be in opposite directions. Hence any closed circuit on F can be reduced to zero or to sums of multiples of two irreducible circuits. These facts show the elliptic function to be doubly periodic over F.

THE GENERAL ELLIPTIC CASE FOR WHICH $f(z)$ HAS REAL ROOTS.

We shall now extend the preceding discussion to a general elliptic function of the type

$$w^2 = z^3 - pz + q \qquad (14)$$

where p is positive and q either positive or negative, and where the roots of

$$z^3 - pz + q = 0 \qquad (15)$$

are all real. It will be shown that the resulting surface $F\ (x, y, u) = 0$ has properties identical with those of the special case already investigated, if judged from the point of view of the investigations of this paper.

We obtain at once, as in the preceding case,

$$F\ (x, y, u) = 4u^4 - 4u^2 S - T^2 = 0 \qquad (16)$$

where

$$S = x^3 - 3xy^2 - px + q \qquad (17)$$

and

$$T = 3x^2y - y^3 - py \qquad (18)$$

The similarity of the XU and XY traces to those in the preceding case is obvious. From (16) we obtain,

$$\frac{\partial u}{\partial y} = \frac{\sqrt{2}\, y[-6x(S^2 - T^2)^{1/2} + 3x^4 + 6x^2y^2 - 6qx + 3y^4 + 4py^2 - p^2}{4\ (S^2 - T^2)^{1/2}\, [S + (S^2 + T^2)^{1/2}\,]^{1/2}}.$$

For $y = 0$, $\frac{\partial u}{\partial y} = 0$ for all values of x except the roots of $x^3 - px + q = 0$, where it is infinite. For all negative values of $x \leqq \sqrt{\frac{p}{3}}$, $\frac{\partial u}{\partial y}$ is positive or negative for values of $y > 0$, according to whether u is positive or negative, and negative or positive for $y < 0$ according as u is positive or negative. Hence for all sections parallel to the $Y\,U$ plane, where $x \leqq \sqrt{\frac{p}{3}}$ there will be a maximum and minimum point for y equal zero and for no other finite value of y. Since the sum of the roots of (15) are zero, at least one root must be negative and at least one positive. It is also evident that the oval passes through the two smaller roots of (15). Let r_1, r_2, r_3, be the roots of (15), where $r_3 > r_2 > r_1$; then $r_1 + r_2 + r_3 = 0$ and $-r_1 r_2 r_3 = q$. From the last relation and the fact that $\frac{2}{3} p \sqrt{\frac{p}{3}} > q$ it is evident that $\frac{2}{3} p \sqrt{\frac{p}{3}} > 2 r^3_2$ and therefore $\sqrt{\frac{p}{3}} > r_2$; in other words, $x = \sqrt{\frac{p}{3}}$ does not lie within the oval.

For $x > \sqrt{\frac{p}{3}}$ there are other maximum and minimum points or double points than for y equal zero. As in the simpler case these sections are parabolic in nature.

These investigations show that this surface has no important characteristics, from our point of view, not common to the more special case and is therefore always reducible to a double-faced disk with one hole.

THE GENERAL ELLIPTIC CASE.

Up to this point the investigations have been confined to the type, $w^2 = z^3 - pz + q$, where p and q were both real, p positive and the roots all real. It will now be shown that no generality is lost by this restriction.

Consider the general elliptic case,

$$w^2 = f(z) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (20).$$

where

$$f(z) = a_0(z - r_1)(z - r_2)(z - r_3)(z - r_4) \quad \ldots (21)$$

and a_0, r_1, r_2, r_3, r_4, are real or imaginary constants. The elliptic integral resulting from this form may by a well known transformation of $f(z)$ be made to depend upon an integral of the type,

$$g(z) = b_0(z^3 - a_2 z - a_3).^* \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (22)$$

No generality is therefore lost by replacing $f(z)$ by $g(z)$. The constants of (22) may be positive or negative, real or imaginary. If a_2 and a_3 are arbitrarily changed the surface F will undergo a deformation. The only matter of interest in the present paper is whether such a deformation increases or decreases the number of holes in F. It is of course evident that if the number of holes is diminished as a_2 and a_3 assume the

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* Boehm, Elliptische Functionen, Zweiter Teil, page 128.

values a^0_2 and a^0_3, that as a_2 and a_3 approach a^0_2 and a^0_3 in value, one or more holes in the surface must be continually decreasing in size in such a way that when a^0_2 and a^0_3 are reached the surface has a node at the point (x_0, y_0, u_0) on F and *vice versa*. If (x_0, y_0, u_0, v_0) is the corresponding point on Φ, the latter will also have a node at this point. Therefore corresponding to nodes on F are nodes on Φ. At such nodes the tangent hyper-planes to

$$P\ (x, y, u, v) = 0$$

and

$$Q\ (x, y, u, v) = 0$$

are coincident. In order to investigate the nature of F at such places write the equations of the tangent hyper-planes to P and Q at the point (x_0, y_0, u_0, v_0), and the conditions for their coincidence. The equations in question are,

$$(x-x_0)\,P'\mathrm{x}_0+(y-y_0)P'\mathrm{y}_0+(v-v_0)P'\mathrm{e}_0+(u-u_0)\,P'\mathrm{u}_0=0, \quad (23)$$

and

$$(x-x_0)Q'\mathrm{x}_0+(y-y_0)Q'\mathrm{y}_0+(u-u_0)Q'\mathrm{u}_0+(v-v_0)Q'\mathrm{v}_0=0 \quad .(24)$$

The conditions for these two hyper-planes to be coincident is that

$$\frac{P'\mathrm{x}_0}{Q'\mathrm{x}_0}=\frac{P'\mathrm{y}_0}{Q'\mathrm{y}_0}=\frac{P'\mathrm{u}_0}{Q'\mathrm{u}_0}=\frac{P'\mathrm{v}_0}{Q'\mathrm{v}_0}\,.$$

It is evident, however, from the relation

$$P\,(x, y, u, v)+i\,Q\,(x, y, u, v)=0$$

that

$$P'\mathrm{x}_0=Q'\mathrm{y}_0,\ P'\mathrm{y}_0=-Q'\mathrm{x}_0,\ P'\mathrm{u}_0=Q'\mathrm{v}_0, \text{ and } P'\mathrm{v}_0=-Q'\mathrm{u}_0\,.$$

Hence

$$P^{2\prime}\mathrm{x}_0+Q^{2\prime}\mathrm{x}_0=0, P^{2\prime}\mathrm{y}_0+Q^{2\prime}\mathrm{y}_0 0,=P^{2\prime}\mathrm{u}_0+Q^{2\prime}\mathrm{u}_0=0 \text{ and } P^{2\prime}\mathrm{v}_0+Q^{2\prime}\mathrm{e}_0=0$$

and therefore

$$P\mathrm{x}'_0=P'\mathrm{y}_0=P'\mathrm{u}_0=P\mathrm{v}_0=Q'\mathrm{x}_0=Q'\mathrm{y}_0=Q'\mathrm{u}_0=Q'\mathrm{v}_0=0.$$

In the above relations

$$P=u^2-v^2-s\ (x, y)$$

and

$$Q=2uv-t\ (x, y),$$

therefore it follows that $u=0$ and $v=0$ and therefore that $g\ (z)=0$. Moreover, since

$$P'\mathrm{x}_0+i\,Q'\mathrm{x}_0=0 \text{ and } P'\mathrm{y}_0+i\,Q'\mathrm{y}_0=0$$

it follows that

$$s'x_0 + it'x_0 = 0 \text{ and } s'y_0 + it'y_0 = 0.$$

Therefore $g'\ (z_0) = 0$, showing that z is a double root of $g\ (z) = 0$. It is evident therefore that the surfaces P and Q, and hence F, may be deformed in any way we please without affecting its analysis situs properties provided that during this deformation $g\ (z) = 0$ never acquires any double roots. These conditions allow a deformation that will change complex roots into real and unequal roots without any two roots becoming equal in the process. Hence we may in this manner transform $g\ (z)$ into $j\ (z)$, where the roots of $j\ (z)$ are real and unequal.

The above conclusions show that no generality is lost in considering the simpler case and thereby avoiding the difficult task of dealing with imaginary coefficients. The difficulty introduced by imaginary coefficients is that due to the lack of symmetry with respect to the XU plane.

It is evident now that the surface constructed from the simplest possible relation is sufficient for a complete exposition of the Riemann surface properties of the most general elliptic function.

A NUMERICAL EXAMPLE OF THE HYPER-ELLIPTIC CASE.

As an introduction to the general hyper-elliptic function we will consider briefly a simple numerical example of the same. The details of the surface F will be considered sufficiently to show that the preceding discussion can be applied in all its essential details to the higher form. For this purpose consider the equation

$$w^2 = (z - 5)\ (z - 1)\ (z + 1)\ (z + 2)\ (z + 3).$$

The surface $F(x, y, u) = 0$ will be represented by

$$4u^4 - 4u^2S - T^2 = 0,$$

where

$$S = x^5 - 10x^3y^2 + 5xy^4 - 20x^3 + 60xy^2 - 30x^2 + 30y^2 + 19x + 30$$

and

$$T = 5x^4y - 10x^2y^3 + y^5 - 60x^2y + 20y^3 - 60xy + 19y.$$

The surface F is symmetric to the XU and XY planes. The trace on the XU plane is the XX axis and the real curve

$$v^2 = (x - 5)\ (x - 1)\ (x + 1)\ (x + 2)\ (x + 3)$$

representing all the real pairs (w, z) satisfying the original equation. The latter consists of two ovals and an infinite branch. The trace on the XY plane is the double curve represented by the equation $T^2 = 0$. This curve is composed of the XX axis and four infinite branches which are hyperbolic in form and coaxial (see fig. VIII).

Sections parallel to the XU plane give rise to curves which have double points on the branches I and III of the double curve, as shown in the figure, and nowhere else. This is shown by an investigation of the value of S in the neighborhood of these branches. For the two branches to hang together or intersect each other, it is necessary that T be equal to zero and S be negative or zero. Every pair of values (x, y) on one of these infinite branches reduces T to zero, but none of these pairs on branch II or IV will cause S to be negative or zero. Therefore the two sheets of the surface F do not cut through each other along either of these branches. The two sheets hang together along the XX axis from $-\infty$ to -3, -2 to -1, from $+1$ to $+5$ and cut each other along the two branches I and III of $T = 0$. To prove, as in the elliptic case, that the two sheets never hang together for any finite value of y except zero would be very complicated, and so another method is employed. It is easily seen that any section parallel to the YU plane will give rise to a curve which has a number, say d, double points. But this curve is composed of two branches which intersect in d points in the XY plane. If d is odd the two branches are odd and hence each branch stretches off to infinity in both directions. If d is even, each branch is even and hence cuts the line at infinity in an even number of places and is accordingly a closed curve. In the first case (d odd) the XX axis must be composed of intersection points, while in the latter it is not. This leads to the conclusion that all sections which cut the curve $u = f(x)$, $y = 0$ give rise to even branches and all others to odd. Hence the former are always reducible to traces of the form, fig. V or fig. VI, while the latter are always reducible to branches of the form fig. VII. From this will follow, as in the elliptic case, that F is two-sheeted and contains two holes. By a deformation similar to the one described in the example of the elliptic case, it may be brought into the form of a double-faced disk with two holes. Hence all closed circuits on F may be reduced to zero or to sums of multiples of four irreducible circuits.

Having considered the elliptic case in detail and investigated briefly a special hyper-elliptic function, we now proceed to the most general hyper-elliptic function, $w = R(z)$, where $R(z)$ is of degree n.

Forming the equation of the surface F in the usual manner, there arises the equation $F(x, y, u) = 0$, where F is of degree $2n$ in (x, y, u). $F(x, y, u) = 0$ may always be put in the form,

$$4u^4 - 4u^2S - T^2 = 0,$$

where S and T are polynomials in x and y of degree n. As has been shown in the preceding considerations, $R(z)$ may be assumed to have only real roots. Hence the surface F is symmetric to the XU and XY planes. The XU trace will consist of the XX axis and a curve representing all real pairs (w, z) satisfying the original equation. The latter curve will consist of one or two infinite branches, according to whether n is odd or even, and p ovals. The XY trace will be a double curve represented by $T = 0$ and consisting of the XX axis and a curve represented by an equation of degree $(n - 1)$. This double curve represents all the real double points of the surface F.

The surface F is composed of two sheets which hang together everywhere along the XX axis except for values of x which satisfy the equation $u = R(x), y = 0$, and cut each other along certain branches of the double curve $T = 0$. Corresponding to the p ovals there will be p holes in F. All closed circuits on F may be reduced to sums of multiples of $2p$ irreducible circuits.

DOUBLE CURVES.

The double curves of the surface F arise as the result of projecting the surface Φ from four space into three space, the center of projection being at infinity. Whenever a projecting line cuts Φ in two places a double point occurs on F. If the two points on Φ be real the double point on F will be a real double point connected with the surface F, but if the two points on Φ be imaginary the resulting double point on F will be isolated. This gives rise to two classes of double curves, one being on the surface F and the other being related to the surface but isolated from it.

In the elliptic case the double curves consisted of the XX axis and an hyperbola. That part of the XX axis included by the real part of the curve $u = f(x)$, $y = 0$ is isolated. Of the hyperbola, that branch lying to the left of the YU plane is isolated.

In the hyper-elliptic example the double curve consists of the XX axis and four infinite branches. What was said of the XX axis for the elliptic case holds here also. Of the four infinite branches two are isolated (see fig. VIII), and two are curves of intersection of the two sheets of the surface.

The same conditions will exist in the general hyper-elliptic case, the XX axis always being a double curve with the same law as to isolated points as in the simpler cases. The other double curves will be partly isolated and partly curves of intersection of the two sheets of the surface. The isolated curves separate themselves from the other class in that they always pass through one or more of the ovals, while the curves of intersection of sheets never do.

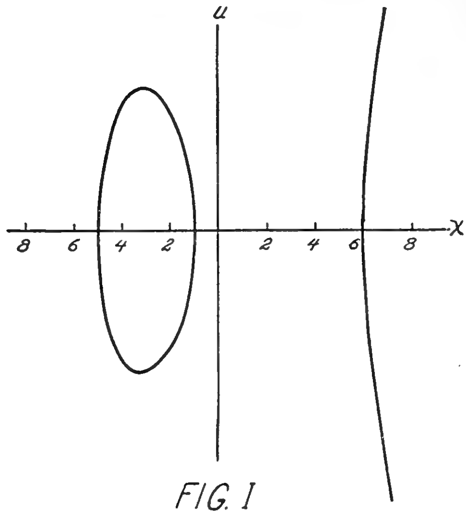

FIG. I

$F(x, y, u) = 0,\ y = 0$

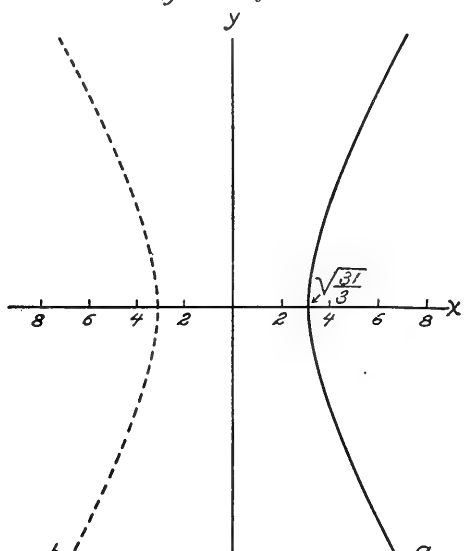

FIG. II

$F(x, y, u) = 0,\ u = 0$, (b) isolated

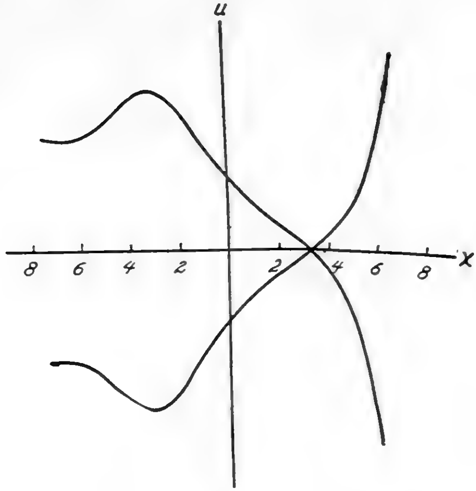

FIG. III

$F(x, y, u) = 0, y = 1$

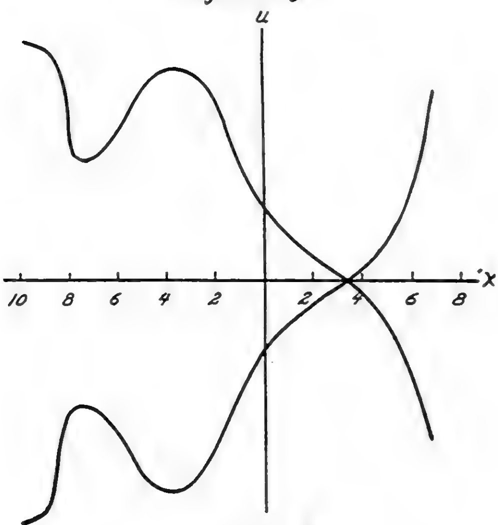

FIG. IV

$F(x, y, u) = 0, y = 2$

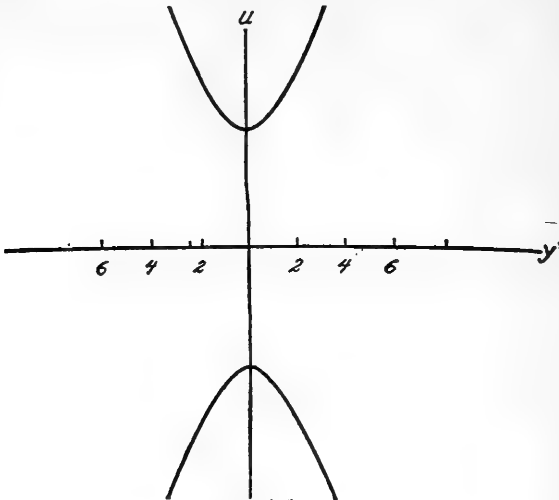

FIG. V
$F(x, y, u) = 0, \ x = -2$

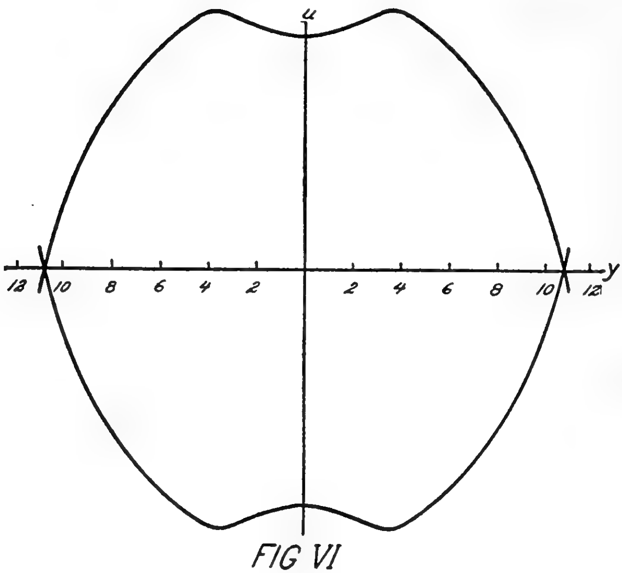

FIG VI
$F(x, y, u) = 0, \ x = 7$

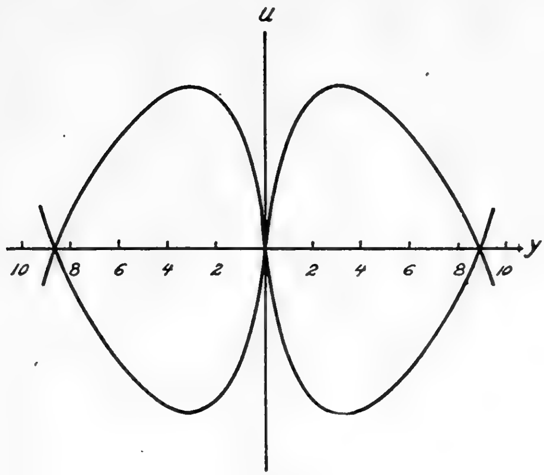

FIG. VII

$F(x, y, u) = 0, \quad x = 6$

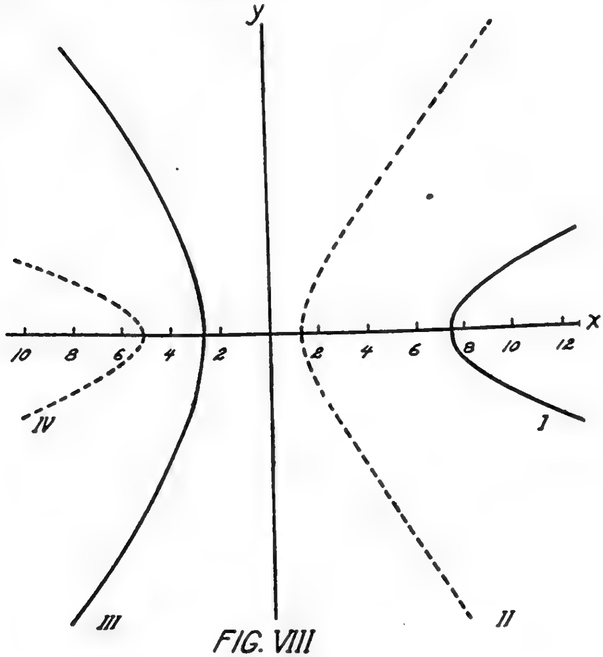

FIG. VIII

$F(x, y, u) = 0, \quad u = 0$ II and IV isolated.

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A Calculation of the Invariants and Covariants for Ruled Surfaces.*

BY E. B. STOUFFER.

IN Wilczynski's *Projective Differential Geometry of Curves and Ruled Surfaces* † it is shown that the projective differential properties of a non-developable ruled surface may be studied by means of a system of differential equations of the form ‡

$$(A)\begin{cases} y''+2p_{11}y'+2p_{12}z'+q_{11}y+q_{12}z=0,\\ z''+2p_{21}y'+2p_{22}z'+q_{21}y+q_{22}z=0,\end{cases}$$

where p_{ik} and q_{ik} are functions of the independent variable x. The most general transformations leaving (A) unchanged in form are given by the equations

$$(1)\begin{cases} y=a_{11}\bar{y}+a_{12}\bar{z},\\ z=a_{21}\bar{y}+a_{22}\bar{z},\end{cases}\qquad \triangle\equiv a_{11}a_{22}-a_{12}a_{21}\neq 0,$$

$$(2)\qquad \xi=\xi(x),$$

where a_{ik} and ξ are arbitrary functions of x.

A function of the coefficients of (A) and their derivatives and of the dependent variables and their derivatives which remains unchanged in value by the transformation (1) is called a *semi-covariant* and if it remains unchanged in value also by the transformation (2) it is called a *covariant*. Semi-covariants or covariants which do not involve the dependent variables or their derivatives are called *seminvariants* or *invariants*, respectively. The invariants and covariants of system (A) are used in the study of the

* Received for publication May 10.

† Teubner, Leipzig, 1906.

‡ Wilczynski writes his system without the factor 2 in the coefficients of y' and z'. Its introduction makes some of the results appear in simpler form.

properties of ruled surfaces. Their calculation as given by Wilczynski involves the solution of several rather complicated systems of partial differential equations. It is the purpose of this paper to obtain the same results by much shorter methods.

In 1915 Green published a paper* in which he obtains the invariants and covariants of the general form of the system of partial differential equations associated with curved surfaces from the invariants and covariants of a canonical form of these equations. Green points out that his general method is of wide application. This scheme of making the calculations first for a simplified system and then transforming to the coefficients of the original system is used in the present paper.

The results in this paper carry the same label as do the corresponding results in Wilczynski's book but there are differences in numerical coefficients and in signs because of the introduction of the binomial coefficients in equations (A) and because of a change of sign in the defining expression for u_{ik}.

1. The Semi-Canonical Form.

Let us make the transformation (1) upon the system (A). There immediately results the system

$$(3)\quad \begin{cases} \alpha_{11}\bar{y}'' + \alpha_{12}\bar{z}'' + 2\,(\alpha'_{11} + p_{11}\alpha_{11} + p_{12}\alpha_{21})\bar{y}' + \\ \qquad\qquad 2\,(\alpha'_{12} + p_{11}\alpha_{12} + p_{12}\alpha_{22})\,\bar{z}' \\ \quad + (\alpha''_{11} + 2\,p_{11}\alpha'_{11} + 2\,p_{12}\alpha'_{21} + q_{11}\alpha_{11} + q_{12}\alpha_{21})\,\bar{y} \\ \quad + (\alpha''_{12} + 2\,p_{11}\alpha'_{12} + 2\,p_{12}\alpha'_{22} + q_{11}\alpha_{12} + q_{12}\alpha_{22})\,\bar{z} = 0, \\ \alpha_{21}\bar{y}'' + \alpha_{22}\bar{z}'' + 2\,(\alpha'_{21} + p_{21}\alpha_{11} + p_{22}\alpha_{21})\,\bar{y}' + \\ \qquad\qquad 2\,(\alpha'_{22} + p_{21}\alpha_{12} + p_{22}\alpha_{22})\bar{z}' \\ \quad + (\alpha''_{21} + 2\,p_{21}\alpha'_{11} + 2\,p_{22}\alpha'_{21} + q_{21}\alpha_{11} + q_{22}\alpha_{21})\,\bar{y} \\ \quad + (\alpha''_{22} + 2\,p_{21}\alpha'_{12} + 2\,p_{22}\alpha'_{22} + q_{21}\alpha_{12} + q_{22}\alpha_{22})\bar{z} = 0. \end{cases}$$

If α_{ik} are so chosen that

$$(4)\quad \alpha'_{ik} = -\sum_{j=1}^{2} p_{ij}\,\alpha_{jk}, \quad (i, k = 1, 2),$$

the coefficients of $\bar{y}'$ and $\bar{z}'$ in (3) vanish. Such a solution for α_{ik} is always possible since it is equivalent merely to choosing $(\alpha_{11}, \alpha_{21})$ and $(\alpha_{12}, \alpha_{22})$ as two distinct pairs of solutions of the system of differential equations

$$\begin{aligned} \rho' &= -\,(p_{11}\,\rho + p_{12}\,\sigma) \\ \sigma' &= -\,(p_{21}\,\rho + p_{22}\,\sigma). \end{aligned}$$

*G. M. Green, *On the Theory of Curved Surfaces, and Canonical Systems in Projective Differential Geometry.* Transactions of the American Mathematical Society, Vol. 16 (1915), pp. 1-12.

The substitution from (4) into (3) now gives

$$(5)\begin{cases} a_{11}\overline{y}'' + a_{12}\overline{z}'' + (u_{11}a_{11} + u_{12}a_{21})\overline{y} + (u_{11}a_{12} + u_{12}a_{22})\overline{z} = 0, \\ a_{21}\overline{y}'' + a_{22}\overline{z}'' + (u_{21}a_{11} + u_{22}a_{21})\overline{y} + (u_{21}a_{12} + u_{22}a_{22})\overline{z} = 0, \end{cases}$$

where*

$$(6)\quad u_{ik} = q_{ik} - p'_{ik} - \sum_{j=1}^{2} p_{ij}p_{jk}, \quad (i, k = 1, 2).$$

The system (5) may be put into the form

$$(B)\begin{cases} \overline{y}'' + \overline{q}_{11}\overline{y} + \overline{q}_{12}\overline{z} = 0, \\ \overline{z}'' + \overline{q}_{21}\overline{y} + \overline{q}_{22}\overline{z} = 0, \end{cases}$$

if we write

$$(7)\quad \triangle\overline{q}_{ik} = \sum_{l=1}^{2}\sum_{j=1}^{2} A_{ji}a_{lk}u_{jl}, \quad (i, k = 1, 2),$$

where A_{ji} is the algebraic minor a_{ji} in the determinant of the transformation (1). Wilczynski calls (B) the semi-canonical form of the system (A).

The differentiation of equations (7) gives

$$(8)\quad \triangle\overline{q}'_{ik} = \sum_{l=1}^{2}\sum_{j=1}^{2}[A_{ji}a_{lk}u'_{jl} + A_{ji}a'_{lk}u_{jl} + A'_{ji}a_{lk}u_{jl}] - \triangle'\overline{q}_{ik}, \quad (i, k = 1, 2).$$

By the use of (4) we find

$$\sum_{j=1}^{2} A'_{ji}u_{jl} = \sum_{j=1}^{2} A_{ji}\left[-(p_{11} + p_{22})u_{jl} + \sum_{m=1}^{2} p_{jm}u_{ml}\right],$$

$$\triangle' = -(p_{11} + p_{22})\triangle,$$

whence it follows at once that

$$(9)\quad \triangle\overline{q}'_{ik} = \sum_{l=1}^{2}\sum_{j=1}^{2} A_{ji}a_{lk}v_{jl}, \qquad (i, k = 1, 2),$$

where

$$(10)\quad v_{ik} = u'_{ik} + \sum_{j=1}^{2}(p_{ij}u_{jk} - p_{jk}u_{ij}), \quad (i, k = 1, 2).$$

It follows without calculation that

$$(11)\quad \triangle\overline{q}''_{ik} = \sum_{l=1}^{2}\sum_{j=1}^{2} A_{ji}a_{lk}w_{jl}, \quad (i, k = 1, 2),$$

where

$$(12)\quad w_{ik} = v'_{ik} + \sum_{j=1}^{2}(p_{ij}v_{jk} - p_{jk}v_{ij}), \quad (i, k = 1, 2).$$

*The expression here used for u_{ik} differs in sign as well as in numerical coefficients from that used by Wilczynski.

Let us rewrite transformations (1) and (2) in the form

$$(13)\quad \begin{cases} \bar{y} = \beta_{11}\, Y + \beta_{12}\, Z, \\ \bar{z} = \beta_{21}\, Y + \beta_{22}\, Z, \end{cases} \qquad \beta_{11}\beta_{22} - \beta_{12}\beta_{21} \neq 0.$$

$$(14)\quad \xi = \xi(x),$$

and find the most general nature which these transformations may have and still leave (B) in the semi-canonical form. By these transformations (B) is converted into

$$(15)\quad \begin{cases} \beta_{11}(\xi')^2 \dfrac{d^2 Y}{d\xi^2} + \beta_{12}(\xi')^2 \dfrac{d^2 Z}{d\xi^2} + (\beta_{11}\xi'' + 2\beta'_{11}\xi') \dfrac{dY}{d\xi} + \\ \qquad (\beta_{12}\xi'' + 2\beta'_{12}\xi') \dfrac{dZ}{d\xi} + (\beta''_{11} + \bar{q}_{11}\beta_{11} + \bar{q}_{12}\beta_{21})\, Y + \\ \qquad\qquad (\beta''_{12} + \bar{q}_{11}\beta_{12} + \bar{q}_{12}\beta_{22})\, Z = 0, \\ \beta_{21}(\xi')^2 \dfrac{d^2 Y}{d\xi^2} + \beta_{22}(\xi')^2 \dfrac{d^2 Z}{d\xi^2} + (\beta_{21}\xi'' + 2\beta'_{21}\xi') \dfrac{dY}{d\xi} + \\ \qquad (\beta_{22}\xi'' + 2\beta'_{22}\xi') \dfrac{dZ}{d\xi} + (\beta''_{21} + \bar{q}_{21}\beta_{11} + \bar{q}_{22}\beta_{21})\, Y + \\ \qquad\qquad (\beta''_{22} + \bar{q}_{21}\beta_{12} + \bar{q}_{22}\beta_{22})\, Z = 0. \end{cases}$$

This system is in the form of system (B) if and only if

$$\beta_{ij}\,\xi'' + 2\,\beta_{ij}\,\xi' = 0, \quad (i, j = 1, 2),$$

that is, if

$$(16)\quad \beta_{ij} = \frac{b_{ij}}{\sqrt{\xi'}}, \quad (i, j = 1, 2),$$

where b_{ij} are constants. If these values for β_{ij} are substituted into (15) that system may be written in the form

$$(C)\quad \begin{cases} \dfrac{d^2 Y}{d\xi^2} + Q_{11}\, Y + Q_{12}\, Z = 0, \\ \dfrac{d^2 Z}{d\xi^2} + Q_{21}\, Y + Q_{22}\, Z = 0, \end{cases}$$

if we put

$$(17)\quad D\,Q_{ik} + \frac{1}{(\xi')^2} \sum_{j=1}^{2} B_{ji}\left[\left(\tfrac{1}{4}\eta^2 - \tfrac{1}{2}\eta'\right) b_{ik} + \sum_{l=1}^{2} b_{lk}\,\bar{q}_{jl}\right], \quad (i, k = 1, 2),$$

where $\eta = \dfrac{\xi''}{\xi'}$ and where B_{ji} is the minor of b_{ji} in the determinant $D \equiv b_{11}b_{22} - b_{12}b_{21}$.

The transformations

$$(18)\quad \begin{cases} \bar{y} = \dfrac{b_{11}}{\sqrt{\xi'}} Y + \dfrac{b_{12}}{\sqrt{\xi'}} Z, \\ \bar{z} = \dfrac{b_{21}}{\sqrt{\xi'}} Y + \dfrac{b_{22}}{\sqrt{\xi'}} Z, \\ \xi = \xi(x). \end{cases}$$

which leave B unchanged in form may be considered as consisting of the transformation

$$(19)\quad \begin{cases} \bar{y} = b_{11} Y + b_{12} Z, \\ z = b_{21} Y + b_{22} Z, \end{cases} \qquad D \equiv b_{11} b_{22} - b_{12} b_{21} \neq 0,$$

in which $\xi = x$, and of the transformations

$$(20)\quad \begin{cases} \bar{y} = \dfrac{1}{\sqrt{\xi'}} Y, \\ \bar{z} = \dfrac{1}{\sqrt{\xi'}} Z, \\ \xi = \xi(x), \end{cases}$$

in which $b_{11} = b_{22} = 1$ and $b_{12} = b_{21} = 0$.

2. The Seminvariants.

Let us first find those functions of the coefficients of (B) and their derivatives which remain unchanged in value by the transformation (19). Equations (17) show that (19) converts $\bar{q}_{ik}$ into Q_{ik} where

$$(21)\quad D Q_{ik} = \sum_{l=1}^{2} \sum_{j=1}^{2} B_{ji} b_{lk} \bar{q}_{jl}, \quad (i, k = 1, 2).$$

If the transformation (19) is made infinitesimal by putting $b_{ii} = 1 + \varphi_{ii}\, \delta t$ and $b_{ij} = \varphi_{ij}\, \delta t$, $(i \neq j)$, where φ_{ij} are arbitrary constants and δt an infinitesimal, the infinitesimal transformations of $\bar{q}_{ik}$ are found from (21) to be

$$(22)\quad \delta \bar{q}_{ik} = \sum_{j=1}^{2} (\varphi_{jk} \bar{q}_{ij} - \varphi_{ij} \bar{q}_{jk})\, \delta t, \quad (i, k = 1, 2).$$

In accordance with the Lie theory the desired functions must satisfy the system of partial differential equations.

$$(23)\quad U_{rs} f \equiv \sum_{l=1}^{2} \left(\bar{q}_{lr} \frac{\delta f}{\delta \bar{q}_{ls}} - \bar{q}_{sl} \frac{\delta f}{\delta \bar{q}_{rl}}\right) = 0, \quad (r, s = 1, 2).$$

Between these four equations there are the two relations

$$(24)\quad U_{11} + U_{22} = 0,$$

(25) $\bar{q}_{12} U_{12} + \bar{q}_{21} U_{21} + \bar{q}_{11} U_{11} + \bar{q}_{22} U_{22} = 0.$

Since the system contains four variables there are just two solutions. These are easily seen to be

$$I = \bar{q}_{11} + \bar{q}_{22}, \quad J = \bar{q}_{11}\bar{q}_{22} - \bar{q}_{12}\bar{q}_{21}.$$

Since the coefficients in (19) are constants the transformations of the various derivatives of $\bar{q}_{ik}$ will be of exactly the same form as the transformations of $\bar{q}_{ik}$. The differential equations for the functions involving $\bar{q}'_{ik}$ as well as $\bar{q}_{ik}$ are simply (23) with terms of the same form in $\bar{q}'_{ik}$ added. The relations (25) ceases to hold so that there are just three more solutions. These are evidently

$$I', J', K = \bar{q}'_{11}\bar{q}'_{22} - \bar{q}'_{12}\bar{q}'_{21}.$$

In the system of equations for the functions involving also $\bar{q}''_{ik}$ there are just three independent equations and four more variables so that there are four more solutions. These are evidently

$$I'', J'', K', L = \bar{q}''_{11}\bar{q}''_{22} - \bar{q}''_{12}\bar{q}''_{21}.$$

A continuation of this process shows that all the desired functions involving higher derivatives of $\bar{q}_{ik}$ can be obtained by forming the successive derivatives of I, J, K, L.

Let us now substitute in I, J, K, L and their derivatives the expressions for $\bar{q}_{ik}$, $\bar{q}'_{ik}$, $\bar{q}''_{ik}$ given in (7), (9) and (11). A comparison of these equations with (21) and its derivatives shows that $\bar{q}_{ik}$ is expressed in terms of u_{ik}, q'_{ik} in terms of v_{ik}, and $\bar{q}''_{ik}$ in terms of w_{ik} in exactly the same way that Q_{ik} is expressed in terms of $\bar{q}_{ik}$, Q'_{ik} in terms $\bar{q}'_{ik}$, and Q''_{ik} in terms of $\bar{q}''_{ik}$, respectively, except of course that a_{lk} replaces b_{lk}. If now in I, J, K, L or in their derivatives we replace $\bar{q}_{ik}$, $\bar{q}'_{ik}$, $\bar{q}''_{ik}$ by Q_{ik}, Q'_{ik}, Q''_{ik} respectively, we obtain the original functions of $\bar{q}_{ik}$, $\bar{q}'_{ik}$, $\bar{q}''_{ik}$. It follows therefore that if in I, J, K, L and their derivatives we replace $\bar{q}_{ik}$, $\bar{q}'_{ik}$, $\bar{q}''_{ik}$ by u_{ik}, v_{ik}, w_{ik}, respectively, we obtain the result of substituting (7), (9), (11) into these functions. In other words

$$(26)\left\{\begin{array}{ll} I = u_{11} + u_{22}, & J = u_{11}u_{22} - u_{12}u_{21}, \\ I' = v_{11} + v_{22}, & J' = u_{11}v_{22} + u_{22}v_{11} - u_{12}v_{21} - u_{21}v_{12}, \\ I'' = w_{11} + w_{22}, & J'' = 2K + u_{11}w_{22} + u_{22}w_{11} - u_{12}w_{21} - u_{21}w_{12}, \\ K = v_{11}v_{22} - v_{12}v_{21}, & L = w_{11}w_{22} - w_{12}w_{21}, \\ K' = v_{11}w_{22} + v_{22}w_{11} - v_{12}w_{21} - v_{21}w_{12}. & \end{array}\right.$$

The expressions (26) and their derivatives are all seminvariants of the system (A) and moreover they form a complete system of seminvariants for the system (A). To show these facts let us suppose that we have two systems of form (A) which are equivalent under a transformation of form (1). Each of these systems may be reduced to a semi-canonical form and these must be equivalent under a transformation of form (19). A seminvariant expression, $\bar{q}_{11} + \bar{q}_{22}$, say, formed for these two semi-canonical forms must be equal and each is equal to the expression $u_{11} + u_{22} = I$ formed for its corresponding original system. Therefore the two expressions for I are equal and I must be a seminvariant. The same reasoning applies to the other expressions (26). That we have a complete system of seminvariants is obvious from the fact that every seminvariant of (A) must have a semi-canonical form which remains unchanged by transformations which leave the semi-canonical form invariant.

3. The Semi-Covariants.

We shall now find the semi-covariants of (A) by finding first the semi-canonical form of these semi-covariants. The transformation (1) when solved for $\bar{y}$ and $\bar{z}$ has the form

$$(27)\quad \begin{cases} \Delta \bar{y} = a_{22}\, y - a_{12}\, z, \\ \Delta \bar{z} = -\, a_{21}\, y + a_{11}\, z. \end{cases}$$

When the coefficients of this transformation are subjected to the conditions (4) we find

$$(28)\quad \begin{cases} \Delta \bar{y}' = a_{22}\, \rho - a_{12}\, \sigma, \\ \Delta \bar{z}' = -\, a_{21}\, \rho + a_{11}\, \sigma. \end{cases}$$

where

$$(29)\quad \rho = y' + p_{11}\, y + p_{12}\, z, \quad \sigma = z' + p_{21}\, y + p_{22}\, z.$$

Evidently semi-covariants need contain no higher derivatives of y and z than the first.

The semi-canonical form of the semi-covariants will be found by subjecting (B) to the transformation (19). Since the coefficients in (19) are constants

$$(30)\quad \begin{cases} \bar{y}' = b_{11}\, Y' + b_{12}\, Z', \\ \bar{z}' = b_{21}\, Y' + b_{22}\, Z', \end{cases}$$

and it follows at once that

$$(31)\quad P = \bar{y}\, \bar{z}' - \bar{y}'\, \bar{z}$$

is a semi-covariant.

The system of differential equations for the semi-canonical form of the semi-covariants is the same as the system for the semi-canonical form of the seminvariants except that each equation contains more terms and there are four more variables. The relations (24) and (25) both cease to hold so that there are three semi-covariants or four relative semi-covariants.

Equations (19) and (21) show that the expressions $\bar{q}_{11}\bar{y} + \bar{q}_{12}\bar{z}$ and $\bar{q}_{21}\bar{y} + \bar{q}_{22}\bar{z}$ are transformed cogrediently with $\bar{y}$ and $\bar{z}$, respectively. The same is of course true of $\bar{q}'_{11}\bar{y} + \bar{q}'_{12}\bar{z}$ and $\bar{q}'_{21}\bar{y} + \bar{q}'_{22}\bar{z}$, respectively. It follows at once that the three expressions

$$(32)\begin{cases} C = (\bar{q}_{11}\bar{y} + \bar{q}_{12}\bar{z})\,\bar{z} - (\bar{q}_{21}\bar{y} + \bar{q}_{22}\bar{z})\,\bar{y}, \\ E = (\bar{q}'_{11}\bar{y} + \bar{q}'_{12}\bar{z})\,\bar{z} - (\bar{q}'_{21}\bar{y} + \bar{q}'_{22}\bar{z})\,\bar{y}, \\ O = (\bar{q}_{11}\bar{y} + \bar{q}_{12}\bar{z})\,\bar{z}' - (\bar{q}_{21}\bar{y} + \bar{q}_{22}\bar{z})\,\bar{y}', \end{cases}$$

are independent relative semi-covariants. A comparison of (19) and (30) with (27) and (28) shows that the semi-covariants (31) and (32) can be expressed in terms of the original variables and coefficients if $\bar{y}$ is replaced by y, $\bar{z}$ by z, $\bar{y}'$ by ρ and $\bar{z}'$ by σ at the same time that $\bar{q}_{ik}$ and $\bar{q}'_{ik}$ are replaced by u_{ik} and v_{ik}, respectively. Thus we have

$$(33)\begin{cases} P = y\sigma - z\rho, \\ C = (u_{11}y + u_{12}z)\,z - (u_{21}y + u_{22}z)\,y, \\ E = (v_{11}y + v_{12}z)\,z - (v_{21}y + v_{22}z)\,y, \\ O = (u_{11}y + u_{12}z)\sigma - (u_{21}y + u_{22}z)\,\rho. \end{cases}$$

By the same argument as in the case of seminvariants these four semi-covariants are known to form a complete system for (A).

4. The Canonical Form and the Invariants.

We shall now proceed to find those functions of the seminvariants in their semi-canonical form which remain unchanged except for a factor $\frac{1}{(\xi')^m}$ by the transformation (20). We shall thus obtain the functions of the coefficients of (B) and their derivatives which remain unchanged by (18), except for the factor $\frac{1}{(\xi')^m}$.

Equation (17) shows that (20) converts (B) into a new system whose coefficients Q_{ik} are given by the equations

$$(34)\begin{cases} Q_{ii} = \frac{1}{(\xi')^2}\left(\frac{1}{4}\eta^2 - \frac{1}{2}\eta' + \overline{q}_{ii}\right), & (i = 1, 2), \\ Q_{ik} = \frac{1}{(\xi')^2}\overline{q}_{ik}, & (i, k = 1, 2;\ i \neq k). \end{cases}$$

We notice that

$$Q_{11} + Q_{22} = \frac{1}{(\xi')^2}\left(\frac{1}{2}\eta^2 - \eta' + \overline{q}_{11} + \overline{q}_{12}\right),$$

so that $Q_{11} + Q_{22} = 0$, provided that

$$(35)\qquad \mu \equiv \eta' - \tfrac{1}{2}\eta^2 = \overline{q}_{11} + \overline{q}_{22}.$$

From equations (34) we have at once, if (35) is satisfied,

$$(36)\begin{cases} Q_{ii} = \frac{1}{(\xi')^2}\left(\overline{q}_{ii} - \frac{1}{2}I\right), & (i = 1, 2), \\ Q_{ik} = \frac{1}{(\xi')^2}\overline{q}_{ik}, & (i, k = 1, 2;\ i \neq k), \end{cases}$$

whence

$$(37)\begin{cases} Q'_{ii} = \frac{1}{(\xi')^3}\left[\overline{q}'_{ii} - \frac{1}{2}I' - 2\eta\left(\overline{q}_{ii} - \frac{1}{2}I\right)\right], \\ Q''_{ii} = \frac{1}{(\xi')^4}\left[\overline{q}''_{ii} - \frac{1}{2}I'' + I^2 - 2I\overline{q}_{ii} - 5\eta\left(\overline{q}'_{ii} - \frac{1}{2}I'\right) + \right. \\ \qquad\qquad\qquad\qquad\qquad\qquad \left. 5\eta^2\left(\overline{q}_{ii} - \frac{1}{2}I\right)\right], \\ Q'_{ik} = \frac{1}{(\xi')^3}\left(\overline{q}'_{ik} - 2\eta\overline{q}_{ik}\right), \quad (i, k = 1, 2;\ i \neq k), \\ Q''_{ik} = \frac{1}{(\xi')^4}\left(\overline{q}''_{ik} - 2I\overline{q}_{ik} - 5\eta\overline{q}'_{ik} + 5\eta^2 q_{ik}\right). \end{cases}$$

Let us now assume that (B) has been converted into

$$(D)\begin{cases} \overline{y}'' + Q_{11}\overline{y} + Q_{12}\overline{z} = 0, \\ \overline{z}'' + Q_{21}\overline{y} + Q_{22}\overline{z} = 0, \end{cases}$$

where Q_{ik} have the values (36) so that $Q_{11} + Q_{22} = 0$. The system (D) is called the canonical form of (A).

If the seminvariants for (D) corresponding to I, J, K, L for (B) are denoted by I_1, J_1, K_1, L_1, respectively, equations (37) show that

$$
(38)\quad \left\{
\begin{aligned}
& I_1 = 0,\ J_1 = \frac{1}{(\xi')^4}\left[J - \tfrac{1}{4}I^2\right], \\
& J'_1 = \frac{1}{(\xi')^5}\left[\frac{d}{dx}(J - \tfrac{1}{4}I^2) - 4\eta\,(J - \tfrac{1}{4}I^2)\right], \\
& J''_1 = \frac{1}{(\xi')^6}\left[\frac{d^2}{dx^2}(J - \tfrac{1}{4}I^2) - 4I\,(J - \tfrac{1}{4}I^2) - \right. \\
& \qquad\qquad \left. 9\eta\frac{d}{dx}(J - \tfrac{1}{4}I^2) + 18\eta^2(J - \tfrac{1}{4}I^2)\right], \\
& K_1 = \frac{1}{(\xi')^6}\left[K - \tfrac{1}{4}(I')^2 - 2\eta\frac{d}{dx}(J - \tfrac{1}{4}I^2) + \right. \\
& \qquad\qquad \left. 4\eta^2(J - \tfrac{1}{4}I^2)\right], \\
& K'_1 = \frac{1}{(\xi')^7}\left[\frac{d}{dx}\left\{K - \tfrac{1}{4}(I')^2\right\} - 2I\frac{d}{dx}(J - \tfrac{1}{4}I^2) - \right. \\
& \qquad 6\eta\left\{K - \tfrac{1}{4}(I')^2\right\} - 2\eta\left\{\frac{d^2}{dx^2}(J - \tfrac{1}{4}I^2) - \right. \\
& \qquad \left. 4I\,(J - \tfrac{1}{4}I^2)\right\} + 15\eta^2\frac{d}{dx}(J - \tfrac{1}{4}I^2) - \\
& \qquad \left. 20\eta^3(J - \tfrac{1}{4}I^2)\right], \\
& I_1 = \frac{1}{(\xi')^8}\left[L - \tfrac{1}{4}(I'')^2 + 4I\left\{K - \tfrac{1}{4}(I')^2\right\}\right. \\
& \qquad - 2I\frac{d^2}{dx^2}(J - \tfrac{1}{4}I^2) + 4I^2(J - \tfrac{1}{4}I^2) \\
& \qquad - 5\eta\left\{\frac{d}{dx}[K - \tfrac{1}{4}(I')^2] - 2I\frac{d}{dx}(J - \tfrac{1}{4}I^2)\right\} \\
& \qquad + 5\eta^2\left\{\frac{d^2}{dx^2}(J - \tfrac{1}{4}I^2) - 4I\,(J - \tfrac{1}{4}I^2)\right\} \\
& \qquad + 15\eta^2\left\{K - \tfrac{1}{4}(I')^2\right\} - 25\eta^3\frac{d}{dx}(J - \tfrac{1}{4}I^2) \\
& \qquad \left. + 25\eta^4(J - \tfrac{1}{4}I^2)\right].
\end{aligned}
\right.
$$

The system (D) is left in the canonical form by the transformation (20) provided that $\mu = 0$. We shall now seek those functions of the seminvariants in their semi-canonical form which are left unchanged in value by the transformation (20) subject to the condition $\mu = 0$.

From (34) or by direct substitution we find that (20) with $\mu = 0$ converts Q_{ik} into

$$
(39)\qquad \overline{Q}_{ik} = \frac{1}{(\xi')^2}Q_{ik}, \quad (i, k = 1, 2),
$$

whence it follows that

$$(40)\left\{\begin{aligned}\bar{Q}'_{ik} &= \frac{1}{(\xi')^3}(Q'_{ik} - 2\eta Q_{ik}),\\ \bar{Q}''_{ik} &= \frac{1}{(\xi')^4}(Q''_{ik} - 5\eta Q'_{ik} + 5\eta^2 Q_{ik}).\end{aligned}\right. \quad (i, k = 1, 2),$$

These results show by direct substitution and by differentiation that J_1, K_1, L_1, and their derivatives for the transformed equations have the values

$$(41)\left\{\begin{aligned}\bar{J}_1 &= \frac{1}{(\xi')^4} J_1, \bar{J}'_1 = \frac{1}{(\xi')^5}(J'_1 - 4\eta J_1),\\ \bar{J}''_1 &= \frac{1}{(\xi')^6}(J''_1 - 9\eta J'_1 + 18\eta J_1),\\ \bar{K}_1 &= \frac{1}{(\xi')^6}(K_1 - 2\eta J'_1 + 4\eta^2 J_1),\\ \bar{K}'_1 &= \frac{1}{(\xi')^7}(K'_1 - 6\eta K_1 - 2\eta J''_1 + 15\eta^2 J'_1 - 20\eta^3 J_1),\\ \bar{L}_1 &= \frac{1}{(\xi')^8}(L_1 - 5\eta K'_1 + 5\eta^2 J''_1 + 15\eta^2 K_1 - 25\eta^3 J'_1\\ &\qquad + 25\eta^4 J_1).\end{aligned}\right.$$

If the transformation (20) is made infinitesimal by putting

$$\xi = x + \varphi(x)\,\delta t$$

where $\varphi(x)$ is an arbitrary function of x and δt is an infinitesimal, the infinitesimal transformations of J_1, K_1, L_1, and their derivatives are found by direct substitution in (41) to be

$$(42)\left\{\begin{aligned}&\delta J_1 = -4\varphi' J_1\,\delta t,\\ &\delta J'_1 = (-5\varphi' J'_1 - 4\varphi'' J_1)\,\delta t,\\ &\delta J''_1 = (-6\varphi' J''_1 - 9\varphi'' J'_1)\,\delta t,\\ &\delta K_1 = (-6\varphi' K_1 - 2\varphi'' J'_1)\,\delta t,\\ &\delta K'_1 = (-7\varphi' K'_1 - 6\varphi'' K_1 - 2\varphi'' J''_1)\,\delta t,\\ &\delta L_1 = (-8\varphi' L_1 - 5\varphi'' K'_1)\,\delta t.\end{aligned}\right.$$

The resulting system of partial differential equations whose solutions are invariants of (D) under the transformation (20) with $\mu = 0$ contains two independent equations. There are therefore four such absolute invariants involving the variables J_1, J'_1, J''_1, K_1, K'_1, L_1. The five relative invariants may be taken to be

$$(43)\left\{\begin{aligned}&\bar{\theta}_4 = J_1,\ \bar{\theta}_{4.1} = 9(J'_1)^2 - 8J_1 J''_1,\\ &\bar{\theta}_{10} = (J'_1)^2 - 4J_1K_1,\ \bar{\theta}_{15} = 5\bar{\theta}_{10}J'_1 - 2\bar{\theta}'_{10}J_1,\\ &\bar{\theta}_{18} = \{(J'_1)^2 - 4J_1K_1\}L + K_1(J''_1 - 2K_1)^2 + J_1(K'_1)^2\\ &\qquad - J'_1K'_1(J''_1 - 2K_1).\end{aligned}\right.$$

The system of equations for the invariants involving also the next higher derivatives of J_1, K_1, L_1, contains no more equations but three more variables. The three solutions may be taken to be

$$(44) \begin{cases} 4\,J_1\,\overline{\theta}'_{4.1} - 9\,J'_1\,\overline{\theta}_{4.1}, \\ 4\,J_1\,\overline{\theta}'_{15} - 15\,J'_1\,\overline{\theta}_{15}, \\ 4\,J_1\,\overline{\theta}_{18} - 18\,J'_1\,\overline{\theta}_{18}. \end{cases}$$

The invariants involving the next higher derivatives of J_1, K_1, L_1, may obviously be obtained by combining J_1 and J'_1 with the invariants (44). A continuation of this process evidently gives all the independent relative invariants.

The invariants (43) may be expressed in terms of I, J, K, L, and their derivatives by means of (38). However, a comparison of (38) and (41) shows that this substitution can be made, except for a factor $\frac{1}{(\xi')^m}$, by replacing in (43) J_1 by $J - \frac{1}{4}I^2$, J'_1 by $\frac{d}{dx}(J - \frac{1}{4}I^2)$, J''_1 by $\frac{d^2}{dx^2}(J - \frac{1}{4}I^2) - 4I\,(J - \frac{1}{4}I^2)$, K_1 by $K - \frac{1}{4}(I')^2$, K'_1 by $\frac{d}{dx}\{K - \frac{1}{4}(I')^2\} - 2I\frac{d}{dx}(J - \frac{1}{4}I^2)$ and L_1 by $L - \frac{1}{4}(I'')^2 + 4I\,\{K - \frac{1}{4}(I')^2\} - 2I\,\frac{d^2}{dx^2}(J - \frac{1}{4}I^2) + 4I^2(J - \frac{1}{4}I^2)$. The results of these substitutions are as follows:

$$(45) \begin{cases} \theta_4 = J - \frac{1}{4}I^2, \\ \theta_{4.1} = 9\,(\theta'_4)^2 - 8\,\theta_4\,\theta''_4 + 32\,I\,\theta_4^2, \\ \theta_{10} = (\theta'_4)^2 - 4\,\theta_4\,\{K - \frac{1}{4}(I')^2\}, \\ \theta_{15} = 5\,\theta_{10}\,\theta'_4 - 2\,\theta'_{10}\,\theta_4, \\ \theta_{18} = \theta_{10}\left[L - \frac{1}{4}(I'')^2 + 4\,I\,\{K - \frac{1}{4}(I')^2\} - 2\,I\,\theta''_4 + \right. \\ \qquad \left. 4\,I^2\,\theta_4\right] + \{K - \frac{1}{4}(I')^2\}\,\{\theta''_4 - 4I\theta_4 - 2K + \frac{1}{2}(I')^2\}^2 \\ \qquad + \theta_4\,(K' - \frac{1}{2}I'\,I'' - 2\,I\,\theta'_4)^2 - \\ \qquad \theta'_4\,(K' - \frac{1}{2}I\,I'' - 2\,I\,\theta'_4)\,\{\theta''_4 - 4\,I\,\theta_4 - 2\,K + \frac{1}{2}(I')^2\} \\ \quad = \theta_{10}\,\{L - \frac{1}{4}(I'')^2\} + \{K - \frac{1}{4}(I')^2\}\,(J'' - \frac{1}{2}I\,I'' - 2K)^2 \\ \qquad + \theta_4\,(K' - \frac{1}{2}I\,I'')^2 - \theta'_4\,(K' - \frac{1}{2}I\,I'')\,(J'' - \frac{1}{2}I\,I'' - 2K). \end{cases}$$

The same reasoning as in the case of the seminvariants shows that the expressions (45) are invariants of (A) and that all independent invariants of (A) are obtained in this way.

There is another expression for an invariant which is easily obtained and which is of geometrical interest. From equation (21) we easily deduce the equations

$$\begin{aligned}
D(Q_{11}-Q_{22}) &= (b_{11}b_{22}+b_{12}b_{21})(\bar q_{11}-\bar q_{22})+2\,b_{21}b_{22}\bar q_{12}-2\,b_{12}b_{11}\bar q_{21},\\
D\,Q_{12} &= \qquad b_{12}b_{22}(\bar q_{11}-\bar q_{22})+\quad b_{22}^2\bar q_{12}-\quad b_{12}^2\bar q_{21},\\
D\,Q_{21} &= \quad -\,b_{21}b_{11}(\bar q_{11}-\bar q_{22})-\quad b_{21}^2\bar q_{12}+\ b_{11}^2\bar q_{21},
\end{aligned}$$

and exactly similar equations involving derivatives of any order. Thus we know at once that the determinant

$$(46)\qquad \begin{vmatrix} \bar q_{11}-\bar q_{22} & \bar q_{12} & \bar q_{21} \\ \bar q'_{11}-\bar q'_{22} & \bar q'_{12} & \bar q'_{21} \\ \bar q''_{11}-\bar q''_{22} & \bar q''_{12} & \bar q''_{21} \end{vmatrix}$$

is the semi-canonical form of a seminvariant. Furthermore equations (39) and (40) show that it is the semi-canonical form of an invariant. The expression in terms of the original coefficients for this invariant is

$$(47)\qquad \theta_9 = \begin{vmatrix} u_{11}-u_{22} & u_{12} & u_{21} \\ v_{11}-v_{22} & v_{12} & v_{21} \\ w_{11}-w_{22} & w_{12} & w_{21} \end{vmatrix}$$

5. The Covariants.

Let us now return to the semi-canonical form of the semi-covariants and assume that they have been written down for equations (D). If they are denoted by P_1, C_1, B_1, O_1, equations (39) and (40) show that their values for the equations obtained by transforming (D) by (20) with $\mu=0$ are as follows:

$$\bar P_1 = P_1,\quad \bar C_1 = \frac{1}{\xi'}C_1,$$

$$\bar E_1 = \frac{1}{(\xi')^2}(E_1 - 2\eta C_1),\ \bar O_1 = \frac{1}{(\xi')^2}(O_1 + \tfrac{1}{2}\eta C_1).$$

Therefore four relative covariants in their canonical form are

$$P_1,\ C_1,\ E_1 + 4\,O_1,\ 2\,J_1E_1 - C_1J'_1.$$

By converting these expressions into the original coefficients and variables we find the complete system of covariants for (A) to be

$$P,\ C,\ C_3 = E + 4\,(O - \tfrac{1}{2}I\,P) = E + 2\,N,\ C_7 = 2\,\theta_4E - \theta'_4\,C.$$

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Possible Methods of Classifying White, Yellow and Orange Staphylococci.*

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INTRODUCTION.

STAPHYLOCOCCI were first found in pus by Pasteur [1] (1880). Ogston [2] confirmed Pasteur's work a year later (1881), and in 1883 Becker [3] was able to isolate staphylococci in pure culture. Rosenback [4] (1884) described *staphylococcus pyogenes,* dividing it into two varieties corresponding to the orange and white pigmentation, calling them var. *aureus* and var. *albus.* In 1908 the Winslows [5] based their classification upon growth, pigment production and liquefaction of gelatin.

Dudgeon [6] (1908) found *staphylococcus albus* commonly in normal tissue while *staphylococcus aureus* was usually obtained from pathogenic sources. He was interested in the interchangeability of these two varieties and worked upon a classification of these organisms, using glucose, lactose, maltose, glycerin, cane sugar, raffinose, erythrite, salacin, litmus milk and neutral red. He finally concluded that they all belonged to the same species.

Winslow, Rothberg and Parsons [7] (1920) studied 180 cultures of white and orange staphylococci to determine their action upon the sugars, glucose, lactose, sucrose, maltose, raffinose, mannitol, dulcitol, salacin and inulin. They used two different media, the dehydrated bacto nutrient broth prepared by

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the Digestive Ferments Company, and the peptone media of Clark and Lubs. They found that: "The action of the staphylococci upon glucose, maltose, sucrose and lactose would seem to offer a possible basis of classification, although the marked differences due to the effect of the medium would suggest the use of this property as a differential test might prove of doubtful value."

They were able to divide the organisms into three main groups. Group I, organisms fermenting all four sugars; group II, organisms fermenting glucose, maltose and sucrose, but not lactose. In group III they classified all the rest of the strains and stated that it was a "highly heterogeneous agglomeration."

They found that "gelatin liquefaction was slightly but distinctly more common among the active fermenters," and that "white and orange pigments were fairly evenly divided among the various fermentative groups with a slightly greater preponderance of vigorous fermenters in the orange than in the white group." Their tests for indol were all negative and nitrate broth gave almost uniformly positive results showing reduction.

Winslow, Rothberg and Parsons, after this extensive work upon various sugars, nitrates, indol chromogenesis and gelatin liquefaction, state that: "Fundamentally we are inclined to agree with Dudgeon in considering the whole group a reasonably homogeneous one, and it seems clear the central type of the whole genus is the orange-pigment forming, vigorously fermenting, gelatin liquefying, somewhat actively pathogenic *St. aureus*. As we depart from this type there is a progressive weakening of the various biochemical activities of this more vigorous form. The loss of one characteristic of the *St. aureus* type tends in some degree to be associated with the loss of others. Thus the white chromogens are less actively pathogenic than the orange forms, less actively gelatinolytic and slightly less vigorous in fermentation action. The forms which fail to liquefy gelatin also tend to be less active fermenters than the liquefiers."

The object of the present paper was to obtain white, yellow and orange staphylococci from as many different sources as possible and to see whether the group would lend itself to rational or satisfactory subdivision making use of fermentation, pigmentation, hemolysis, proteolysis on milk agar plates, liquefaction of gelatin, blackening of lead acetate agar, and the determining of limiting hydrogen ion concentrations of each strain in dextrose broth. I hoped to see if there was a correlation of any of these with source and pathogenicity.

In order to do this, I have subdivided this work under six headings, as follows:

1. Assuming as Dudgeon that staphylococci seemed to be one species and disregarding the characteristic of pigment production and liquefaction of gelatin, is it possible to subdivide staphylococci in general upon a basis of fermentation of carbohydrates. In determining data for this question, I have asked myself to note the following questions: Does the classification by fermentation reaction offer any correlation with pigment production, liquefaction of gelatin, with pathogenicity, with source? and, Is there a correlation between rapidity of fermentation and of pigment production and pathogenicity as suggested by Winslow?

2. After studying staphylococci as a whole from the standpoint of fermentation reactions, it was next decided to assume pigmentation as the primary differentiation into subgroups of white, yellow and orange staphylococci and attempt the subdivision of each of these by means of fermentation reaction. The borderline yellows and orange pigment producers were placed in their respective groups of yellow or orange.

3. The next step was to assume, as before, pigmentation as a primary differentiation into white, yellow and orange staphylococci then to attempt a subdivision of each of these by means of blood agar plates, placing the hemolizers and nonhemolizers in separate groups as has been done for streptococci, these were again subdivided upon the basis of fermentation reactions. In the work on hemolysis, a comparative study was made using different kinds of blood, such as rabbit, sheep and human.

4. A similar study of staphylococci in which pigmentation was made use of for primary subdivision of each group, subdivided again in accordance with the ability of various strains in that group to produce proteolysis upon milk agar plates. This gave proteolytic and nonproteolytic subdivision. These were further divided upon the basis of fermentation. It was necessary to study the reationship between reaction of media and degree of proteolysis in obtaining data for this work.

5. To study the ability of the various staphylococci to produce hydrogen sulphide, all staphylococci were first inoculated into both one per cent peptone broth agar containing lead acetate, and three per cent peptone broth agar containing lead acetate to see whether there was any correlation between the blackening of lead acetate and any other characteristics. I might say there was noted apparently a correlation between pathogenicity and blackening of three per cent peptone lead acetate agar.

6. Lastly, it was thought worth while to determine the limiting hydrogen ion concentrations of all these various staphylococci in dextrose dipotassium phosphate broth to see whether there exist high and low

ratio groups and whether these correlate with any other characteristics and data.

In all, 75 strains of staphylococci were studied. These were obtained from pathological conditions, in various foods and three strains from the American Museum of Natural History. My tentative definition for staphylococci was cocci in which the division was in two planes giving rise to flat sheets of cells and irregular masses.

TECHNIQUE.

All organisms used in this work were freshly isolated and were first grown upon agar, + 1 to phenolphthalein, then inoculated into plain broth to determine morphology.

In studying fermentation, the organisms were inoculated into one per cent sugar broth solutions of dextrose, lactose, saccharose, mannite, maltose, salacin, dulcite, inulin, raffinose, glycerin, galactose and xylose, and tested in 48 to 72 hours with litmus.

For confirmation, the organisms were inoculated into Hess's semisolid medium containing Andrede as an indicator plus the following carbohydrates—dextrose, lactose, saccharose and mannite.

One per cent peptone lead acetate agar and three per cent peptone lead acetate agar were made according to directions given by Jordan.

Litmus milk, one per cent peptone gelatin, Dunham's peptone, nitrate broth were made according to directions in Standard Methods of Water Analysis.

Gram stains were made from cultures after 24 hours' growth upon an agar slant, using carbol gentian violet as the primary stain and counterstaining with an aqueous solution Bismarck brown.

The chromogenic power was determined by spreading a portion of a culture two weeks old upon white paper, as suggested by Winslow.

Blood agar plates were made by adding 3 cc. of whole defibrinated blood to 100 cc. of agar neutral to phenolphthalein. Sheep, rabbit and human blood were used. The sheep blood was all obtained from the same animal, three different rabbits were bled, and human blood was obtained from several individuals.

Milk plates were made by adding 10 cc. of milk to 100 cc. of agar. The agar was adjusted to + 2, + 1, 1, and — 1 to phenolphthalein.

The chlorimetric or indicator method was used in determining the hydrogen ion concentration. Buffers were made up according to Cole.[8] Methyl red, Phenol red and brom cresol purple were used as indicators as suggested by Clark and Lubs.[9]

The synthetic media used contained .5 per cent Bacto peptone (Digestive Ferments Company), .5 per cent dextrose and .5 per cent K_2HPO_4 titrated neutral to methyl orange. The media was sterilized at 10 pounds for 15 minutes, in order not to destroy the vitamines. After sterilization the hydrogen ion concentration of the broth was 7.3.

As previously mentioned, the first division of this work was a study of the fermentation reaction of all strains of staphylococci, especially with regard to dextrose, lactose, saccharose and mannite. As a matter of supplying additional information maltose, galactose, xylose, salacin are included in the report.

The summary of this data is included in table I.

Nomenclature was taken from Winslow's Systematic Relationship of *Coccaceæ*.

TABLE I.

CLASS 1—Organisms fermenting dextrose, lactose, saccharose and mannite.

No.	Source.	Pigm.	Dex.	Lac.	Sach.	Man.	Malt.	Gal.	Xyl.	Sal.	Glyc.	Milk.*	Milk.**	Gel.	K_2PO_4 Broth.	Nitr.	Lead Acct.	Gram Stain.
5	Pus from ear	White	+	+	+	+	+	+	−	+	+	+	Pep	+	+	−	−	+ Albus.
30	Boil (Acalia)	O	+	+	+	+	+	+	+	−	−	+	+	+	+	+	+	+ Aureus.
31	Boil (Johnson)	O	+	+	+	+	+	+	+	−	−	+	+	+	+	+	+	+ Aureus.
38	Rabbit sore	White	+	+	+	+	+	+	+	−	−	+	+	+	+	+	+	+ Albus.
48	Oyster	Clear	+	+	+	+	+	+	−	+	−	+	Pep	+	+	+	−	+ Albus.
17	H. Urine (Flu)	White	+	+	+	+	+	+	+	+	−	+	Pep	−	+	−	−	+ Albus.
49	Oyster	Clear	+	+	+	+	+	+	−	+	−	+	Pep	+	+	−	−	+ Albus.
16	L. Urine (Flu)	White	+	+	+	+	+	+	+	......	−	+	Pep	+	−	−	−	+ Albus.
6	Milk	Y	+	+	+	+	+	+	+	−	−	−	+	+	+	+	−	+ Citreus.
12	Milk	White	+	+	+	+	+	−	+	−	−	+	Cog	+	−	+	+	+ Albus.
20	Rabbit Abscess	White	+	+	+	+	+	−	+	−	−	+	Cog	+	−	+	+	+ Albus.
27	Throat	White	+	+	+	+	+	−	−	+	−	+	+	+	+	+	+	+ Albus.
39	T. B. Infection	O	+	+	+	+	+	+	+	−	−	+	+	+	+	+	+	+ Aureus.
40	Infected Tooth	White	+	+	+	+	+	+	−	−	+	+	+	−	−	−	−	+ Albus.
57	Sore Throat	O	+	+	+	+	+	+	−	−	−	+	+	+	......	+	+	+ Aureus.
7	Milk	Y	+	+	+	+	+	+	+	−	−	+	Cog	+	−	+	+	+ Citreus.
3	Air	White	+	+	+	+	+	−	−	−	−	+	+	−	−	+	−	+ (?)
8	Milk	White	+	+	+	+	+	−	−	−	−	+	Pep	+	−	+	−	+ Albus.
9	Milk	O	+	+	+	+	+	−	−	−	−	−	Pep	+	+	+	+	+ Aureus.
55	Chronic Eye Infection	O	+	+	+	+	+	−	−	−	−	+	Pep	−	+	+	+	+ Aurantiacii.
58	J. P.	W	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	Variable Epidermidis.
59	Boil	O	+	+	+	+	+	+	+	−	−	+	+	+	+	+	+	Aureus.
61	—	O	+	+	+	+	+	+	+	−	−	+	......	+	+	+	−	+ Aureus.
62	—	O	+	+	+	+	+	+	−	−	−	+	+	+	+	+	+	+ Aureus.
63	—	O	+	+	+	+	+	+	+	−	−	+	+	+	+	+	+	+ Aureus.
64	—	O	+	+	+	+	+	+	+	−	−	+	Pep	+	+	+	−	+ Aureus.
65	—	W	+	+	+	+	+	+	−	−	−	+	Cog. pep.	+	+	+	+	+ Albus.
66	—	W	+	+	+	+	+	+	+	−	−	+	+	+	+	+	+	+ Albus.
67	—	W	+	+	+	+	+	−	+	−	−	+	+	+	+	+	+	+ Albus.
68	—	O	+	+	+	+	+	+	+	−	−	+	+	+	+	+	−	+ Aureus.
72	Aureus	O	+	+	+	+	−	+	−	−	+	......	Cog. pep.	+	+	+	−	+ Aureus.
76	Milk	O	+	+	+	+	+	+	−	−	−	+	Pep	+	+	+	+	+ Aureus.
78	Boil	O	+	+	+	+	+	+	−	−	−	+	+	+	+	+	+	+ Aureus.
83	313	O	+	+	+	+	+	+	−	−	−	+	Cog	+	+	+	−	+ Aureus.
84	348	O	+	+	+	+	+	+	−	+	−	+	Pep	−	−	+	+	+ Aurantiacii.
85	457	O	+	+	+	+	+	−	−	−	−	+	−	−	+	+	+	+ Aurantiacii.
86	Boil	O	+	+	+	+	+	+	−	−	−	+	+	+	+	+	−	+ Aureus.
87	Pus	O	+	+	+	+	+	+	−	−	−	+	+	+	+	+	+	+ Aureus.
88	Pus	O	+	+	+	+	+	+	−	−	−	+	+	+	+	+	+	+ Aureus.
89	Pus	O	+	+	+	+	+	+	−	−	−	+	+	+	+	−	+	+ Aureus.
90	Pus	O	+	+	+	+	+	+	−	−	−	+	+	+	+	+	+	+ Aureus.
91	Pus	O	+	+	+	+	+	−	−	−	−	+	+	+	+	+	+	+ Aureus.

O = Orange; W = White; Y = Yellow, C = Clear

TABLE I—CONTINUED.

CLASS 2—Organisms Fermenting Dextrose, Lactose, Saccharose but not Mannite.

No.	Source.	Pigm.	Dex.	Lac.	Sach.	Man.	Malt.	Gal.	Xyl.	Sal.	Glyc.	Milk.	Milk.	Gel.	K_2PO_4 Broth.	Nitr.	Lead.	Milk plates, Gram stain.
29	Acne	White	+	+	+	—	+	+	+	—	......	+	Cog	+	+	+	—	+ Epidemus.
34	Milk	White	+	+	+	—	+	+	+	—	......	+	+	+	—	+	+	+ Epidemus.
37	Arm Infection	White	+	+	+	—	+	+	+	—	......	—	—	+	+	+	—	+ Epidemus.
35	Milk	White	+	+	+	—	+	+	+	—	......	+	+	+	+	—	+	+ Albus.
28	Acne	White	+	+	+	—	+	+	+	—	......	+	+	+	+	+	—	+ Epidemus.
2	Skin of Nose	White	+	+	+	—	+	+	—	—	......	+	Cog	+	+	+	—	+ Epidemus.
41	Butter	White	+	+	+	—	+	+	—	—	......	+	+	—	—	+	—	+ Candidus.
43	Oleomargarine	Y	+	+	+	—	+	+	—	—	......	+	+	—	—	+	—	— Luteus.
46	Butter	Y	+	+	+	—	+	+	—	—	......	+	+	+	—	+	—	+ Citreus.
47	Infected Tooth	White	+	+	+	—	+	+	—	—	......	+	Pep	+	—	+	—	+ Epidemus.
26	Throat	White	+	+	+	—	+	—	—	—	......	+	+	—	—	—	+	+ Candidus.
52	Tonsil	O	+	+	+	—	+	—	—	—	......	+	Pep	+	—	+	+	— Aureus.
33	Sneeze	White	+	+	+	—	+	—	—	—	......	+	+	—	—	+	—	+ Candidus.
69	—	White	+	+	+	—	+	+	+	—	—	+	....	+	—	—	+ +	+ Albus.
70	—	O	+	+	+	—	+	+	—	—	—	+	....	+	—	—	+ —	+ Aureus.
77	Milk	Y	+	+	+	—	+	+	+	+	—	+	....	+	—	+	+ +	+ Citreus.
80	Hamberger	Y	+	+	+	—	—	—	—	—	—	+	....	+	—	—	— +	+ Flavius.
81	Nose	W	+	+	+	—	+	+	—	—	—	+	....	+	+	+	— +	+ Epidermidis.
82	Nose	W	+	+	+	—	+	+	—	—	—	+	....	+	+	+	— +	+ Epidermidis

TABLE I—CONTINUED.

CLASS 3—Organisms Fermenting Dextrose and Saccharose but not Lactose or Mannite.

No.	Source.	Pigm.	Dex.	Lac.	Sach.	Man.	Malt.	Gal.	Xyl.	Sal.	Milk.	Milk.	Gel.	Red.	Mit.	Lead.	Gram Stain.
4	Air	White	+	—	+	—	+	—	—	—	—	Pep	+	—	—	+	+ Albus.
53	Tonsil	O	+	+	+	—	+	—	—	—	—	—	......	—	+	+	+
32	Sneeze	Y	+	—	+	—	+	—	—	—	—	—	—	—	—	—	— Luteus.
15	Scalp	Y	+	—	+	—	+	—	—	—	—	—	—	—	—	+	+ Luteus.

TABLE I—CONTINUED.

CLASS 4—Organisms not Fermenting Dextrose, Lactose, Saccharose or Mannite.

No.	SOURCE.	Pigm.	Dex.	Lac.	Sach.	Man.	Malt.	Gal.	Xyl.	Sal.	Milk.	Milk.	Gel.	Red.	Mit.	Lead.	Gram Stain.
21	Feces (Flu)	Light Yellow	—	—	—	—	—	—	—	—	—	—	+	—	+	—	+ Citreus.
25	Milk	Light Yellow	—	—	—	—	—	—	—	—	—	—	+	+	—	+	+ Flavus.
22	Feces (Flu)	Light Yellow	—	—	—	—	—	—	—	—	—	—	—	—	—	+	+ Luteus.
54	Infected Tooth	White	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+
50	Oyster	White	—	—	—	—	—	—	—	—	—	Pep	—	—	—	—	+
51	Sore Throat	Orange White	—	—	—	—	—	—	—	—	—	—	—	—	—	+	+ Aurantiacus.

TABLE I—CONCLUDED.

CLASS 5—Irregular Organisms.

No.	SOURCE.	Pigm.	Dex.	Lac.	Sach.	Man.	Malt.	Gal.	Xyl.	Sal.	Milk.	Milk.	Gel.	Red.	Mit.	Lead.	Gram Stain.
11	Milk	Orange-White	+	—	+	+	+	—	—	—	—	Pep	+	+	+	+	+ Aureus.
23	Unknown	White	+	—	+	+	—	—	—	+	—	Pep	+	+	+	+	+ Epidermidis.
14	Pus from Rabbit	Light Yellow	+	—	—	—	—	—	—	—	—	—	—	—	—	—	+ Luteus.
45	Air	Light Yellow	+	—	—	—	—	—	—	—	—	Pep	+	—	—	+	+ Flavus.

It will be observed that results in table I have divided all of the staphylococci into five classes. Class I, those staphylococci which ferment all four of the sugars, dextrose, lactose, saccharose and mannite; class II, those that ferment dextrose, lactose, saccharose, but are negative upon mannite; class III, those fermenting dextrose and saccharose but negative upon lactose and mannite; class IV, includes all staphylococci which failed to produce acid in any of the four sugars; and class V, includes four strains that are irregular.

It can readily be seen that there is no correlation between these classes in source, pathogenicity or pigmentation. For this reason, classifying staphylococci purely on fermentation reactions, disregarding pigment production and liquefaction of gelatin, does not seem to give a satisfactory classification.

The second phase was to assume pigmentation as a primary classification, using white, yellow and orange, and subdividing each of these, making use of the fermentation reaction of the sugars. In doing this, I have assumed that dextrose, lactose and mannite are of importance in the order named and have developed the classifications which are shown in table II.

Again it can be seen that there is no apparent correlation between these fermentation reactions and pigmentation or source or pathogenicity.

Subdivision 3 of this problem comprises an application of the phenomena of hemolysis to subdivision of various pigmented types of staphylococci. There are various and conflicting statements in literature as to most suitable kind of blood for determining hemolysis by staphylococci. It is quite generally recommended that a washed suspension of red blood cells be used, but for routine laboratory work this process is not ordinarily followed, largely because of the lack of facilities and the desire for speed. In order to duplicate ordinary laboratory methods, I have made use of blood agar prepared by adding defibrinated blood to melted agar cooled to 45° C.

Before attempting this work I tried the hemolytic properties of these organisms for rabbit, sheep and human bloods to determine which gave the most positive and fairly consistent results. These are embodied in table III.

TABLE II.

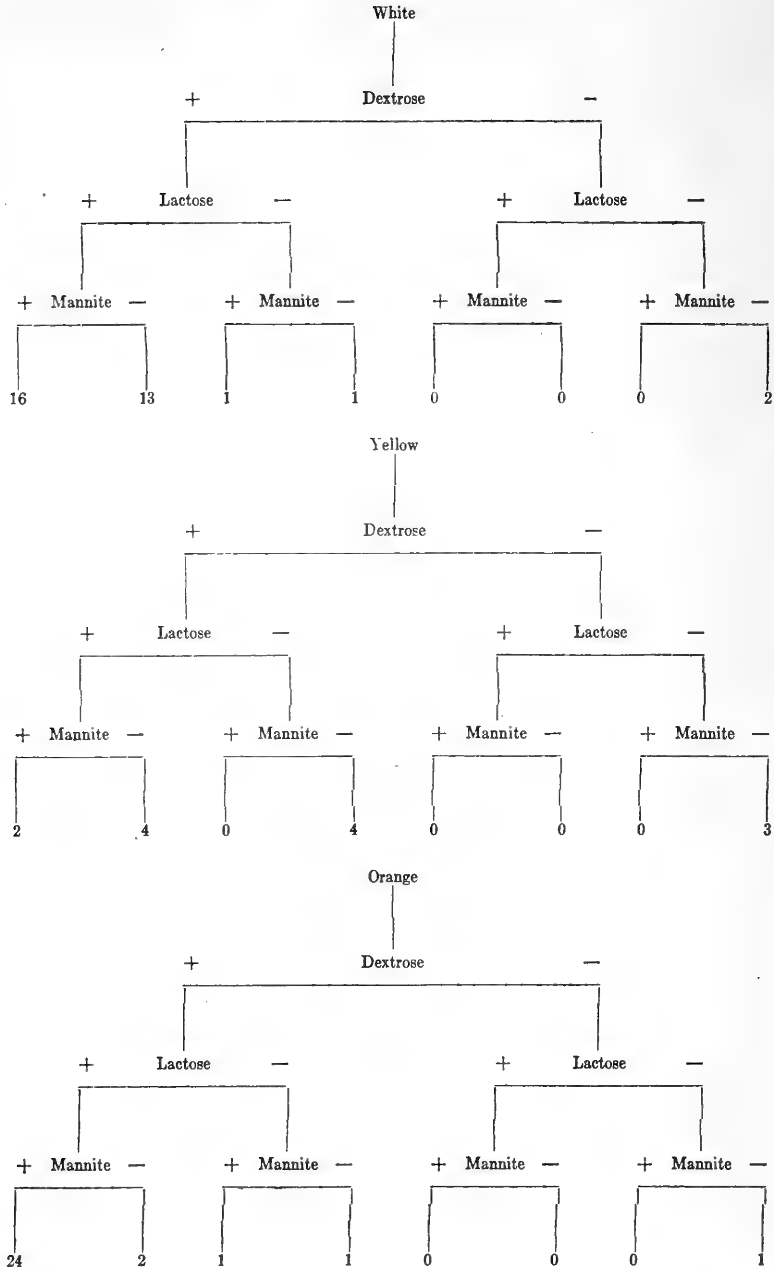
White
+ Dextrose –
+ Lactose –
+ Lactose –
+ Mannite –
+ Mannite –
+ Mannite –
+ Mannite –
16 13 1 1 0 0 0 2
Yellow
+ Dextrose –
+ Lactose –
+ Lactose –
+ Mannite –
+ Mannite –
+ Mannite –
+ Mannite –
2 4 0 4 0 0 0 3
Orange
+ Dextrose –
+ Lactose –
+ Lactose –
+ Mannite –
+ Mannite –
+ Mannite –
+ Mannite –
24 2 1 1 0 0 0 1

TABLE III.

SOURCE.	Strain and Group No.	Pigm.	Rabbit Blood + Hemolysis — +	−	Sheep Blood + Hemolysis — +	−	Human Blood + Hemolysis — +	−	Milk Plates + Proteolysis — +	−
Air..........	3^1	White	....	—	....	—	....	—	....	—
Milk.........	8^1	White	....	—	+	....	+	....	+	....
Milk.........	12^1	White	....	—	....	—	....	—	....	—
Urine F......	17^1	White	....	—	....	—	....	—	....	—
Rab. Absc....	20^1	White	....	—	+	....	+	....	....	—
Throat.......	27^1	White	+	....	+	....	+	....	+	....
Rab. Sore....	38^1	White	+	....	....	—	+	....	....	—
Urine F	16^1	White	....	—	....	—	+	....	+	....
Inf. Tooth....	40^1	White	+	....	+	....	+	....	....	—
Pus—ear.....	5^1	White	....	—	....	—	....	—	+	....
Oyster.......	48^1	Clear	....	—	....	—	....	—	+	....
Oyster.......	49^1	Clear	....	—	+	....	+	....	+	....
—...........	65^1	White	....	—	+	....	+	....	+	....
G. P. Autopsy	58^1	White	+	....	+	....	+	....	....	—
—	66^1	White	+	—	....	—	+	....	....	—
—	67^1	White	....	—	....	—	+	....	+	....
Acne........	29^2	White	....	—	....	—	....	—	+	....
Milk........	34^2	White	+	....	+	....	+	....	+	....
Arm. Inf.....	37^2	White	....	—	....	—	....	—	+	....
Milk........	35^2	White	+	....	+	....	+	....	....	—
Acne........	28^2	White	....	—	....	—	....	—	+	....
Skin—nose...	2^2	White	....	—	....	—	....	—	....	—
Butter.......	41^2	White	....	—	....	—	....	—	+	....
Inf. Tooth....	47^2	White	....	—	+	....	+	....	+	....
Throat	26^2	White	+	....	....	—	....	—	....	—
Sneeze.......	33^2	White	....	—	....	—	....	—	....	—
—	69^2	White	+	....	+	....	+	....	+	....
None	81^2	White	....	—	....	—	....	—	+	....
None	82^2	White	+	....	....	—	+	....	+	....
—	54^3	Lost	....	....	....	....	....	....	....	....
Oyster.......	50^3	Lost	....	—	....	—	....	—	....	—
....	4^4	Lost	....	....	....	....	....	....	....	....
....	23 ir	Lost	....	....	....	....	....	....	....	....
Milk........	6^1	Y. White	+	....	....	—	+	....	....	—
Milk........	7^1	Y. White	....	—	....	—	....	—	....	—
Oleomargarine	43^2	Y. White	....	—	+	....	+	....	+	....
Butter.......	46^2	Y. White	....	—	....	—	....	—	....	—
Milk........	77^2	Yellow	....	—	+	....	+	....	+	....
Hamburger...	80^2	Yellow	....	—	....	—	+	....	+	....
Feces........	21^3	Yellow	+	....	+	....	+	....	+	....
Milk........	25^3	Yellow	+	....	+	....	+	....	+	....
Feces........	22^3	Yellow	+	....	+	....	+	....	+	....
Rab. Pus.....	14^3	Yellow	....	—	....	—	....	—	....	—
Air..........	45^3	Yellow	+	....	+	....	+	....	+	....
Scalp........	15^4	Yellow	....	—	....	—	+	....	+	....
Milk........	9^1	Orange	....	—	....	—	....	—	+	....
Boil.........	30^1	Orange	....	—	+	....	+	....	....	—
Boil.........	31^1	Orange	....	—	....	—	....	—	+	....
T. B. Inf.....	39^1	Orange	....	—	....	—	+	....	....	—
Sore Throat..	57^1	Orange	....	—	+	....	+	....	+	....
Eye.........	55^1	Orange	+	....	+	....	+	....	+	....
Boil.........	59^1	Orange	....	—	+	....	+	....	+	....
—	61^1	Orange	+	....	+	....	+	....	+	....
—	62^1	Orange	....	—	+	....	+	....	+	....
—	63^1	Orange	+	....	+	....	+	....	+	....
—	64^1	Orange	+	....	+	....	+	....	....	—
—	68^1	Orange	....	—	....	—	+	....	+	....
Lab. St.	72^1	Orange	+	....	+	....	+	....	....	—
Boil.........	78^1	Orange	....	—	+	....	+	....	+	....
Aureus	83^1	Or. nge	....	—	....	—	+	....	....	—
Aurientiacus,	84^1	Orange	+	....	+	....	+	....	+	....
Aurientiacus,	85^1	Orange	....	—	+	....	+	....	+	....
Boil.........	86^1	Orange	+	....	+	....	+	....	....	—
Boil.........	87^1	Orange	+	....	+	....	+	....	+	....
Boil.........	88^1	Orange	+	....	+	....	+	....	+	....
Boil.........	89^1	Orange	+	....	+	....	+	....	+	....
Boil.........	90^1	Orange	+	....	+	....	+	....	+	....
Boil.........	91^1	Orange	+	....	+	....	+	....	+	....
Milk........	76^1	Orange	....	—	....	—	+	....	....	....
Tonsil.......	52^2	....	+	....	+	....	+	....	+	....
—	70^2	Orange	....	—	....	—	....	—	....	—
Sore Throat..	51^3	Orange	....	—	+	....	+	....	....	—
Milk........	11 ir	Orange	+	....	+	....	+	....	+	....
Tonsil.......	53^4	Orange	+	....	+	....	+	....	+	....

It is quite evident that human blood gave the most positive results.

I decided, as mentioned above, to use pigmentation as the primary method of division and blood agar plates secondarily, subdividing each of these into hemolytic and nonhemolytic staphylococci, and the fermentation reactions as described in table II were made use of for further subdivision. The results of this are summarized in table IV.

It will be observed that the white staphylococci were evenly divided between hemolytic and nonhemolytic strains, 16 strains were hemolytic and 14 strains were nonhemolytic. This condition shows a gradual change as you go through the yellow and orange staphylococci. For example, out of 13 yellow staphylococci, one was lost before hemolytic properties were determined and of the remaining 12, 9 were hemolytic and 3 were nonhemolytic. Among the orange staphylococci, 26 strains were hemolytic and 3 nonhemolytic. Of these 26 hemolytic orange staphylococci, 19 were from the animal body as compared with one among the three of the nonhemolyzers. Of the 19 from the animal body, 16 were positive in all sugars. Among the yellow, only one was from the animal body and that one was nonhemolytic and fermented dextrose but not lactose or mannite. Among the white hemolytic staphylococci, 7 were from the animal body and of these 7, 6 fermented all sugars. Among the 14 nonhemolyzers, 2 were from the animal body. This suggests that in general staphylococci associated with the animal body seem to be hemolyzers. The history of organisms obtained from the air and various foods is not known further than the source mentioned.

As the fourth phase of this problem, we have attempted to study a possible classification of staphylococci, making use of pigment as a primary division and next the ability of the staphylococci to produce proteolysis or conversely failure to produce proteolysis. This is followed by making use of carbohydrates as in previous tables. It will be observed that the only difference between this and the third phase is that proteolysis is substituted for hemolysis.

Very little work has been published showing the use of milk agar plates in the attempt to classify any kinds of bacteria at all. As a preliminary it was found necessary to determine the optimum reaction of media for proteolysis. Accordingly, studies were made on milk plates + 2, + 1, 1, and — 1 to phenolphthalein. The results are summarized in table V.

TABLE IV.

Color	Hemolysis	Dextrose	Lactose	Mannite	Number
White	+	+	+	+	11
White	+	+	+	−	5
White	+	+	−	+	0
White	+	+	−	−	0
White	+	−	+	+	0
White	+	−	+	−	0
White	+	−	−	+	0
White	+	−	−	−	0
White	−	+	+	+	5
White	−	+	+	−	8
White	−	+	−	+	0
White	−	+	−	−	0
White	−	−	+	+	0
White	−	−	+	−	0
White	−	−	−	+	0
White	−	−	−	−	1
Yellow	+	+	+	+	1
Yellow	+	+	+	−	3
Yellow	+	+	−	+	0
Yellow	+	+	−	−	1
Yellow	+	−	+	+	0
Yellow	+	−	+	−	0
Yellow	+	−	−	+	0
Yellow	+	−	−	−	4
Yellow	−	+	+	+	1
Yellow	−	+	+	−	1
Yellow	−	+	−	+	*0
Yellow	−	+	−	−	1
Yellow	−	−	+	+	0
Yellow	−	−	+	−	0
Yellow	−	−	−	+	0
Yellow	−	−	−	−	0
Orange	+	+	+	+	22
Orange	+	+	+	−	1
Orange	+	+	−	+	1
Orange	+	+	−	−	1
Orange	+	−	+	+	0
Orange	+	−	+	−	0
Orange	+	−	−	+	0
Orange	+	−	−	−	1
Orange	−	+	+	+	2
Orange	−	+	+	−	1
Orange	−	+	−	+	0
Orange	−	+	−	−	0
Orange	−	−	+	+	0
Orange	−	−	+	−	0
Orange	−	−	−	+	0
Orange	−	−	−	−	0

TABLE V.—Effect of Reaction of Media on Proteolysis on Milk Agar Plates.

Pigment.	Total number of strains.	Reaction of media and number of strains showing proteolysis.															
		+ 2 to phenolphthalein.				+ 1 to phenolphthalein.				1 to phenolphthalein.				1 to phenolphthalein.			
		None.	Trace.	Fair.	Good.	None.	Trace.	Fair.	Good.	None.	Trace.	Fair.	Good.	None.	Trace.	Fair.	Good.
White...........	30	18	4	0	8	16	6	......	8	14	4	2	10	15	5	1	9
Yellow..........	12	7	2	0	3	7	2	......	3	6	0	0	6	6	4	0	2
Orange..........	29	15	6	3	5	14	4	6	5	12	3	9	5	10	11	5	3

It is quite evident that the best reaction was neutral to phenolphthalein, the end point was a pronounced end point and corresponded to a P_h of about 8.8.

Applying this in the same manner as blood agar plates in table IV, I have summarized the data in table VI.

Of the white staphylococci, it will be observed that 17 were proteolytic and 12 nonproteolytic. Of the 17 proteolytic, it was rather interesting to note that only 3 were body organisms. In comparing results with hemolysis in table IV, it was noted that on milk agar plates there were 17 proteolytic staphylococci and 12 nonproteolytic, whereas there were 16 hemolyzers to 13 nonhemolyzers. While the total number found proteolytic compares very closely with the total found hemolytic, it is an interesting observation that organisms that are proteolytic are not necessarily the same ones that are hemolytic. For example, of the 11 hemolyzers that fermented all sugars, only 8 are proteolytic. Of the 9 proteolytic organisms that ferment dextrose and lactose but do not ferment mannite, 5 are hemolytic, 4 failing to show hemolysis. Thus it is quite evident that proteolysis and hemolysis are not consistent in their actions although about the same number of staphylococci were proteolytic as were hemolytic.

Among the yellow staphylococci it is observed that 8 were proteolytic and 4 nonproteolytic and that 9 were hemolytic and 3 nonhemolytic. The one hemolyzer which fermented all sugars was not proteolytic and one of the two proteolytic organisms that fermented dextrose, lactose and mannite was not hemolytic, which was very similar to the observations made on white staphylococci.

Among the orange staphylococci, it was previously observed that 26 were hemolytic and three nonhemolytic. Using milk agar plates, we observed that there were 21 proteolytic and 8 nonproteolytic. In other words, 4 of 22 of the hemolytic orange staphylococci that fermented all of the sugars were not proteolytic and one of the 2 proteolytic orange staphylococci that fermented dextrose but failed to ferment lactose or mannite was not hemolytic.

Now as to source, it will be observed that 14 of the 21 proteolytic staphylococci were obtained from the animal body. The percentage of organisms associated with the animal body was greater with the nonproteolytic than with the nonhemolytic orange staphylococci.

TABLE VI.

Color	Proteolysis	Dextrose	Lactose	Mannite	Number
White	+	+	+	+	8
White	+	+	+	−	9
White	+	+	−	+	0
White	+	+	−	−	0
White	+	−	+	+	0
White	+	−	+	−	0
White	+	−	−	+	0
White	+	−	−	−	0
White	−	+	+	+	8
White	−	+	+	−	4
White	−	+	−	+	0
White	−	+	−	−	0
White	−	−	+	+	0
White	−	−	+	−	0
White	−	−	−	+	0
White	−	−	−	−	1
Yellow	+	+	+	+	0
Yellow	+	+	+	−	3
Yellow	+	+	−	+	0
Yellow	+	+	−	−	2
Yellow	+	−	+	+	0
Yellow	+	−	+	−	0
Yellow	+	−	−	+	0
Yellow	+	−	−	−	3
Yellow	−	+	+	+	2
Yellow	−	+	+	−	1
Yellow	−	+	−	+	0
Yellow	−	+	−	−	1
Yellow	−	−	+	+	0
Yellow	−	−	+	−	0
Yellow	−	−	−	+	0
Yellow	−	−	−	−	0
Orange	+	+	+	+	18
Orange	+	+	+	−	1
Orange	+	+	−	+	0
Orange	+	+	−	−	2
Orange	+	−	+	+	0
Orange	+	−	+	−	0
Orange	+	−	−	+	6
Orange	+	−	−	−	1
Orange	−	+	+	+	0
Orange	−	+	+	−	0
Orange	−	+	−	+	0
Orange	−	+	−	−	0
Orange	−	−	+	+	0
Orange	−	−	+	−	0
Orange	−	−	−	+	0
Orange	−	−	−	−	1

The fifth subdivision of this paper has to do with the action of all staphylococci upon lead acetate agar. A summary of this data is embodied in table I. It will be observed that, with two exceptions, all staphylococci isolated from pus or boils blackened lead acetate agar. I doubt, however, that this could be depended upon to denote pathogenicity.

In regard to the sixth subdivision of the paper applying to the various hydrogen ion concentrations, I hope to do more extensive work in the future. I selected 6 from class 1, table I, 6 from class 2, 2 from class 3, and 4 from class 4, and grew them in dextrose dipotassium phosphate broth, as described in the paragraph on technique, and determined the hydrogen ion from day to day for a period of five days.

These results suggest the possibility of dividing staphylococci into subdivisions depending upon the limiting P_h. This is analogous to the attempt to subdivide the coliærogenes group. It might be of some value if used with pigment production as a basis of classification and the high ratio determined for white, yellow and orange separately.

I have also considered the value of the group number system as suggested in the descriptive chart of the American Association of Bacteriology, but have decided not to include the various group numbers of the various staphylococci in question.

SUMMARY AND CONCLUSIONS.

That disregarding pigmentation and liquefaction of gelatin staphylococci may be arranged into five types according to their ability to ferment dextrose, lactose, saccharose and mannite. These types do not correlate with any other observed characteristics such as source, pathogenicity, pigmentation or liquefaction of gelatin. It would seem that this method of classifying staphylococci would only lead to confusion and offers nothing of basic value.

That while routine laboratory work might warrant only the data on morphology, gram stain, type of growth and pigment production on plain agar slants, yet it would seem advisable, at least from the standpoint of comparison when reporting upon staphylococci in the literature, to follow some such plan as follows: Gram stain, pigment production, liquefaction of gelatin, action on blood agar plates where kind of blood, amount and P_h of medium are given, and the fermentation reaction in dextrose, lactose and mannite. Instead of blood agar plates it would seem that for comparison milk agar plates might equally well be substituted and perhaps prove equally reliable. In either proteolysis or milk agar plates or hemolysis, it is apparently important to have an optimum and known hydrogen-ion concentration in the medium. This is very easily a source of discrepancies. The blackening of lead acetate agar might also be worth including.

There does not seem to be any uniform correlation between the property of proteolysis of milk agar plates and hemolysis on blood agar plates.

Apparently most staphylococci from the animal body are hemolytic.

Contrary to frequent statements in the literature, human blood seemed to be superior to either rabbit or sheep blood.

As might well be expected, hydrogen-ion determinations show that staphylococci can rightly be grouped into at least two groups with respect to some one indicator such as methyl red, and into more groups if desired. I do not know that this is consistent or will prove of value.

Acknowledgment is hereby made to two members of the department of bacteriology of the University of Kansas, Prof. N. P. Sherwood and Miss Cornelia M. Downs, for many valuable suggestions and criticisms of my work.

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Anguillavus hackberryensis.*

A new species and a new genus of fish from the Niobrara Cretaceous of Kansas.

BY H. T. MARTIN.

(Plate VI.)

ALTHOUGH not a new genus of fish in the proper sense of of the word (the generic name having been given by Hay† to similar forms from the Upper Cretaceous of Mount Lebanon, Syria), this is the first time so far as the writer is aware that this genus has been reported from the Niobrara Cretaceous of Kansas, hence the term.

The species I have named for the locality in which the specimen was found, a locality made famous by the early discoveries of Williston and Mudge.

It is rather strange that, after fifty years of collecting by as many parties, not a single fragment has been found referable to this genus. Yet one would naturally expect that among the thousands of fossil fishes that have been collected from the deposits of this once great inland sea some member of this group would have been recognized.

The specimen here figured and described was found by the writer during the University Expedition of 1919, on Hackberry creek, Gove county, Kansas, six miles east of Gove City.

When found the specimen was weathered out and fully exposed as shown in the plate. The process of weathering had unfortunately carried away the greater part of the front portion of the skeleton, leaving only one or two bones of the skull,

* Received for publication on May 18, 1921.

† On a collection of Upper Cretaceous fishes from Mount Lebanon, Syria, with descriptions of four new genera and nineteen new species, p. 439, by O. P. Hay.

with impressions where other parts had been washed away. The only part of the head remaining was a fragment of one dentary and one quadrate.

From all indications the skull was disarticulated and scattered over quite an area, while the hinder part of the skeleton was missing from the level of the sixty-fifth vertebra backward. The vertebræ remaining are connected in series which has made possible the retaining of the dorsal and anal fin in position. In size the Kansas specimen greatly exceeds those described by Hay from Mount Lebanon.

DESCRIPTION.

Ventral Fin.

The ventral fin is represented by two separate and distinct groups of four or five small irregular oblong plates, which are evidently the baseost bones of the fins. These plates and portions of the girdle appear at the level of the thirtieth vertebra in line with the well-defined outline of the body. The plates are 3 mm. wide and 4 mm. long. As the basal plates may have moved from their original position it is not certain that the ventral fins commenced at the thirtieth vertebra, although they appear to have done so.

Anal Fin.

The anal fin commences at the thirty-fifth vertebra or just behind the baseost bones of the ventral fin and continues without break to the last vertebra remaining in the preserved series.

Dorsal Fin.

Owing to the weathering away of the matrix towards the front part of the specimen, the dorsal fin does not show distinctly its whole length, the rays being disassociated and scattered, but in such a way that the fin appears to have commenced at or very near the occipital. From the thirty-fifth vertebra backward they are in position to the last vertebra remaining.

Vertebræ.

From the position made clear by impressions in the matrix, where the first vertebra occurred, to the eighteenth, the vertebræ are missing. The nineteenth, twentieth, twenty-first and twenty-second are represented by a half of each vertebra, the twenty-second to the thirty-seventh are missing entirely, but from here on to the sixty-fifth the vertebræ connected with the dorsal and anal fins are perfect. Twenty-five vertebræ here measure 100 mm. All vertebræ are very constricted in their center and are a little wider than long.

The entire specimen is crushed laterally, leaving the dorsal and anal fins in their natural position. The average distance across from the upper edge of the dorsal fin to the lower edge of the anal fin is 22 mm. At one point where the matrix has flaked away there appear six or seven delicate ribs attached to the underside of the vertebræ.

The following measurements have been made: Length of specimen from impression of first vertebra to the sixty-fifth and last remaining vertebra, 255 mm.; length of quadrate, 6 mm.

DESCRIPTION OF PLATE VI.

FIG. 1. Photograph of entire specimen as preserved in the matrix.

df. = Dorsal fin.
af. = Anal fin.
Bp. of Vf. = Basal plates of ventral fins.
X. = Impressions of first vertebræ.
Qd. = One quadrate 6 mm. long.
Dent. = Portion of dentary.

FIG. 2. Section of the hinder portion of the specimen, about natural size.

df. = Dorsal fin.
af. = Anal fin.
Br. of Vf. = Basal plates of ventral fins.

ANGUILLAVUS HACKBERRYENSIS.
H. T. Martin.

PLATE VI.

FIG. 1.

FIG. 2.

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Continuation of Investigation of a Possible Rainfall Period Equal to One-ninth the Sun-spot Period.*

BY DINSMORE ALTER.

IN THE *Monthly Weather Review* for February, 1921, is published a preliminary report of the investigation of all the state averages of rainfall for the whole United States. Certain conclusions are reached tentatively, subject to further investigation. These are that there is evidence tending to show the existence of a correlation between rainfall and sun spots and that the rainfall follows a period of one-ninth the sun-spot period, varying its length always to keep in step with the sun-spot cycle. In this paper it is assumed that the reader is familiar with the previous discussion and only very brief reference will be made to any point discussed there. As stated in the conclusion of the other paper, the work has been continued in an attempt to fix more definitely the probability of the phenomenon.

The first continuation of the work was to answer definitely the question whether it might be that excessive rainfall or severe droughths in a very few of the months under discussion had produced the variations noted in the means of the two halves of the time as recorded in the previous paper. To do this, it was necessary to obtain the percentages of rainfall through each of the cycles for which data are available. For the eastern group state averages from two states are available beginning January, 1883, and for all states from the latter nineties. These averages give us twenty-four consecutive

* Received for publication August 5, 1921.

cycles. In investigating individual cycles it is necessary to eliminate the seasonal effect from each individual month. This has, therefore, been done for each month and each state by dividing the actual rainfall of each state for each month by the normal of that state and month. As stated in the first paper, this method is as reliable as the former one, except on the extreme western coast of the country where normals are practically zero for certain months, and where these zero months are thus given an equal weight with months of heavy normal rainfall. The results for these twenty-four consecutive cycles are tabulated as table 1. The attention of the reader is called to the fact that in twenty-two cycles there are only two in which the percentage of rainfall, for months when the cycle calls for a minimum, has actually been above normal. Each of these cycles is strictly independent of any other and their lengths are dependent only upon extra-terrestial causes. For the maximum phase it is to be noted that sixteen are above normal, seven below and one exactly normal. The author believes that this table establishes the probability much more strongly than the previous treatment, so strongly in fact that only very strong definite negative evidence can combat it.

California, western Washington and western Oregon are, as shown in the preceding paragraph, not available for treatment by individual cycles unless the summer months are entirely disregarded. It has been felt best, therefore, to treat, instead of the whole Pacific group of the first paper, the states of eastern Washington and Oregon, Idaho, Montana, Utah and Nevada as a unit. For these states there are available eighteen consecutives cycles. The results are shown as table 2. For the minimum phase fifteen of the eighteen are found to be below normal and for the maximum phase thirteen out of the eighteen are above normal.

As shown in the first paper, it is impossible to continue the varying period beyond the last date which is followed by both a sun-spot maximum and sun-spot minimum. This is 1913. The tables previously referred to are based on Wolfer's estimate of May, 1913, as epoch of minimum. This has been revised by him, placing the minimum nearly three months later.[1]

1. Prof. A. Wolfer. *Monthly Weather Review,* July, 1915, p. 314; August, 1920, pp. 459-461.

However, since the effect of changing this one date would affect only the latter part of tables 1 and 2, and since they were computed before the new estimate became available, I have merely inspected them to see approximately what the result of the shift in the latter cycles will be. The reader can see by such an inspection that this will make the results slightly more striking than they are at present.

It is desirable to make some use of the rainfall data since 1913 if possible. Since it is impossible to use the period which actually applies, it is only possible to use a constant periodicity and thus get some approximation to the truth, although some of the amplitude is certain to be damped. Every indication from the sun spots and rainfall was that the period averaged approximately fourteen months since the last sun-spot minimum. I have, therefore, plotted all the data of these two sections on the basis of such a constant periodicity. The results are given as table 3. These show once more the regularity with which the phases hold for each cycle, although, since the constant period is, of course, only an approximation to the true variable one, the same accuracy cannot be expected as has been found before. It should be noted that should the investigator be engaged in the entirely different problem of hunting for a possible date of a future minimum instead of, as in this paper, justifying the assumption of existence of the period, he would no longer be bound by this constancy, but could adjust the lengths as seemed best to fit the data in hand.

The mathematical reason for the greater reliability of minima in comparison with maxima is shown at once by table 10 of the first paper. The 15-month primary period has its minimum at phase 13.4 and its maximum at 5.9 in the Eastern group. The second harmonic has minima at 13.3 and at 5.8, with maxima at 2.0 and 9.5. The third harmonic has minima at 13.4, 8.4 and 3.4, with maxima at 10.9, 5.9 and 0.9. It is, therefore, evident that amplitude variation between these harmonics will have very little effect on the principal minimum, but that changes in relative intensity will shift the principal maximum from phase 6, its normal value, whenever the second harmonic gains in relative strength sufficiently, to a principal maximum between phases 1 and 2.

TABLE 1.—Eastern Group. Rainfall data for twenty-four consecutive cycles ending 1913. Sun-spot minimum occurs in phase 4.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
74	258	64	129	127	122	110	71	66	224	149	116	94	184	117
89	99	110	118	60	109	109	103	60	110	127	68	28	92	92
89	102	84	148	96	144	144	108	80	115	87	102	90	90	120
114	73	98	102	102	55	146	86	85	85	158	69	91	78	77
91	93	93	73	73	113	76	131	106	106	89	132	64	124	124
89	78	134	137	137	133	130	85	114	71	71	69	72	101	124
138	68	68	117	75	163	64	119	138	130	97	132	91	83	124
146	159	63	86	121	149	137	71	59	98	106	119	59	66	136
96	121	79	94	111	124	132	105	98	89	36	125	79	70	138
102	136	101	70	99	102	120	100	88	83	117	72	98	91	80
76	123	108	71	95	134	48	82	98	84	96	90	54	64	116
113	65	122	82	77	109	132	76	121	77	138	49	94	131	122
87	88	117	82	46	68	129	112	98	92	96	93	88	108	142
101	169	105	98	120	132	66	81	80	95	83	83	96	82	88
144	101	110	82	141	99	75	82	120	139	80	69	106	132	122
94	88	150	104	59	62	156	70	104	99	76	118	91	78	144
121	118	140	96	162	131	97	78	126	97	90	83	68	76	96
77	110	83	83	88	101	101	88	104	63	97	90	94	87	100
120	107	116	118	97	130	74	129	105	60	127	62	92	114	126
121	123	126	95	111	100	66	80	113	134	107	99	88	147	85
146	130	89	136	100	116	134	80	96	103	65	63	64	65	81
138	102	134	119	104	87	91	72	66	100	106	105	26	104	105
120	105	80	92	126	78	77	87	67	70	130	53	94	79	137
108	143	136	133	92	87	147	148	116	85	107	103	122	79	80
14	16	14	11	11	16	14	8	11	8	11	9	2	9	15 Above normal.
10	8	10	13	12	7	10	15	13	15	13	15	22	15	8 Below normal.
108	115	105	103	101	110	107	94	96	100	101	90	84	97	112 Mean.

TABLE 2.—Rainfall data of six western states September, 1889, to April, 1913. Phase numbers same as for Eastern group.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
......	......	......	*36	*255	*164	*409	200	120	146	66	106	67	38	318
114	50	14	70	45	187	105	94	147	250	215	86	128	28	46
169	62	54	106	119	127	106	85	28	30	71	122	128	69	125
156	127	47	86	44	174	113	124	94	138	116	156	91	101	82
67	109	82	30	141	150	94	85	76	69	68	43	118	26	82
116	115	62	120	149	61	126	137	88	74	198	85	80	160	118
67	119	100	55	108	146	167	138	64	87	72	161	100	76	80
63	82	86	104	116	126	91	89	86	56	211	62	151	100	79
81	70	188	86	54	45	108	115	164	113	86	123	72	86	97
78	62	74	133	78	65	120	51	141	100	104	44	173	68	54
40	154	130	117	47	100	86	84	92	112	107	82	126	63	76
190	206	93	67	69	109	67	64	103	26	96	71	69	118	97
119	109	57	53	131	98	102	65	114	98	130	109	169	134	75
162	86	57	152	171	155	132	156	98	95	181	108	180	90	83
51	139	65	91	102	66	145	132	121	110	121	190	43	68	190
127	72	69	77	109	160	157	80	188	136	110	125	73	82	70
82	84	47	140	133	148	95	148	93	62	79	111	149	61	74
161	99	92	83	108	82	104	158	111	109	174	172	94	148	85
101	88	91	......	......	......	......	......	......	......	......	......	......	......	......
10	8	2	7	12	11	13	9	9	8	11	11	9	5	4 Above normal.
8	10	15	11	6	6	5	9	9	9	7	7	8	12	14 Below normal.
108	102	74	92	101	118	113	112	107	100	122	108	112	84	102 Mean.

* These months not used in mean since only one state's data available.

TABLE 3.—Rainfall since August, 1913, plotted as constant 14-month approximate periodicity.

EASTERN GROUP.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
93	71	89	78	121	134	87	76	79	97	83	107	56	73
86	118	73	105	91	130	144	102	44	44	130	95	114	144
100	124	97	123	111	81	77	78	112	125	138	83	87	87
74	102	108	72	127	95	86	110	102	95	95	121	31	53
60	60	58	145	95	87	75	87	113	153	99	126	92	98
116	91	146	101	112	109	65	188	138	86	98	88	107	161
86	107	102	129	107	53	124	124	75	82	......	......	......	.....
1	4	3	5	5	3	2	4	4	2	2	3	2	2 Above normal.
5	3	4	2	2	4	5	3	3	5	4	3	4	4 Below normal.
88	96	96	108	109	98	94	109	95	97	107	103	81	101 Mean.

SIX WESTERN STATES.

90	192	150	142	94	124	134	90	163	97	47	145	70	213
128	38	130	149	39	50	66	116	72	137	161	92	185	41
119	50	120	136	172	142	146	78	80	116	184	108	72	150
69	132	74	116	96	170	147	49	64	41	113	22	70	211
110	105	97	64	64	89	164	141	156	156	75	96	61	162
90	87	60	12	54	54	129	126	101	115	64	98	130	177
69	98	......	......	......	......	......	......	......	......	......	......	......	......
3	3	3	4	1	3	5	3	3	4	3	2	2	5 Above normal.
4	4	3	2	5	3	1	3	3	2	3	4	4	1 Below normal.
96	100	105	103	86	105	131	100	106	110	107	94	98	159 Mean*.

* Since these years averaged much wetter than normal the average of the phase means is 107 instead of 100.

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Application of Marvin's Periodocrite to Rainfall Periodicity.*

BY DINSMORE ALTER.

(Plates VII and VIII.)

PROFESSOR MARVIN has recently [1] published a criterion for discrimination between real periodicities and fortuitous ones. This criterion, called by him the periodocrite, seems to me to fill a real need, and I hope that it, or a slight modification of it, may be adopted generally for such purposes.

If the data covers q of the suspected cycles they are arranged in q rows and p columns. The total number of observations is N. $\sigma_0 = \pm \sqrt{\frac{\Sigma V_n^2}{N}} = \frac{\Sigma V_n}{.7979\,N}$ is then formed. Let n be any number of the rows or cycles. The mean is taken of the n observations, in each column, and $\sigma_n = \pm \sqrt{\frac{\Sigma V^2}{n}} = \frac{\Sigma V}{.7979\,n}$ is formed. The ratios $\frac{\sigma_n}{\sigma_0}$ are plotted as ordinates and $\frac{1}{\sqrt{n}}$ as abscissæ. "When y is substantially and consistently greater than x a real periodicity is indicated of greater or less amplitude."

In the first of these two papers published here I have given two tables continuing the work of the previous paper on a rainfall period equalling one-ninth the principal sun-spot period. The first of these tables shows the percentages of normal for each phase of each of twenty-four consecutive

* Received for publication August 5, 1921.

1. Monthly Weather Review, March, 1921, pp. 115-124.

cycles in the eastern third of the United States. The second table shows the same for each of seventeen consecutive cycles of a large western group. These tables are peculiarly well adapted for application of Professor Marvin's Periodocrite.

In table 1 of this paper I have formed the means of the first n cycles for each column of the Eastern group table described above, allowing n to assume each integral value from one to twenty-four. These means are the tabular values printed under each phase number. From these I have computed x and y, beginning with $n = 3$. In table 2 I have done the same thing for the Western group.

The last columns show the ratios y/x. Each of these thirty-five ratios is greater than one, the mean for the first table being about 1.4 and for the second about 1.2.

In plate VII I have shown these results graphically, and for purposes of comparison have copied the curves representing the annual cycles of Washington, D. C., and of Boston from the figure given by Professor Marvin in his paper.

The following has no connection with the application I have just made of the periodocrite to rainfall, but I believe that a slight modification of its graphical representation, not in any way changing its principle nor the method of analysis, will make it even more useful to discriminate between accidental and real periodicities of small amplitude.

When x is plotted as $\frac{1}{\sqrt{n}}$ the abscissæ corresponding to successive values of n become very closely crowded together, so much so that in the case of of 24 cycles the last half of them are represented by a very short portion of the curve, one easily overlooked in comparison with the much longer part representing the first half of the data. For a larger number of cycles the case becomes even worse. Yet these are the cycles in which accidental errors have been damped, to a large extent, and in which any true periodicity of small amplitude will show itself most clearly. Furthermore $\frac{\sigma_n}{\sigma_0}$ has become small, if the amplitude of a real periodicity is small, and the distance that is plotted above the line of perfect fortuity seems to the eye to be negligible, despite the fact that y/x, the real criterion, may rapidly be increasing to a large value.

I would therefore suggest that the graphical representation be changed to $X = n$ and $Y = y/x$. If this be done Y will, in general, decrease when X is small, even though there be a real periodicity of small amplitude superimposed on observations with large accidental errors; then, when n has become large enough to damp out the major portion of these errors, increase rapidly, no matter how small the real periodicity, to an infinite limit. If, however, there are no real periodicity Y will approach one as a limit. Such cases as the annual cycle at Boston, where the amplitude is small but where n has become very large, and which look doubtful as plotted by Professor Marvin, despite our knowledge of their truth, will show clearly the differences between themselves and accidental combinations. In plate VIII I have replotted in this way the four curves of plate VII.

In conclusion, I wish to warn against a possible misunderstanding on the part of the reader concerning Professor Marvin's statement on page 118 of his article mentioned above, that "other sequences 15 months, 16 months, one-ninth the variable sun-spot period, like the circles, all fall in the class of perfect fortuity." In a letter to me of later date he says: "I would like to know what the testimony of the periodocrite principle would be in reference to the alleged cycles you have examined. I am sure it is easily possible for you to make the application, as you have all the tabulations and data most fully worked up, whereas for me to do the thing myself would mean practically the entire duplication of the work you have already done." It is evident from this statement that he means to refer only to the five towns in Iowa and not, as some might erroneously infer, to the great mass of data I have used.

TABLE 1.—Eastern group rainfall.

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	y	x	$\frac{y}{x}$
1	74	258	64	129	127	122	110	71	66	224	142	116	94	184	117	....	....	....
2	82	178	87	124	94	116	110	87	63	167	138	92	61	138	104	....	....	....
3	84	153	86	132	94	125	121	94	69	150	121	95	71	122	110	1.10	58	1.90
4	92	133	89	124	96	108	127	92	73	134	130	89	76	111	102	.79	.50	1.58
5	91	125	90	114	92	109	117	100	79	128	122	97	73	114	106	.61	.45	1.35
6	91	117	97	118	99	113	119	97	85	118	114	93	73	112	109	.53	.41	1,29
7	98	110	93	118	96	121	111	100	93	120	111	98	76	107	111	.47	.38	1.24
8	104	116	89	114	99	125	114	97	88	117	110	101	74	102	114	.50	.35	1.43
9	103	117	88	112	100	125	116	98	90	114	102	104	74	99	117	.48	.33	1.45
10	103	119	89	107	100	122	117	98	89	111	104	100	77	98	113	.44	.32	1.38
11	100	119	91	104	100	123	111	96	90	109	103	99	75	95	113	.42	.30	1.40
12	101	115	94	102	98	122	112	95	93	106	106	95	76	98	114	.39	.29	1.34
13	100	113	95	101	94	118	113	96	93	105	105	95	77	99	116	.37	.28	1.32
14	100	117	96	100	96	119	110	95	92	104	104	94	78	97	114	.37	.27	1.37
15	103	116	97	99	99	118	108	94	94	107	102	93	80	100	115	.35	.26	1.35
16	103	114	100	100	96	115	111	93	95	106	100	94	81	98	117	.34	.25	1.36
17	104	114	103	99	100	115	110	92	96	106	100	94	80	97	115	.33	.24	1.37
18	102	114	102	98	99	115	110	92	97	103	100	93	81	96	114	.32	.23	1.39
19	103	114	102	99	99	115	107	94	98	101	101	92	82	97	115	.32	.22	1.45
20	104	114	104	99	100	115	106	93	98	103	101	92	82	100	114	.31	.22	1.41
21	106	115	103	101	100	115	107	92	98	103	100	91	81	98	112	.31	.22	1.41
22	108	114	104	102	100	113	106	91	97	102	100	92	79	98	112	.31	.21	1.48
23	108	114	103	101	101	112	105	91	95	101	101	90	79	98	113	.31	.21	1.48
24	108	115	105	103	101	110	107	94	96	100	101	90	81	97	112	31	.20	1.50

TABLE 2.—Pacific group rainfall.

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	y	x	$\frac{y}{x}$
1	114	50	14	70	45	187	105	94	147	250	215	86	128	28	46	......	......	......
2	142	56	34	88	82	157	106	90	88	140	143	104	128	48	86	......	......	......
3	146	80	38	87	69	163	108	101	90	139	134	121	116	66	84	84	.58	1.45
4	126	87	49	73	87	160	104	97	86	122	118	102	116	56	84	.68	.50	1.36
5	124	93	52	82	100	140	109	105	87	112	134	98	109	77	91	.52	.45	1.15
6	115	97	60	78	101	141	118	110	83	108	123	109	108	77	89	.52	.41	1.27
7	107	95	64	82	103	137	115	107	83	101	136	102	114	80	87	.48	.38	1.27
8	104	92	79	82	97	127	114	108	93	102	130	105	108	81	89	.38	.35	1.08
9	101	88	79	88	95	120	114	102	99	102	127	98	116	79	85	.37	.33	1.12
10	95	95	84	91	90	118	112	100	98	103	125	96	117	78	84	.36	.32	1.12
11	104	105	85	89	88	117	108	97	98	96	122	94	112	81	85	.33	.30	1.10
12	105	105	82	86	92	116	107	94	100	96	123	96	117	86	84	.34	.29	1.17
13	109	104	80	91	98	119	109	99	100	96	127	96	122	86	84	.34	.28	1.21
14	105	106	79	91	98	115	112	101	101	98	127	103	116	85	92	.29	.27	1.07
15	107	104	79	90	99	118	115	100	107	100	126	104	113	85	90	.30	.26	1.15
16	105	103	77	93	101	120	114	103	106	97	123	105	116	83	89	.30	.25	1.20
17	108	102	78	92	101	118	113	106	106	98	126	109	114	87	88	.31	24	1.29

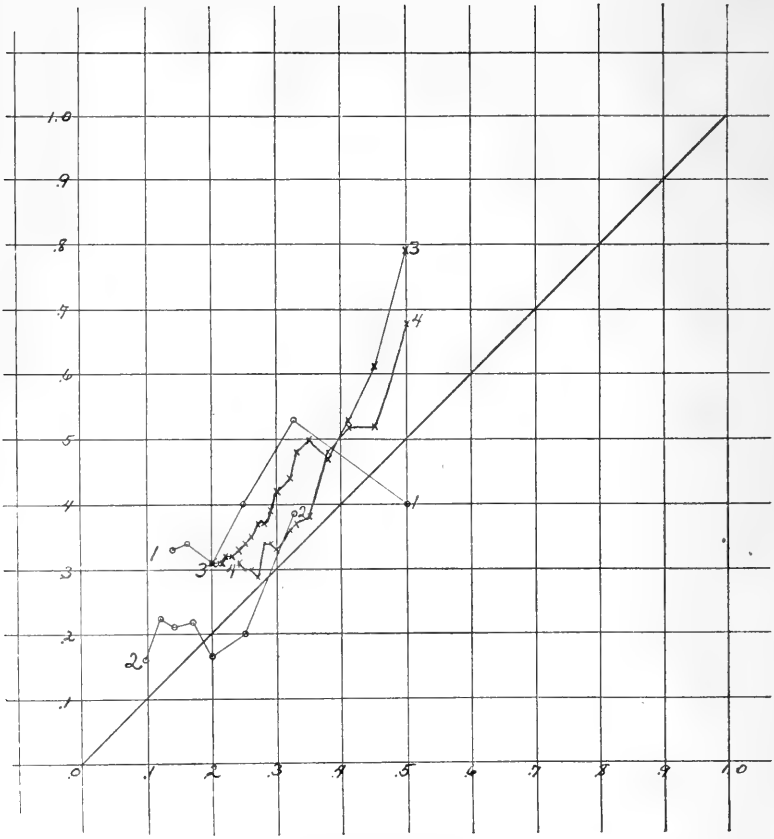

PLATE VII.—Application of Professor Marvin's periodocrites to various periodocrites.

1. Annual cycle, Washington, D. C., rainfall, fifty-year record.
2. Annual cycle, Boston rainfall, 103-year record.
3. Twenty-four cycles ninth harmonic of sun-spot period in Eastern group rainfall.
4. Seventeen cycles of same in Western group rainfall.

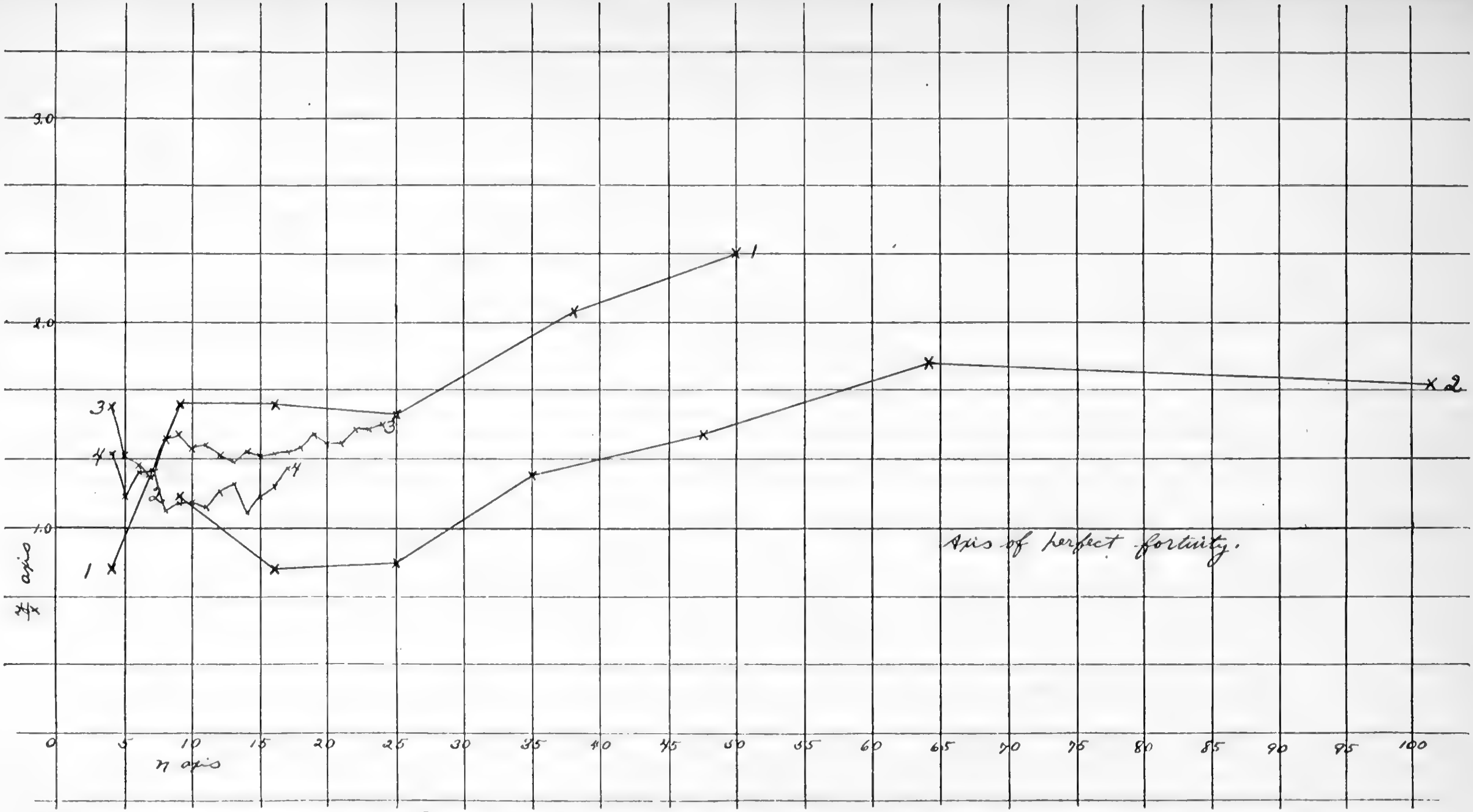

PLATE VIII.—Modification of Periodocrite. Periodocrites numbered same as in plate VII.

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On the Preparation of the Aryl Isothiocyanates.

BY F. B. DAINS, R. Q. BREWSTER, C. P. OLANDER.

THE aromatic mustard oils, RNCS, which have been the subject of many investigations on account of their reactivity, have been prepared by a number of different methods. The most common one involves the synthesis of the disubstituted thioureas from the amines and the subsequent splitting of the thioureas into aryl isothiocyanates and the amine or some derivative. Thus thiocarbanilide, when boiled with concentrated hydrochloric acid, 20 per cent sulphuric acid or concentrated phosphoric acid gave phenyl mustard oil and varying amounts of aniline and triphenyl guanidine.

The yield of mustard oil, based on the aniline used, in general is far from satisfactory on account of losses incurred in the preparation of the thiourea and the subsequent splitting with acid.[1]

An interesting modification in the preparation of these compounds depends upon the action of acetic anhydride or an acid chloride such as acetyl chloride upon the thiourea.[2] The acetyl derivative of the thiourea, which is first formed, readily breaks down into the mustard oil and an acyl-aryl amide,

$$RNHCSNCOCH_3R = RNCS + RNHCOCH_3.$$

While the above methods are of general applicability, it is evident that only one-half of the original amine can be converted into the isothiocyanate, and that it necessitates the synthesis of the substituted thiourea.

Fortunately, however, H. S. Fry's[3] interesting method for the preparation of the diaryl thiocarbamides has made readily accessible various thioureas that were difficult to obtain by the older methods.

1. J. 1858, 394. Z. 1869, 359. Ber. 15, 986 (1882).
2. J. Chem. Soc., 59, 400 (1891). J. Am. Chem. Soc., 22, 188 (1900).
3. J. A. Chem. Soc., 35, 1539 (1903).

A second general method for the synthesis of the mustard oils is based upon the intermediate formation of the salt of a substituted dithiocarbamic acid, RNHCSSMe. This is illustrated by the Hofmann[4] syntheses of alkyl isothiocyanates, which involve the desulphurization of the salt $RNHCSSNH_3R$ with mercuric chloride, silver nitrate, etc.

In the aromatic series compounds of the type $RNHCSSNH_3R$ cannot, as a rule, be isolated, but instead lose hydrogen sulphide and go over to the ordinary thiourea, RNHCSNHR. On the other hand, the aryl amines react with carbon bisulphide and ammonia and give almost quantitatively the corresponding ammonium salts, $RNHCSSNH_4$. This should afford a convenient source of mustard oils, provided some simple means could be devised for removing a mole of NH_4SH.

METHODS FOR SUCH ELIMINATION.

Andreasch[5] and others have shown that the ammonium dithiocarbamates react with ethyl chloroformate with the formation of aryl isothiocyanates, RNCS. The yields, however, are varying and the products are apt to be contaminated with the corresponding oxygen ureas. The method involves, too, the use of the expensive ethyl chloroformate.

In a paper published in 1891, Losanitsch[6] described a number of salts of phenyl dithiocarbamic acid and obtained from the ammonium dithiocarbamate, in water solution, the corresponding colored salts of copper, nickel, cobalt, iron, mercury and manganese. The statement was made "that the best method for the preparation of phenyl mustard oil is to treat a solution of ammonium phenyl dithiocarbamate with copper sulphate and distill with steam. The yield of mustard oil is theoretical." No confirmatory data, however, were given for this statement. Later Heller and Bauer[7] found that lead carbonate reacted with the ammonium aryl dithiocarbamates, yielding mixtures of the aryl isothiocyanates and monoaryl thioureas.

Since considerable amounts of the aryl isothiocyanates were needed in another investigation in this laboratory, it seemed advisable to follow up this observation of Losanitsch and ascertain

4. Ber. 1, 170 (1868). Ber. 8, 108 (1875). Ann. 371, 201 (1909).

5. Monat. 27, 1211 (1906). Monat. 30, 701 (1909). Monat. 33, 363 (1912). Am. Ch. J. 24, 432 (1902). Ber. 35, 3368 (1902). Ber. 36, 3520 (1903). Ber. 40, 2198 (1912).

6. Ber. 24, 3021 (1891).

7. J. Prak. Ch. (2) 65, 365 (1902).

whether the method was really a practical one and to determine if possible the optimum conditions.

The investigation has shown that the general method suggested by Losanitsch is capable of giving very satisfactory results in the synthesis of aryl isothiocyanates. Yields of mustard oil up to 77 per cent based upon the weight of the amine have been obtained—a result which is impossible by the usual method.

REACTIONS INVOLVED IN THE DESULPHURIZATION OF THE ARYL DITHIOCARBAMATES.

Using aniline as a typical aryl amine the synthesis is best illustrated by the following reactions:

$$\text{I.}\quad C_6H_5NH_2 + CS_2 + NH_4OH = C_6H_5NHCSSNH_4 + H_2O.$$

$$\text{II.}\quad C_6H_5NHCSSNH_4 + Pb(NO_3)_2 = C_6H_5NCS + NH_4NO_3 + HNO_3 + PbS.$$

Equation II does not occur directly, since the addition of the lead nitrate causes the precipitation of the lead salt—

$$\text{III.}\quad 2C_6H_5NHCSSNH_4 + Pb(NO_3)_2 = (C_6H_5NHCSS)_2Pb + 2NH_4NO_3.$$

The lead phenyl dithiocarbamate on heating breaks down as follows:

$$\text{IV.}\quad (C_6H_5NHCSS)_2Pb = C_6H_5NCS + C_6H_5NHCSSH + PbS.$$

The free phenyl dithiocarbamic acid tends to decompose with the formation of thiocarbanilide, aniline, etc. To prevent this a second mole of lead nitrate is used:

$$\text{V.}\quad (C_6H_5NHCSS)_2Pb + Pb(NO_3)_2 = 2C_6H_5NCS + 2PbS + 2HNO_3.$$

Since the nitric acid diminishes the yield by freeing phenyl dithiocarbamic acid from its NH_4 salt, an excess of ammonium hydroxide is added. The ideal proportions would be:

$$\text{VI.}\quad 2C_6H_5NHCSSNH_4 + 2Pb(NO_3)_2 + 2NH_4OH = 2C_6H_5NCS + 2PbS + 4NH_4NO_3.$$

For the best results, the solution after the addition of the lead nitrate should be neutral or only slightly acid. An excess of ammonia converts the mustard oil into monophenyl thiourea.

EXPERIMENTAL.

PREPARATION AND ISOLATION OF THE AMMONIUM PHENYL DITHIOCARBAMATE.

The following procedure, which is a modification of the method described by Heller and Bauer,[8] was found to give the best results. Carbon bisulphide (54 gms.) and 28 per cent ammonium hydroxide

8. J. Prak. Chem. (2) 65, 369 (1902).

(80 gms.) were mixed in a wide-mouthed flask or tall beaker set in ice. To this was added through a dropping funnel, in the course of 15 minutes, aniline (54 gms.), the whole being kept in agitation with an automatic stirrer.

The milky heterogeneous mixture, which first resulted, became clear and homogeneous after the addition of the aniline. The ammonium salt soon began to separate, and the mixture may become so thick as to stop the stirrer. After standing an hour in the ice bath the white ammonium salt was filtered, the mass washed with a little alcohol and dried quickly on a porous plate or between filter paper. The best yield of this salt was 86 per cent of the theory, although this may vary decidedly, not only in the case of aniline but also with the other aryl amines. This is due to the incomplete separation of the ammonium salt rather than to its nonformation.

PROPERTIES OF THE AMMONIUM PHENYL DITHIOCARBAMATE.

On standing, the salt slowly decomposed with the formation of hydrogen sulphide, ammonia, carbon bisulphide, aniline and thiocarbanilide. The decomposition was hastened when the salt was boiled with water. The results here indicated that the two main reactions were as follows, the first predominating:

$$\text{I.}\quad C_6H_5NHCSSNH_4 = C_6H_5NH_2 + CS_2 + NH_3.$$
$$\text{II.}\quad C_6H_5NHCSSNH_4 = C_6H_5NCS + H_2S + NH_3.$$

The mustard oil and aniline reacted to give thiocarbanilide, but the yield is low, only about 20 per cent of the theoretical.

With the ammonium salts of the p-chloro and p-bromophenyl dithiocarbamates, where the amines and isothiocyanates are less volatile, 55 to 60 per cent yields of the substituted thiocarbanilides have been obtained by this method.

DECOMPOSITION WITH ACIDS.

When an aqueous solution of the salt is treated with hydrochloric acid the quantitative decomposition can be expressed as follows:

$$C_6H_5NHCSSNH_4 + 2HCl = C_6H_5NH_2HCl + CS_2 + NH_4Cl.$$

Only traces of hydrogen sulphide and phenyl isothiocyanate are formed.

PREPARATION OF THE ARYL ISOTHIOCYANATES FROM THE AMMONIUM SALTS.

It is evident, then, that in order to produce the mustard oil, RNCS, from the dithiocarbamate, $RNHCSSNH_4$, some metallic salt must be used which will form a stable sulphide and an ammonium salt. To determine the best conditions for such a decomposition the following experiments were undertaken, using the dry ammonium salt of the aryl dithiocarbamates.

FERROUS SULPHATE.

A solution of 60 gms. of the iron salt in the minimum volume of water was added to 40 gms. of the ammonium phenyl dithiocarbamate in 200 cc. of water. A yellowish-brown precipitate formed immediately. The mixture, which had a noticeable odor of the phenyl isothiocyanate, was allowed to stand for an hour and then distilled with steam, but with the result that only 3 cc. of an impure mustard oil was obtained.

ZINC SULPHATE.

On mixing 30 gms. of the ammonium salt in 300 cc. of water with 47 gms. of zinc sulphate in 150 cc. of water a thick, white precipitate of the zinc phenyl dithiocarbamate was formed. This changed on steam distillation to zinc sulphide and gave a 23 per cent yield of the phenyl isothiocyanate.

COPPER SULPHATE.

To a solution of 25 gms. of the ammonium salt in 150 cc. of water was added 34 gms. of copper sulphate in the same volume of water. The odor of mustard oil was very pronounced, and the yellowish-brown copper salt changed readily, on distilling the mixture with steam, to the black copper sulphide. The yield of oil in this case was 71.7 per cent—a very decided increase.

LEAD NITRATE.

Using the same concentrations as above, 25 gms. of the ammonium salt and 40 gms. of lead nitrate gave the brown lead salt with a subsequent yield of 77.2 per cent phenyl isothiocyanate—a maximum which has not been exceeded.

In general it has been found that while both the copper and lead salts are suitable desulphurizing agents, the use of lead nitrate gave the better result in about the above ratio.

PREPARATION OF PHENYL ISOTHIOCYANATE WITHOUT SEPARATION OF THE AMMONIUM SALT.

The data obtained from the preparation of the ammonium salts of the aryl dithiocarbamates showed that the isolation of this compound might be far from quantitative, with the result that the yield of mustard oil based on the amine used would be proportionately lowered. This was proved directly by many experiments, two of which will be described in detail.

In each case the following amounts of reagents were used and the same procedure followed as exactly as possible:

Aniline	26 gms.
Carbon bisulphide	27 gms.
Ammonium hydroxide (28%)	44 gms.
Alcohol	20 cc.
Lead nitrate	100 gms.

The addition of the aniline required one-half hour. The stirring was then continued for another one-half hour, and the mixture filtered after standing for an additional hour. The separated salt was dissolved in 200 cc. of water, treated with the lead nitrate (in 200 cc. water), and distilled with steam. The yield of pure mustard oil was 20 gms. (53 per cent).

In the second case the unfiltered solution and salt was made up to 200 cc. with water and desulphurized as before. The product weighed 28 gms.—a yield of 74.2 per cent, based on the aniline used. The best yield obtained under these conditions was 76.8 per cent pure phenyl isothiocyanate. The difference in yield in the above experiments between 53 per cent and 74 per cent is due without question to the solubility of the ammonium salt in the aqueous ammonia.

LABORATORY PREPARATION.

The following directions are given as suitable for a laboratory experiment in the preparation of the phenyl isothiocyanate:

Place 54 grams of carbon bisulphide and 80 grams of conc. NH_4OH (28 per cent) in a tall beaker, surrounded by ice, and stir the mixture with a turbine. Drop 56 gms. of aniline into this mixture from a separatory funnel during the course of 20 minutes. The separation of ammonium phenyl dithiocarbamate soon begins. Continue the stirring for 30 minutes after all of the aniline has been added. Then allow the mixture to stand for another period of 30 minutes without stirring.

Dissolve the salt by the addition of 800 cc. of water, and add to the solution (with constant stirring) 200 gms. of lead nitrate dissolved in 400 cc. of water. Steam-distill the product from a 5-liter flask.

Put in the receiver a little dilute sulphuric acid; this will combine with traces of ammonia or aniline that might be driven over, and thus prevent the formation of any mono- or diphenyl thiourea.

LARGER-SCALE PRODUCTION.

The preparation of the mustard oil was carried out in a number of experiments, using from five to ten times the amount of the reagents listed above, with corresponding dilution. The percentage yields, however, were not so great as with smaller amounts. For instance, 280 gms. of aniline gave 232 gms. of product, and 560 gms. of aniline yielded 435 gms. of pure redistilled phenyl isothiocyanate. The low results were due in part to difficulties in properly mixing the reagents. If much free nitric acid was formed it decomposed the ammonium phenyl dithiocarbamate, thus preventing the formation of the lead phenyl dithiocarbamate. Other by-products that occurred were ammonium thiocyanate, diphenyl thiourea, triphenyl guanidine, which appeared as the nitrate, and monophenyl thiourea, where any excess of ammonia was present. In addition a strong current of steam is needed to separate the oil from the mass of lead sulphide formed.

ACTION OF LEAD NITRATE ON OTHER SALTS OF THE PHENYL DITHIOCARBAMIC ACID.

It seemed worth while to try the desulphurization of other than the ammonium salts, since in the absence of that reagent certain side reactions might be prevented.

Sodium Salt. $C_6H_5NHCSSNa$.

Aniline	28.0 gms.
Carbon bisulphide	27.0 gms.
Sodium hydroxide	13.1 in 50 cc. water.
Lead nitrate	100.0 in 300 cc. water.

The sodium salt which formed on mixing the reagents was so thick that the stirrer was stopped. Alcohol, 22 cc., was therefore added, and the stirring continued for one-half hour. After standing for an hour the orange-colored mixture was dissolved in 300 cc. of water and treated with the lead nitrate solution. Only a 30.2 per cent yield of the mustard oil was obtained, the greater portion of the aniline having been converted into thiocarbanilide.

Barium Salt. $(C_6H_5NHCSS)_2Ba$.

Aniline	28 gms.
Carbon bisulphide	30 gms.
Crys. barium hydroxide	47.5 gms. in 110 cc. of water.
Zinc chloride	42.1 gms. in 42 cc. of water.
Sodium hydroxide	9.6 gms. in 18 cc. of water.

The aniline was slowly added to the mixture of barium hydroxide and carbon bisulphide and then stirred for an additional hour. The odor of hydrogen sulphide became noticeable, showing decomposition. The zinc hydroxide formed by the addition of the sodium hydroxide to the zinc chloride was now added and the mixture allowed to stand overnight. On distillation with steam, 15.2 gms. of mustard oil, or 37.4 per cent, was isolated.

CALCIUM SALT. $(C_6H_5NHCSS)_2Ca$.

Parallel experiments were now made, substituting calcium for barium hydroxide, the other conditions remaining the same. Very little phenyl isothiocyanate was obtained, the main product being thiocarbanilide.

In the report on "The Manufacture of War Gases in Germany,"[9] it is stated that Kalle & Co. made the phenyl mustard oil used in the preparation of phenyl iminophosgene from the calcium phenyl dithiocarbamate, which was then desulphurized with a mixture of zinc chloride and sodium hydroxide.

That calcium phenyl dithiocarbamate was formed from the carbon bisulphide and calcium hydroxide was shown in the following experiment:

Aniline	28.0 gms.
Carbon bisulphide	27.2 gms.
Calcium hydroxide	12.0 gms. in 26 cc. of water.
Lead nitrate	100.0 gms. in 300 cc. of water.

On the addition of the aniline there was a tendency for the mass to collect in a gummy paste. This was prevented by the addition of a little alcohol and stirring the mixture for 24 hours. After desulphurization with lead nitrate 15.6 gms. of oil were isolated, which corresponded to a yield of 38.4 per cent. The increase in mustard oil is doubtless due to longer stirring and the more efficient desulphurizing agent, lead nitrate.

PREPARATION OF OTHER ARYL ISOTHIOCYANATES.

The following experiments were carried out in order to ascertain whether the method was suitable for the preparation of other aryl isothiocyanates:

o-TOLYL ISOTHIOCYANATE. o-C_7H_7NCS.

o-Toluidine	32.2 gms.
Carbon bisulphide	27.0 gms.
Ammonia water	47.0 gms.
Alcohol	20.0 cc.
Lead nitrate	100.0 gms. in 200 cc. water.

9. J. F. Norris, J. Ind. Eng. Chem. 11, 827 (1919).

The ammonium salt crystallized out readily after addition of the amine. The mixture was then brought into solution by the addition of 400 cc. of water and treated as before. The weight of pure o-tolyl mustard oil was 32.8 gms., or 73.27 per cent.

m-Tolyl Isothiocyanate. m-C_7H_7NCS.

Using the same proportions as before, the solid ammonium salt, which is easily soluble in water, soon formed. From the reaction mixture was isolated 33.5 gms. of oil, or 74.7 per cent yield.

p-Tolyl Isothiocyanate. p-C_7H_7NCS.

Under the above conditions 32.3 gms. (72.1 per cent) of the p-tolyl mustard oil (b. p. 270) were obtained.

1, 3, 4,-Xylyl Isothiocyanate. $(CH_3)_2C_6H_3NCS$.

1, 3, 4-Xylidine	36.4 gms.
Carbon bisulphide	27.0 gms.
Ammonium hydroxide	47.0 gms.
Lead nitrate	100.0 gms. in 200 cc. of water.

After three hours' stirring the ammonium salt separated in coarse crystals, which were dissolved in 400 cc. of water before the addition of the lead nitrate. The mustard oil was very slowly volatile with steam, and was obtained partly by this method and partly by extraction of the oily lead sulphide with carbon bisulphide. The separation was not complete, and only 25.5 gms. (52 per cent) of the xylyl isothiocyanate (m. p. 31°) were obtained.

Pseudocumyl Isothiocyanate. 1, 2, 4, 5, $(CH_3)_3C_6H_2NCS$.

Pseudocumidine	20.0 gms.
Carbon bisulphide	15.0 gms.
Ammonium hydroxide	23.0 gms.
Alcohol	22.0 cc.
Lead nitrate	49.0 gms.

The ammonium salt separated after two hours' stirring. It was dissolved in 1,000 cc. of water and treated with the lead nitrate in the same dilution. The isothiocyanate is difficultly volatile with steam, and the yield, 50.2 per cent, could probably have been increased by extracting the sulphide residue with some solvent.

Alpha-Naphthyl Isothiocyanate. A-$C_{10}H_7NCS$.

Alpha-naphthylamine	20.0 gms.
Carbon bisulphide	15.0 gms.
Ammonium hydroxide	22.0 gms.
Alcohol	20 cc.
Lead nitrate	46.2 gms. in 200 cc. of water.

The reaction mixture was dark colored and required long stirring before the ammonium salt separated. It was then dissolved in 400 cc. of water and desulphurized.

The isothiocyanate, which melted at 35°, was isolated by extracting the sulphide precipitate with repeated portions of alcohol. The product weighed 17.6 gms. (68.2 per cent).

BETA-NAPHTHYL ISOTHIOCYANATE.

The procedure was the same as with the alpha-naphthylamine, and while the ammonium salt, which was readily formed, reacted with the lead nitrate, no isothiocyanate could be isolated from the residue using alcohol as a solvent. It is probable that some other solvent would have proved more suitable.

o-ANISYL ISOTHIOCYANATE. o-$CH_3OC_6H_4NCS$.

o-Anisidin	37.1 gms.
Carbon bisulphide	27.0 gms.
Ammonium hydroxide	47.0 gms.
Alcohol	20 cc.
Lead nitrate	100.0 gms. in 200 cc. of water.

The ammonium salt separated quickly as a mass of coarse crystals. The mixture was allowed to stand for one hour and then dissolved in 800 cc. of water and desulphurized. The mustard oil, which distilled slowly with steam, weighed 35.2 gms. (70.7 per cent).

p-ANISYL ISOTHIOCYANATE. p-$CH_3OC_6H_4NCS$.

p-Anisidine	10.0 gms.
Carbon bisulphide	10.0 gms.
Ammonium hydroxide	13.0 gms.
Alcohol	15.0 cc.
Lead nitrate	27.0 gms. in 500 cc. of water.

The salt formed readily in large white crystals. After standing two hours the mixture was dissolved in 500 cc. of water and treated as usual. The mustard oil was easily volatile with steam and gave a yield of 9.2 gms. (68.6 per cent).

p-PHENETIDYL ISOTHIOCYANATE. p-$C_2H_5OC_6H_4NCS$.

In this case the weight of p-phenetidine was 41.3 gms.; otherwise the amounts of reagents corresponded to those used in the preparation of the o-anisyl isothiocyanate. The mustard oil distilled slowly with steam and gave a yield of 72.7 per cent.

HALOGEN SUBSTITUTED PHENYL MUSTARD OILS.

m-BROMOPHENYL ISOTHIOCYANATE. m-BrC_6H_4NCS.

m-Bromoaniline	15 gms.
Carbon bisulphide	10 gms.
Ammonium hydroxide	13.6 gms.
Lead nitrate	29.0 gms. in 500 cc. of water.

The dithiocarbamate formed very slowly and coarse crystals of the ammonium salt began to appear only after an hour's stirring. These were dissolved in 500 cc. of water.

The oil which came over with the steam solidified on cooling. The yield, however, was only 7 gms. (37.4 per cent).

p-BROMOPHENYL ISOTHIOCYANATE. p-BrC_6H_4NCS.

The same quantity of reagents were used as in the preceding preparation except that 15 cc. of alcohol was added in order to decrease the solubility of the ammonium salt, which separated in the form of fine, needle-shaped crystals. After standing overnight the mixture was dissolved in 500 cc. of water and filtered from a little unchanged p-bromoaniline. The yield of mustard oil was 39.6 per cent.

p-CHLOROPHENYL ISOTHIOCYANATE. p-ClC_6H_4NCS.

p-Chloroaniline	20.0 gms.
Carbon bisulphide	15.0 gms.
Ammonium hydroxide	24.5 gms.
Alcohol	20 cc.
Lead nitrate	52.0 gms.

The mixture containing the ammonium dithiocarbamate was dissolved in 500 cc. of water and treated as usual. The yield was 15.8 gms. of the solid isothiocyanate (59.6%).

p-IODOPHENYL ISOTHIOCYANATE. p-IC_6H_4NCS.

p-Iodoaniline	20 gms.
Carbon bisulphide	12 gms.
Ammonium hydroxide	14.2 gms.
Alcohol	20 cc.
Lead nitrate	30.2 gms.

The crystals separated after 30 minutes' stirring. The mixture after standing for four hours was added to 500 cc. of water, and later filtered from a dark-colored insoluble residue. The mustard oil, which was obtained in a 53.4 per cent yield, was volatile with steam and melted at 79°.

p-NITROANILINE.

All efforts to prepare the ammonium p-nitrophenyl dithiocarbamate failed, the nitroaniline being recovered unchanged.

RÉSUMÉ OF RESULTS.

Aryl isothiocyanates.	Per cent yields based on amines used.
Phenyl	76.8
o-Tolyl	73.2
m-Tolyl	74.7
p-Tolyl	72.1
1, 3, 4,-Xylyl	52.0
Pseudocumyl	50.7
Alpha-naphthyl	68.0
Beta-naphthyl	00.0
o-Anisyl	70.7
p-Anisyl	68.6
p-Phenetidyl	72.7
m-Bromophenyl	37.4
p-Bromophenyl	39.6
p-Chlorophenyl	59.3
p-Iodophenyl	53.3
p-Nitrophenyl	00.0

From the consideration of the foregoing results, it is evident that the success of the method is dependent upon at least three factors: First, the completeness of the formation of the ammonium aryl dithiocarbamate, $RNHCSSNH_4$. Second, the ease and completeness of separation from the sulphide precipitate. Third, the avoidance of side reactions leading to the formation of free aryl dithiocarbamic acid, aniline, etc. The low yield in the case of the xylyl, cumyl and alpha-naphthyl derivatives would seem to be due to their slight volatility with steam and the difficulty of extracting the oils from the mass of lead sulphide.

The cause of the failure with beta-naphthylamine must be determined by further investigation.

With the halogen substituted anilines which are less basic than the aniline, toluidine, etc., there is probably incomplete salt formation, which would thus account for the lower yields.

SUMMARY.

The paper describes a method for the preparation of aryl isothiocyanates which is relatively simple and inexpensive and which gives yields greater than any which require the intermediate formation of the diaryl thioureas.

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THE KANSAS UNIVERSITY SCIENCE BULLETIN.

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A Rainfall Period Equal to One-ninth the Sun-spot Period.

DINSMORE ALTER.

SYNOPSIS.

PRELIMINARY discussions based on the rainfall of the United States have been published in the *Monthly Weather Review* and the *University of Kansas Science Bulletin.* The present paper completes the investigation of this period, using much longer records and the data from the United States, Northern Europe, Central Siberia, the Punjab in India, Chile, South Australia, Jamaica and Madagascar. Numerous tables and curves are given. The conclusion reached is that the period does exist, and that the relationship to sun spots is not a direct one, but due to an unknown common cause. In purely continental areas, minimum rainfall is connected with a maximum of sun spots; in purely marine, with a minimum of sun spots. For areas with rainfall between these types the period is not plainly found.

INTRODUCTORY.

In August, 1915, Dr. A. E. Douglass read a very interesting paper before the Berkeley meeting of the American Astronomical Society regarding an investigation of the growth of trees in many parts of the world, indicating an eleven-year period in rainfall (1).

It seemed to me that the data collected by the Weather Bureau should definitely settle such a question of periods. Some preliminary reading showed, however, that a tremendous amount of time had been spent on the problem (2), and that if solvable it must be very complicated. Other work prevented starting any actual investigation; then the war intervened and the problem was untouched till the spring of 1919. The first data examined were those from

Lawrence, Kan., where records since 1868 are available. Several hundred hours of work showed nothing. Once a stretch of five years was found which resembled another five quite closely after eliminating the seasonal curve. Another time resemblances were found after about twenty-two years. All such were easily explainable as accidental. It seemed useless to carry the work further with the data at hand.

A paper by Professor Turner (3), however, gave me a new suggestion, although there was little if any logical reason for any connection. In this paper Professor Turner shows plainly the existence of a period in earthquakes with a length between 14.8421 and 14.8448 months. It occurred to me that this period might be commensurable with the sun-spot period. Upon multiplying it by 9, I obtained 11.13 years, which is the mean sun-spot period to the exact hundredth of a year. Such an exact coincidence is very probably not accidental (4*a*).

The next move was to examine all sun-spot data in order to find whether such a period also exists in sun spots. The results have been inconclusive, some evidence favoring the existence of the period, but not being definite enough to settle the question either way. The general conclusion seems to be that any relationship of sun spots to weather is not a direct one, and that periodicities which are commensurable may exist in each separately, as might happen if the variations were due to a common cause. This will be more fully developed in the general discussion of results.

In three preliminary papers (4*b*) I have investigated the rainfall of the United States, and in them arrived at the conclusion that they afford evidence toward the existence of the rainfall periodicity. When these papers were published it was recognized that they did not constitute proof, that data were needed from all parts of the world and, as Marvin (5) stated in a critical discussion, long records were needed. Since the publication of the first papers I have been gathering all available data, much of it in unpublished manuscripts sent me by meteorologists from many countries of the world. The reduction of these data has been a long job, even requiring hundreds of hours to prepare a single table. For example, the rainfall of many separate stations were given for Sweden; these had to be combined as one table. The same was true of the Punjab in India, where data from twenty-five stations were copied out of Eliot's book and averaged to give a district record to 1900. After that it was necessary to borrow seventeen large volumes and copy a little from each to complete the tables. To complicate the task, these data were given for fifty-five districts during the early years and for thirty-three during the later. From some countries averages made correctly were sent in form to use, but in the main the data, as secured, required much work to put it in a form to begin the investigation. Such tables are added to this paper in order that other investigators may be saved the preliminary computations. All long records have been studied, with the exception of Canada, which is so close to the United States that it was felt the results secured would not be worth the work of averaging many stations together to get district values in usable form. In the proper places comments will be made on the methods of securing district averages in the United States and other countries. It is believed that many of these should be remade.

MATERIAL SUITABLE FOR HARMONIC ANALYSIS.

A mass of observational material, when plotted with time as abscissæ and observed values as ordinates, may show no repetition of the same curve, even though such a curve might exist. There may be nothing definite about it to indicate a period. In such cases ordinary methods of harmonic analysis become useless. This failure to repeat values, when a period exists, may be due to any one or more of the four following causes:

(*a*) Incommensurable periods may coexist. In this case the curve will never repeat itself, although for short periods of time there may be a fairly close approximation to such repetition. If there are three or more incommensurable periods the curve obtained for the data is very complex. For example, the seasonal variation of the rainfall would be incommensurable with a possible one equaling the sun-spot period. Of course, if one of such periods is known, as in the case of the seasonal variation in the example above, it may be eliminated.

(*b*) There may be large accidental errors. Such errors mask a periodicity almost completely in any one cycle and disappear only when the data values in each of a number of well-distributed phases are added through many cycles. From the theory of errors, their influence will be inversely proportional to the square root of the number of cycles added.

(*c*) Long-period variations may exist. If there are periods longer than the interval of the data they will produce much the same effect as accidental errors or incommensurable periods.

(*d*) There may be periods which vary in length. An example of such a period is the sun-spot period, which, although averaging

11.13 years, has varied from 7.3 to 17.1 years during the last 115 years.

When any of these four difficulties exists it is almost impossible successfully to treat the problem unless the investigator stumbles upon the true period, either by a fortunate suggestion or by some reason extraneous to the problem, or by the patient trial-and-error method by which Kepler found his three laws of planetary motion. Schuster (6) has developed a method designated as the periodogram, which will avail in some cases.

METHOD USED BY TURNER IN EXAMINING THE EARTHQUAKE DATA.

The exact form of this method seems to be due to Schuster (6), and is a slight modification of the one astronomers have used for generations. Suppose that we have a mass of material—for example, the number of earthquakes recorded per month, or the rainfall per month—through many years. Plotting shows no periodicity, or at the most only a faint hint of such. Chance or Schuster's periodogram leads us to suspect a period of, for example, 15 months. We can write the first 15 months' data in a row as the heads of as many columns. The sixteenth month, the thirty-first, etc., will follow successively in the first column, the seventeenth, thirty-second, etc., in the second column, and so on, the thirtieth, forty-fifth, etc., in the fifteenth column. Each column will then contain only months which are in the same phase of the suspected period, if it actually exists.

We will refer to one such row as a cycle, and to the columns as phases. Suppose the period to exist. It may not show in a single cycle, probably will not, because of large accidental errors or incommensurable periods, either or both of which may be present. But the months of any phase of an incommensurable period will, in the long run, be almost evenly distributed through all the phases of our assumed period, and will, therefore, be subject to the same laws as accidental errors, namely, their influence will be inversely proportional to the square root of the number of cycles. In the course of four cycles (five years in our present example) their importance will be only half as great as for any one cycle; after sixteen cycles one-quarter as great, etc. However, the effect of our assumed fifteen-month period will be equal in each, and therefore as prominent in the average as in any one cycle. Thus, no matter how large the accidental errors, or the variation due to incommensurable periods, the true variation from phase to phase will begin to appear.

If the assumed period does not exist, the mean values of the phases will approach each other as we increase the number of cycles.

This last point gives us two very powerful criteria for the verity of our assumed period:

(*a*) Having given *a large number of cycles,* we may compare the phase values of the first half of the cycles with those of the latter half. If the variation be real the curves from the two halves of the data should agree fairly well. If the variation be accidental there can be only chance resemblance. Unless the assumed period exists, the two halves of the data are entirely independent, when there are enough cycles to eliminate residuals of other periods that might exist. A very simple test for a real relationship between the two curves may be made as follows: There is an even chance that if the results are purely accidental, any pair of values from the same phase in the two curves will lie on the same side of the normal. If there are three curves, one-fourth of them should show all three curves on the same side. Much departure from this accidental grouping indicates strongly a correlation.

(*b*) Having obtained the phase values, as above, for each half of the data, we may consider half the difference of identical phases in the first and last halves of our data as a measure of the deviation of the two curves from each other and of the amount of chance error left in each phase. Call this half difference d. We will have in this example $d_1, d_2, \ldots d_{15}$. The probable error of any point on the curve which is formed from the whole of the data will be given by the formula,

$$\epsilon = 0.6745 \sqrt{\frac{\Sigma(d^2)}{n-1}}.$$

If this probable error is as large as half the variation from maximum to minimum phase there is approximately an even chance that the variation is accidental. If the ratio of ϵ to the variation is smaller than about one-eighth, the chances are less than one in a thousand that it is accidental. These ratios are tabulated in the general discussion of results for each set of data. Both these criteria must be applied in any case under discussion.

Let us suppose that the assumed period is not an exact number of months; for example, $14\frac{6}{7}$ months. In this case 7 cycles will equal 104 instead of 105 months. We must spread our 104 months over 7 cycles of 15 phases each; that is, over 105 phases. To do this we will fill each of the first 6 cycles and the first 14 phases of the seventh cycle just as formerly, using all the data that we have for 7 cycles. We will then use the month's data which we used for the fourteenth phase of the seventh cycle again in the fifteenth phase. Doing this, no month will fall more than a half phase from the proper one as determined by the mean of all positions. If we assume a period of 15 1/7 months we will merely skip one of the month's data, or better still, average it with the next following one. In this manner any period may be plotted with any number of phases desired, and no month's data more than a half phase from its proper place.

FIRST APPLICATION OF THIS METHOD TO RAINFALL.

One-ninth of the mean sun-spot period is very nearly 14 6/7 months. I tabulated all the rainfall data from Lawrence, Kan., beginning with 1868, according to the method outlined above. The result showed a variation of about 12 per cent each side of the normal. Next I divided the data into halves and found the two to agree fairly well. Following this I examined data from all of Kansas, from Nebraska, New England and Ohio. The data from Ohio checked fairly well; those from New England and Nebraska gave results which were discordant with themselves. The variation of the sun-spot period now came to mind. If there were any real variations due to sun-spots or to a common cause they would certainly have to keep a constant relationship with the phases of the sun-spot period.

Table 1 shows the dates of maxima and minima of sun-spots as determined by Wolf and Wolfer (7). It also shows the number of years intervening between successive maxima or minima; in other words, the actual sun-spot periods during those years. As a first approximation to keeping the phases in step with the sun spots, I plotted the rainfall between the dates of each pair of consecutive minima on a period one-ninth that interval. Minima occurred in 1889, August, and in 1901, September. The interval is 145 months. I therefore used a period of 16 1/9 months between those dates. The next minimum occurred in 1913, May. This interval is 141 months, and I used a period of 15 6/9 between these dates. When this was done I secured very much better results than before, so much better that I could not believe them due to accident. I obtained similar curves for each state the whole length of the Atlantic and Gulf coasts as far as Texas. When the data of New England and Pennsylvania were divided in halves, curves of similar shape were obtained for each, differing only in phase. This improvement over the results from a constant period indicated that a more rigid method of keeping constant relationship with the sun-spot phases should be devised before definite conclusions were drawn.

RIGID FOLLOWING OF THE SUN-SPOT PHASES.

It is evident that the sun-spot period between the minima named above had values of 145 and 141 months, respectively. Let us examine the two maxima occurring between these dates. One occurred in 1894, February, and the other in 1906, May, with an interval of 147 months. This must have been the average value of the sun-spot period between these dates. It is longer than the period obtained from either pair of minima named above, yet it occurs as part of each of them and contains no part that is not in one or the other of them. We are forced, therefore, to the conclusion that if continuous (8*a*)—

The length of the sun-spot period is continuously varying and a value of the period obtained between successive maxima or successive minima is merely an average of all values passed through in this interval.

If we had a curve with time plotted along the axis of abscissæ and the corresponding values of the sun-spot period as ordinates, the average value of the sun-spot period between two maxima or two minima occurring at t_1 and t_2 would be given by—

$$t_1 - t_2 = \text{average value} = \int_{t_1}^{t_2} \frac{\text{curve}}{t_1 - t_2}\,.$$

If we plotted abscissæ and ordinates on the same scale, these average values would form squares bounded by ordinates through the dates which limit them. The area between the axis of abscissæ and the unknown curve, described above, representing the actual value of the period at all times, would in the interval between two maxima or two minima have to equal the corresponding known square. Since these squares overlap, we know the value of a series of overlapping definite integrals of the unknown curve. From these data it is possible, assuming the simplest curve to be the true one, by the aid of a planimeter, to construct the curve without knowledge of its mathematical form. In doing this it is easier to choose some convenient period as the axis of abscissæ and to measure departures from this period. Changing the axis in this way merely changes all the integrals by a known constant amount and changes the known squares into known rectangles. It is also practical to magnify the scale of ordinates very much over the scale of abscissæ. Locating the curve consists first in measuring the area of each of the rectangles; then penciling in what appears to be the curve, measuring the definite integrals of the approximate curve with the planimeter; erasing for a new approximation, and repeating many times. In the curve of the sun-spot values reproduced as Figure 1, I have erased each part of the curve probably a hundred times. Although very laborious, the process, with enough patience, yields very good results. The accuracy of the period curve depends upon the accuracy with which the epochs of maxima and minima are obtained. A steep but narrow peak, such as that of 1861, may be unreal for this reason. However, due to the short duration of such a peak and the fact that it must almost immediately be counterbalanced, there will usually be little effect in data extending over a long range.

In the preceding paragraph I have spoken of the sun-spot period at any date as a varying quantity, not even approximately constant through a single cycle. This may necessitate a definition of "period" somewhat different from what is ordinarily understood. I therefore give the following definition, which will be adhered to whether referring to sun spots or rainfall.

The length of the period at any date is the reciprocal of the rate of change of phase at that date and need not continue even approximately through a complete cycle.

From this curve I have taken the mean value of the sun-spot period for each year. These values are given as column 2 of table 2. Column 3 gives the departures from 15 months of one-ninth these values. Obviously, 15 months was chosen because it is the nearest integral number of months to one-ninth of a period. If, for example, the number given for any year in column 3 were + 9, it would mean that during that year one-ninth of the sun-spot period was 16 months. If it were — 9 it would mean that the period was 14 months. In the first case it would be necessary, working on a 15-phase basis, to skip a month every 16 months as long as that length of period persisted; in the second case to repeat one every 14 months. We can thus construct a table of months to be repeated in the analysis of our rainfall data when the ninth of the sun-spot period is less than 15 months, or to be skipped (or better still, averaged with the next adjacent one) when the ninth is more than 15, in order that Wolfer's sun-spot maxima may all fall in one phase and his sun-spot minima in one.

In this work I have in each case averaged the month to be skipped with the next following one instead of actually skipping. Thus three months' data give two phases, the result desired through skipping, and all data are used. There is, however, such a slight gain in accuracy that I scarcely believe it worth the slight extra work involved. If this averaging and repeating is done correctly the epoch of maximum of each of the cycles of the sun spots will always fall in one phase of the suspected rainfall variation and also each minimum in one. Wolfer's values of maxima and minima are uncertain by a month or so, and therefore in the first paper the placing of them within one phase from the mean was considered as a perfect check in determining the months to be averaged or repeated. When there was a greater error than this in determining the position of a maximum or a minimum it meant that there was a slight error in the curve and that it was necessary to apply a slight adjustment factor to the values of the period taken from it. In no case did I have a large factor to apply, thereby showing that the curve as constructed was approximately correct. Indications from the work explained above were that the period taken from it could be relied upon to within three or four months, and that such errors as did occur were canceled in most cases by ones of opposite sign before adjustment had become serious.

I did not realize at the time that readers might think this discrepancy purposely made by me in order to better my results. To avoid this objection I have, in this paper, made the Wolf-Wolfer epochs fall exactly in the same phase each cycle. The phase in which the sun-spot maximum falls has been numbered 1 and that in which minimum falls 8. For 1913 Wolfer has published two dates of sun-spot minimum, first May, and later August. I used the former in the first paper before seeing his later work. The sun-spot curve seems to me to indicate May, or even an earlier epoch, correct. Wolfer's later epoch may, therefore, be a typographical error, and I have continued to use May. Since a short period locates its epochs of maxima and minima more exactly than a long one, it will be possible later, if the existence of the short rainfall period be admitted, to revise the Wolf-Wolfer epochs from the rainfall data. Such a gain in accuracy would mean much in an investigation of the sun-spot periodicity.

Table 3 shows which months I have averaged and repeated in the analysis of the rainfall data of each country investigated. It is probably useless to emphasize that there was no change in this table for any of the countries under consideration. At first thought the results of table 3 and of figure 1 are startling. However, an inspection of the much greater changes in the period which have persisted through entire cycles during the last 115 years, namely, from 88 to 205 months, shows that these variations through short periods of time are to be expected. Moreover, there is no way to draw a curve satisfying the necessary conditions and having smaller variations, unless possibly by introducing more points of maxima and minima upon it. Such a complication would be much less probable than the variations shown by the present one, all of which are less than the variations from the mean value of complete cycles of approximately 11 years have been in the rather recent past, as shown by table 1.

THE RAINFALL DATA EXAMINED.

I have examined the rainfall averages of each of the forty-two sections in which the United States has been divided by the Weather Bureau, of a number of stations in Central Siberia, of the Punjab in India, of a few towns in Chile, of complete records of Denmark and Sweden and stations in Holland and England, of South Australia, of Jamaica, and of Tananarive, Madagascar. I had a small amount of data from the Soudan and Abyssinia and scattered small amounts from other countries, but none of these enough to examine with any weight. There were also data such as received from Canada, where the proximity of countries for which I had data made it seem unwise to take the great amount of time necessary to average the individual stations, and where, unlike Madagascar, thousands of miles from the nearest data used, it seemed useless to obtain results with the little weight that would be attached to one station.

The results from each of the sections named above are discussed here, the tables are given from which these results are deduced, the values are given for each individual cycle, and the means of the halves or thirds are given and plotted, as also the curves from the whole data. The sections are grouped in three main divisions:

(A) Interiors and eastern coasts of large continents. There are three such sections: Eastern United States, Central Siberia, and the Punjab.

(B) Western coasts of continents. This group includes the Pacific coast of the United States, the group of countries from the northwest European coast, and a very small amount of data from Chile.

(C) Other sections. This includes South Australia, Jamaica and Tananarive, Madagascar.

The last sun-spot maximum occurred in 1917, and all data since then are thus unavailable for use in examining the existence of the period. This would not be a serious handicap for predicting, if the period should be proved to exist, since the course of the maxima and minima could be followed from cycle to cycle by using means from a large number of sections and an extrapolation made for a cycle in advance without serious error. Indeed, in such a case it might be possible to predict the time of the next sun-spot maximum or minimum quite accurately from the rainfall data.

Effect of Annual Cycle. In many cases the residual left from the seasonal variation is large enough to distort the curves materially. I have, therefore, always carefully eliminated it, no matter how large or how small. To do this I have, wherever it is very pronounced, prepared two tables for each section according to the plan previously outlined, repeating and averaging in each one the months determined by table 3. In the first of these tables I have used the actual values of the rainfall. In the second I have used instead of each January the mean of all the Januaries, and so on for each month of the year. In this second table the mean monthly values were repeated or averaged exactly as in the first one, to give a table entirely similar to the first table. The variation from phase to phase in this second table is, therefore, entirely the seasonal residual and contains all of it. For the average state in the United States it is approximately four per cent each side of the normal, the rest of the seasonal variation having been damped out by the process of tabulating the incommensurable period which is being investigated. The quotients of the sums of each phase of the first table by the second give us the percentage of normal rainfall of that phase for the section concerned throughout all the years of the data. Each month is in this way weighted in accordance with its normal rainfall. In no case has there been any smoothing of results other than that marked in the tables where the *mean* has sometimes been smoothed by averaging each phase with the ones immediately adjoining for better examination.

In the eastern United States and northern Europe the yearly variation of rainfall is small enough that each month may be weighted the same without serious error. I have, therefore, in these two cases divided the actual rainfall of each month by its normal and thus obtained the percentage of normal to plot. This has the advantage for the reader that he need look at but one table instead of two to see how the period has been followed from cycle to cycle.

It may occur to some that possibly there is in some manner a residual of the seasonal effect left in this period, despite the elimination explained above. There are three answers that may be givn to this objection, all of which are merely the same one in different forms.

(*a*) In Professor Schuster's discussion of the periodogram (6) method of searching for periods we find the following: "There is a limit beyond which it is useless to go. This limit is reached when the values of A and B for two closely adjoining values n_1 and n_2 are no longer independent of each other. The theory of vibration shows that independence begins when there is an ultimate disagreement of phase amounting to about one-quarter of a period."

(*b*) Professor Turner has worked out the effects of any period on adjoining periods (8*b*). He divides the data into integral parts and calls any one of these submultiples q; p is a period near q, such that $q+x=p.x<1$. From the Fourier sequence the periods q and $q+1$ are independent. Let us consider the seasonal period as q and the ninth harmonic of the sun-spot period as p. In order that x may be as small as 1, we must have $q=3$. That x be less, requires $q=2$. But, quoting Professor Turner, "q is a fairly large integer for any periodicity worth serious consideration."

(*c*) The work involved in computing the periods near 12 months for each state is much greater than the value of the results. I have, however, taken Pennsylvania as typical of the United States and computed periods of 12, 13, 14, 15 and 16 months.

For 12 months, which is the seasonal period, the amplitude of the variation is 34 per cent; for 13 months it is 11 per cent; for 14 months it is 12 per cent; for 15 months it is 10 per cent; and for 16 months it is 17 per cent; the amplitude of the ninth harmonic of the sun-spot period is 26 per cent. The mean value of the ninth harmonic during this interval of years was 15.8 months, showing the increase in amplitude at the nearest of the other periods as demanded by the theory or the periodogram (6) or by the Fourier sequence (8*c*).

A serious source of weakness in the state averages published by the United States Weather Bureau and by almost every other meteorological service developed during this investigation. This may well be illustrated by the state of Washington as a fair sample. Within one year the number of stations used in the state average varied between 105 and 130. Over a number of years the range is larger. The eastern part of the state is very much drier than the western. If one is comparing two months' rainfall it becomes imperative that he know what stations were omitted each month. The month showing the greater fall may be below normal and that showing less may be above because of omission of eastern stations in the first and western in the latter. I realize that it is impossible to obtain a perfectly homogeneous record, since volunteer observers must sometimes fail, often through no fault of their own, but I would venture to suggest a method by which the records may be reduced to a near homogeneity. The sum of the actual rainfall for all the stations used may be divided by the sum of the normals of the several stations and the quotient published as the percentage of normal which fell that month. The means of the normals of stations chosen for accuracy of records and geographical distribution may then well be taken as the normal of the state, and when multiplied by this quotient will give a weighted mean of the state that will be practically homogeneous from year to year. This lack of homogeneity in state records is much more serious in investigation of long periodicities such as the Brückner and eleven-year cycles, and might easily show entirely negative results where the period actually exists. An example of the reduction of scattered material to homogeneity is given in this paper in the treatment of Chile, where long records are available from five towns with widely differing normals. These records begin in different years and omit certain years irregularly. The sums of the actual rainfall given were tabulated for the fifteen-month periodicity, as were also the sums of the normals for each month that a station was used. These sums were then added through each half of the data for each phase, and the quotient of actual by normal was taken. These tables are Nos. 19 and 20. In the eastern part of the United States the normals from one part of a state to another vary by small enough amounts that the records are not seriously impaired. For the western part I felt it best to take instead the stations on the coast having perfect records extending as far back as 1880. All such were used except where stations in California happened to be very close together, in which cases one was always omitted in order not to give that small section of the coast undue weight. Nineteen such stations in California and western Oregon were available. No station in Washington had such a long record without break. This procedure also has the advantage of almost doubling the length of record over the published state averages. The results from these stations are shown as tables 10 to 12. The names of the stations will be found at the heads of these tables. The Adelaide Observatory in South Australia seems to have kept the most ideal record from 1861 to 1907. They averaged the same fifty towns, apparently, from the beginning to the end of that period. Unfortunately, this method was discontinued and the present one of averaging all available stations, as in the United

States, instituted. The great shift in normal made it impossible to compare the early and the later records. This investigation of Australian rainfall ends, therefore, with 1907, although the later results kindly sent by the meteorological director of the commonwealth are published here for information:

GROUP A.

	Eastern United States.	Siberia.	The Punjab, India (smoothed).
ϵ	2.7	2.4	3.6
Range of curve from whole data	23	17	29
Ratio	0.117	0.141	0.138
Number phases on one side of normal	12	10	*9 8

The ratios in each of these cases are approximately one-eighth, showing, as previously developed, a very small chance of such accidental agreement. In the case of India the same ϵ was derived from the relationship of both the first and last of its three curves to the middle one. Since the ratio given measures the possibility of chance agreement of either of these curves with the middle one, the chance that both agree in this manner by accident is only the square of the chance that one does.

GROUP B.

	Pacific coast (smoothed).	Northern Europe.	Chile.
ϵ	3.8	2.5	3.9
Range	43	22	25
Ratio	0.088	0.114	0.156
Number of phases on one side of normal	*11 12	12	10

As would be expected from an examination of the curves, the chance of mere accidental agreement between the two halves of the Pacific coast and northern European curves is negligible. In the case of Chile, just as one would judge from the appearance of the curves, it is much larger than for the other two, but is still small.

GROUP C.

	South Australia.	Jamaica.	Madagascar (smoothed).
ϵ	4.6	3.5	5.1
Range	24	19	28
Ratio	0.193	0.184	0.182
Number of phases on one side of normal	8	10	8

The results of group C, while favoring the true existence of the periodicity to some extent, do not show the certainty of groups A and B. This is to be expected in the case of Jamaica, which is a

* Unsmoothed.

small, mountainous island, where, as Professor Pickering says, "The rainfall is very unequal in different portions of the island." It varies from 33 inches west of the mountains to 248 on the eastern end of the island. For Madagascar there is but one station, with a record over only 21 cycles, so that the correlation is all that one could expect. In the case of South Australia, however, we have a long, homogeneous record from fifty stations. The effect of the period is evidently much less certain there than in the region of groups A and B. In this it reminds one of the results obtained from the central third of the United States, a region located between the two types represented by groups A and B. Data are not at hand to show whether such a reversal, as in the United States, would be found between the northern and southern parts of South Australia. An investigation of this character would, I venture to predict, show the reversal. I hope to secure data to examine this region more thoroughly.

GENERAL DISCUSSION.

In group A, which consists of interiors or eastern coasts of large continents, we find *the minimum of our curves coming exactly at phase 1 in each case. This is the phase, as told above, which every ninth cycle contains the sun-spot maximum.* Each of these curves shows also the effect of a second harmonic of this period with one minimum at this same phase, the other neutralizing the maximum, which would normally fall at phase 8. This much can safely be accepted as true features of purely continental curves.

In group B we find more variation in curves from one section to another. For the Pacific coast we find the minimum at phase 7 and the maximum at phase 13; for northern Europe the minimum at 7, if we smooth our curve, and the maximum at 14. The small amount of data from Chile does not give any very definite results, almost equal minima at 2 and 12, with maxima at 10 and 14. The marine type seems, then, with considerable uncertainty, to give a minimum of rainfall at time of sun-spot minimum and a maximum shortly before the sun-spot maximum.

The halves or thirds of the curves at any one place will differ from each other for one or more, probably all, of the following reasons:

(*a*) Accidental errors and other periodicities are not entirely damped out.

(*b*) The epochs of sun-spot maxima and minima are uncertain, and consequently some data are incorrectly placed by one or more phases. If this periodicity is generally accepted, the recent sun-spot epochs can be revised to give the best rainfall results, since the short period and the great amount of data will locate them more accurately than the sun-spot counts themselves.

(*c*) The curve probably actually undergoes changes, similar in shape and magnitude to those of the sun spots, one maximum of which will be several times higher than another. This is indicated directly by the persistency with which a phase for quite a number of consecutive cycles will often differ from its mean by fairly large amounts.

(*d*) If the rainfall is not a *pure continental* or *pure marine* type, we will have one type often prevailing, although in the long run the other dominates.

Although I have examined this period as though it varied in length, I do not desire to stand in the least committed to an actual variation. This period, the eleven-year period and the Brückner are all harmonics. When examined by itself each is found to be variable. However, it is quite possible that their variations and that of the sun-spot period are only apparent, being caused by the superposition of a number of constant periodicities. Regardless of this constancy, I believe these three periods not to be separate, but merely terms in an irregular, long-period rainfall variation. It is very important that a search be made very carefully to determine what other terms there may be of such large magnitude as these.

If the relationship between sun spots and rainfall were a direct one, the eleven-year period would certainly far overshadow both this and the Brückner. Instead, its magnitude seems usually to be less than either. The search for a thirty-three-year period in sun spots has been inconclusive, although analysis shows a very strong sun-spot variation of twice this length. The relationship of the Brückner cycle to the sun-spot period stands out vividly, however, if we look for its epochs in long, homogeneous records from which the eleven-year period has been eliminated by averaging between consecutive sun-spot maxima or minima. In concluding, I desire to quote from Pickering's statement, at the close of his article mentioned above, as most nearly expressing my own opinion on this relationship:

> "I do not believe that the sun spots themselves, or their absence, cause the droughts. The spots are merely a surface indication of an overturn of material and temperature occurring beneath the solar surface in connection with magnetic storms. . . . I have only to derive statistics from observed rainfall data to show the coincidence."

I wish to acknowledge the assistance of the research committee of the Graduate School, whose grants for computers have been a very important factor in the prosecution of the work. Mr. Anthony Oates was engaged as computer for the earlier stages of the work and Miss Nellie Lynn for the later. Prof. F. E. Kester has devoted a great deal of time to discussing each phase of the problem, and to his suggestions is due much of the success. Prof. C. F. Talman has loaned me many books from the library of the United States Weather Bureau. Mr. S. D. Flora has thrown open to me all the records in the state meteorological office at Topeka. Prof. Carl Ryder has sent me a great deal of manuscript matter, which has been extremely valuable. The Governor General of Madagascar sent manuscript tables of rainfall and temperature at Tananarive. The Egyptian government sent valuable manuscript records of Soudan and Abyssinia, which unfortunately do not extend back far enough for present uses. Supplemented by the next ten years' records, they will be very valuable. Meteorologists of several other countries have sent all available printed records. To all these I owe my most sincere thanks.

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TABLE 1.—Wolf's & Wolfer's table of sunspot maxima and minima.
(Copied from *Monthly Weather Review*, August, 1920.)

Minima.			Maxima.		
Epochs.	Weights.	Periods.	Epochs.	Weights.	Periods.
1610.8	5	....	1615.5	2	....
1619.0	1	8.2	1626.0	5	10.5
1634.0	2	15.0	1639.5	2	13.5
1645.0	5	11.0	1649.0	1	9.5
1655.0	1	10.0	1660.0	1	11.0
1666.0	2	11.0	1675.0	2	15.0
1679.5	2	13.5	1685.0	2	10.0
1689.5	2	10.0	1693.0	1	8.0
1698.0	1	8.5	1705.5	4	12.5
1712.0	3	14.0	1718.2	6	12.7
1723.5	2	11.5	1727.5	4	9.3
1734.0	2	10.5	1738.7	2	11.2
1745.0	2	11.0	1750.3	7	11.6
1755.2	9	10.2	1761.5	7	11.2
1766.5	5	11.3	1769.7	8	8.2
1775.5	7	9.0	1778.4	5	8.7
1784.7	4	9.2	1788.1	4	9.7
1798.3	9	13.6	1805.2	5	17.1
1810.6	8	12.3	1816.4	8	11.2
1823.3	10	12.7	1829.9	10	13.5
1833.9	10	10.6	1837.2	10	7.3
1843.5	10	9.6	1848.1	10	10.9
1856.0	10	12.5	1860.1	10	12.0
1867.2	10	11.2	1870.6	10	10.5
1878.9	10	11.7	1883.9	10	13.3
1889.6	10	10.7	1894.1	10	10.2
1901.7	10	12.1	1906.4	10	12.3
1913.4*	10	11.7	1917.6	10	11.2

* See text.

TABLE 2.

Year.	Period.	Departure.	Year.	Period.	Departure.	Year.	Period.	Departure.
	Months.			*Months.*			*Months.*	
1850	180	+45	1871	106	—29	1892	144	+ 9
51	176	+41	72	135	0	93	145	+10
52	165	+30	73	156	+21	94	146	+11
53	146	+11	74	170	+35	95	147	+12
54	125	—10	75	180	+45	96	148	+13
55	100	—35	76	184	+49	97	149	+14
56	90	—45	77	184	+49	98	149	+14
57	93	—42	78	184	+49	99	149	+14
58	125	—10	79	181	+46	1900	149	+14
59	174	+39	1880	173	+38	01	149	+14
1860	196	+61	81	161	+26	02	148	+13
61	196	+61	82	144	+ 9	03	147	+12
62	173	+38	83	113	—22	04	146	+11
63	143	+ 8	84	102	—33	05	144	+ 9
64	104	—31	85	100	—35	06	142	+ 7
65	97	—38	86	100	—35	07	140	+ 5
66	94	—41	87	101	—34	08	138	+ 3
67	93	—42	88	108	—27	09	137	+ 2
68	93	—42	89	128	— 7	1910	136	+ 1
69	94	—41	1890	138	+ 3	11	136	+ 1
1870	96	—39	91	142	+ 7	12	135	0

TABLE 3.—Data repeated or averaged in keeping rainfall periodicity in step with sun spots.

Skipped or averaged.	Repeated.	Skipped or averaged.
1861......Mar., Sept.	1865......July.	1872......April.
1862......June.	1866......July.	1873......Sept.
1863......June.	1867......Mar., June, Sept., Dec.	1874......April, Sept.
	1868......Jan., Apr., Jun., Aug., Nov.	1875......Mar., June, Nov.
	1869......Feb., June, Oct.	1876......Feb., May, Aug., Nov.
	1870......April, Oct.	1877......Jan., Apr., Jul., Sept., Dec.
	1871......April.	1878......Mar., June, Aug., Nov.
		1879......Mar., July, Nov.
		1880......April, Oct.
		1881......July.
		1883......Mar.
Repeated.	**Skipped or averaged.**	**Repeated.**
1884......Jan., Sept.	1891......Jan.	1915......Jan.
1885......April, Oct.	1894......May.	1917......July.
1886......Jan., May, Sept.	1895......Jan. Sept.	
1887......Jan., May, Sept.	1896......April.	
1888......Jan., May, Sept.	1897......Mar.	
1889......Feb.	1898......Jan., Dec.	
	1899......Dec.	
	1901......Jan., Nov.	
	1902......June.	
	1903......Sept.	
	1909......July.	
	1913......Jan.	

TABLE 4.—Eastern United States. Table of observed per cent of normal of 26 states, comprising 20 meteorological districts.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1878	57	103	89	128	132	82	82	125	64	162	67	117
79	63	73	75	62	59	102	100	123	45	83	171	133
1880	131	120	92	117	131	98	85	113	100	98	93	73
81	58	208	129	77	58	172	73	31	118	277	180	147
82	94	214	148	115	165	200	98	115	57	162	105	108
83	74	258	64	129	127	122	110	71	36	218	149	116
84	94	184	117	89	99	121	117	60	109	103	60	170
85	127	68	28	93	89	102	84	138	96	145	108	80
86	115	87	102	90	120	89	73	96	102	56	146	86
87	91	158	69	91	79	82	93	93	73	113	80	131
88	110	89	131	64	124	87	77	134	135	132	130	85
89	114	71	61	73	103	123	138	68	117	76	163	64
1890	121	138	130	97	132	99	84	124	144	152	62	86
91	129	149	71	129	59	98	106	119	56	66	136	96
92	127	78	90	113	124	132	104	97	90	36	117	77
93	99	137	76	131	134	98	69	99	104	119	101	88
94	83	116	71	80	113	69	78	85	126	101	71	95
95	135	50	81	112	87	83	95	90	54	65	116	113
96	66	121	101	62	88	114	134	76	123	75	139	49
97	90	125	135	110	87	86	122	82	63	68	129	112
98	128	69	110	96	92	87	108	142	102	168	136	81
99	112	125	131	63	80	80	96	83	94	74	70	93
1900	86	114	100	107	84	104	99	77	83	116	139	82
01	79	74	105	131	120	93	88	149	106	59	59	156
02	71	103	117	77	75	120	92	74	137	120	112	140
03	95	162	130	97	86	126	97	111	65	103	69	77
04	95	73	109	83	82	88	101	111	89	54	62	97
05	90	94	86	101	115	107	116	117	98	116	73	129
06	106	60	126	63	92	114	126	121	126	124	92	110
07	102	66	79	113	134	107	98	88	145	85	145	127
08	90	136	99	116	134	79	97	105	65	70	61	90
09	78	141	97	137	117	125	90	84	93	71	67	100
1910	105	105	45	104	102	121	99	80	83	125	72	77
11	89	68	69	130	56	94	79	138	111	142	133	136
12	93	88	146	148	116	93	105	103	125	79	79	106
13	145	83	159	95	94	70	89	78	123	140	87	76
14	79	97	82	108	56	73	85	67	74	104	91	130
15	145	102	53	43	130	94	114	145	101	122	96	112
16	113	81	76	78	112	125	138	80	90	87	74	100
17	108	72	126	100	86	110	102	100	96	120	31	55
18	118	60	72	146	95	87	77	88	115	150	99	125
19	93	89	115	91	145	100	114	109	66	186	128	86

TABLE 5.—Eastern United States, beginning January, 1887. Observed percentages of normal.

Cycles.	Phase numbers.														
	(15)	(1)	(2)	(3)	(4)	(5)	(6)	7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1..........	91	91	158	69	91	79	79	82	93	93	73	73	113	80	131
2..........	110	110	89	131	64	124	124	87	77	134	135	135	132	130	85
3..........	114	71	71	61	73	103	123	138	(68)	117	76	163	64	121	138
4..........	130	97	132	99	84	124	144	152	62	108	149	71	129	59	98
5..........	106	119	56	66	136	96	127	78	90	113	124	132	104	97	90
6..........	36	117	77	99	137	76	131	134	98	69	99	104	119	101	88
7..........	83	(116)	71	96	69	78	85	126	101	71	115	50	81	112	87
8..........	83	95	72	65	116	113	66	121	82	88	114	134	76	123	75
9..........	139	49	90	130	110	87	86	122	82	63	68	129	120	69	110
10..........	96	92	87	108	142	102	168	108	112	125	131	63	80	80	96
11..........	83	94	74	82	86	114	100	107	84	104	99	77	83	116	139
12..........	80	74	105	131	120	93	88	149	(106)	59	156	71	103	117	75
13..........	98	92	74	137	120	112	140	95	162	130	97	86	126	97	88
14..........	103	69	77	95	73	109	83	82	88	101	101	89	54	62	97
15..........	90	94	86	101	115	107	116	117	98	116	73	129	106	60	126
16..........	63	(92)	114	126	121	126	124	92	110	102	66	79	113	134	107
17..........	98	88	145	85	145	127	90	136	99	116	134	79	97	105	65
18..........	70	61	90	78	141	97	137	117	125	90	84	93	71	67	100
19..........	105	105	45	104	102	121	99	80	83	125	72	77	89	68	69
20..........	130	56	94	79	138	111	142	133	114	88	146	148	116	93	105
21..........	103	125	79	79	126	83	159	95	(94)	70	89	73	123	140	87
22..........	76	79	97	82	108	56	73	85	67	74	104	91	130	145	145
23..........	102	53	43	130	94	114	145	101	122	96	112	113	81	76	78
24..........	112	125	138	80	90	87	74	100	108	72	126	100	86	110	102
Mean, 1-12,	96	94	90	95	102	99	110	117	88	95	112	100	100	100	101
Mean, 13-24,	96	87	90	98	114	104	115	103	106	98	100	97	99	96	97
Mean of all	96	90	90	96	108	102	113	110	97	97	106	98	100	98	99

TABLE 6.—Central Siberia. Table of observed percentages of normal.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1838	13	50	21	82	54	87	95	118	101	62	79	18
39	8	41	57	128	150	118	55	129	117	203	162	119
40	3	42	127	126	160	103	146	63	120	79	46	17
41	41	4	47	76	185	150	106	43	134	201	40	28
42	21	31	4	31	80	92	155	129	188	50	50	27
43	36	16	26	35	73	234	99	129	46	90	89	22
44	19	83	123	74	60	114	110	201	130	40	118	73
45	68	2	65	81	103	89	147	79	97	17	10	45
46	0	63	84	220	108	146	118	151	5	104	140	222
47	33	43	106	43	35	230	183	119	156	19	49	36
48	133	6	66	39	62	76	96	106	168	144	23	39
49	72	15	43	44	73	73	108	164	165	82	34	7
1850	43	31	52	85	24	108	57	90	48	56	16	97
51	106	58	91	138	104	22	81	117	111	132	139	28
52	33	151	162	32	145	98	64	56	91	95	112	35
53	21	27	95	145	61	74	59	72	58	111	91	62
54	162	18	84	37	118	75	58	197	121	42	47	64
55	16	60	132	49	99	37	43	36	5	36	91	77
56	38	51	69	111	195	148	115	71	177	94	75	134
57	5	72	61	97	58	70	96	33	71	98	122	71
58	60	115	11	96	69	68	40	79	52	53	79	54
59	15	134	55	60	72	120	95	43	137	26	82	32
1860	27	29	54	72	27	51	39	52	50	45	38	33
61	29	36	41	34	86	89	49	94	101	65	126	24
62	20	39	18	74	64	98	56	31	70	26	11	18
63	48	12	79	2	18	91	111	40	121	40	30	11
64	48	38	61	46	59	57	52	121	91	29	50	36
65	56	36	20	66	43	22	95	50	53	58	87	72
66	44	43	94	12	87	26	31	170	182	57	12	28
67	121	45	165	42	10	54	35	106	90	65	13	69
68	88	23	55	43	31	127	114	102	113	19	61	86
69	39	40	51	42	25	112	140	70	53	25	53	38
1870	55	34	61	63	98	25	120	162	61	43	99	91
71	52	56	29	76	66	93	86	106	70	38	72	89
72	24	85	67	68	102	69	142	123	91	85	100	95
73	43	70	86	74	118	38	52	81	121	96	10	133
74	125	65	122	171	43	57	45	110	75	115	108	81
75	112	85	141	93	99	86	63	101	90	91	63	132
76	70	116	101	145	87	119	105	119	63	96	78	140
77	86	112	90	124	49	66	120	66	86	58	57	41
78	48	57	16	58	106	148	72	68	122	120	153	79
79	77	126	24	89	127	92	92	163	129	86	96	113
1880	47	88	138	41	70	128	79	147	110	148	54	35
81	111	83	33	42	128	115	127	80	135	84	101	39
82	129	63	104	66	117	132	139	61	109	83	61	69
83	90	205	46	21	103	116	124	72	72	74	47	98
84	98	91	83	43	46	112	68	118	81	34	31	91
85	86	121	54	76	107	95	114	85	125	183	64	123
86	125	99	105	78	105	64	107	93	85	64	78	99
87	69	108	119	89	125	70	61	112	125	94	121	125
88	63	90	128	117	69	69	74	72	58	84	109	96
89	71	56	123	88	103	93	123	109	61	105	92	77
1890	95	157	105	145	121	105	102	91	109	101	124	109
91	116	69	105	99	132	134	78	68	117	150	120	118
92	97	107	86	92	93	128	82	93	58	77	80	105
93	66	113	115	86	77	134	125	91	74	135	127	116
94	133	123	96	136	145	89	115	136	116	46	117	90
95	129	125	116	167	81	129	77	81	67	132	101	80
96	100	86	47	117	89	98	109	113	106	107	129	86
97	113	84	87	117	128	118	94	116	98	125	83	97
98	123	71	36	117	115	51	61	73	85	104	145	99
99	153	92	107	98	116	109	131	60	60	65	82	67
1900	70	148	84	82	87	45	92	99	108	98	92	78
01	91	81	140	153	75	58	88	123	81	135	138	93
02	222	94	252	90	117	123	93	80	74	140	115	133
03	144	104	100	138	99	89	109	110	145	83	100	139
04	110	286	87	103	100	108	96	131	104	101	95	125
05	116	71	89	93	124	84	83	122	130	154	127	112
06	154	73	134	80	134	160	153	104	101	107	114	144
07	143	89	77	86	110	110	120	130	99	144	111	155
08	105	103	155	72	105	137	115	108	172	54	124	119
09	109	130	134	125	87	51	112	64	147	80	172	98

Three or more stations available beginning April, 1873.

TABLE 7.—Central Siberia. Observed percentages of normal is tabulated beginning April, 1873.

Cycles	Phase numbers.														
	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(1)	(2)	(3)
1......	74	118	38	52	101	96	110	133	125	65	146	43	57	45	92
2......	115	108	81	112	113	93	92	63	101	90	77	132	93	101	116
3......	119	112	63	87	113	112	107	49	93	76	58	49	48	62	58
4......	127	70	122	136	(79)	77	75	89	127	92	163	129	91	113	47
5......	88	90	70	128	79	147	129	54	35	111	83	33	42	128	121
6......	80	135	84	101	39	129	63	104	66	117	132	139	61	109	83
7......	61	69	90	126	21	103	116	124	72	72	74	47	(98)	98	98
8......	91	83	43	46	112	68	118	81	81	34	31	91	86	121	54
9......	76	76	107	95	114	85	125	183	183	64	123	125	125	99	105
10......	78	105	105	64	107	93	85	85	64	78	99	69	69	108	119
11......	89	125	125	70	61	112	125	125	94	121	125	63	63	90	128
12......	117	69	69	69	74	72	58	58	84	109	96	71	56	56	123
13......	88	103	93	123	(109)	61	105	92	77	95	157	105	145	121	105
14......	102	91	109	101	124	112	69	105	99	132	134	78	68	117	150
15......	120	118	97	107	86	92	93	128	82	93	58	77	80	105	66
16......	113	115	86	77	134	125	91	74	135	127	116	133	(123)	96	140
17......	89	115	136	116	46	117	110	125	116	167	81	129	77	74	132
18......	101	80	100	86	82	89	98	109	113	106	107	129	86	113	86
19......	117	128	118	94	116	98	125	83	110	71	36	117	115	51	61
20......	73	85	104	122	153	92	107	98	116	109	131	60	60	65	74
21......	70	148	84	82	87	45	92	99	108	98	97	84	81	140	153
22......	75	58	88	123	(81)	136	93	222	94	252	90	120	93	80	74
23......	140	115	133	144	104	100	138	99	89	109	128	83	100	139	110
24......	286	87	103	100	108	96	131	104	101	95	125	116	71	89	93
25......	124	84	83	122	130	154	127	112	154	73	134	80	(134)	160	153
26......	104	101	107	114	144	143	89	77	86	110	116	120	130	99	144
27......	111	155	105	103	155	72	105	137	115	108	172	54	124	119	109
28......	130	134	125	87	82	64	147	80	172	98	......	......	......	......	......
1=14	102	106	93	102	96	104	105	106	99	97	112	85	85	106	105
15=28	108	99	97	96	100	100	103	100	106	107	102	94	91	94	102
1=28	105	103	95	99	98	102	104	103	102	102	107	90	88	100	104

The means above are adjusted to make their mean values 100.

TABLE 8.—The Punjab, India. Means of 25 towns, 1863 to 1900, and of Punjab meteorological districts, 1901 to 1918. Data in inches and hundredths.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1863	209	13	116	36	26	415	1413	658	70	179	13	59
64	64	108	48	175	152	97	553	658	190	2	0	57
65	128	322	263	83	49	74	344	782	518	0	7	203
66	178	83	32	72	26	233	765	695	55	20	0	0
67	34	34	87	122	170	79	536	854	162	3	0	52
68	89	188	130	143	48	149	503	253	65	44	0	30
69	139	31	447	13	1	135	766	188	541	56	0	8
1870	6	18	154	39	11	303	322	639	178	16	0	38
71	20	206	5	16	87	499	548	208	115	0	0	93
72	140	70	113	59	93	226	893	671	296	6	0	56
73	44	13	48	2	174	29	855	548	380	69	2	64
74	127	86	129	30	26	342	700	353	240	1	0	3
75	6	151	9	1	90	59	626	943	1080	65	14	46
76	38	44	149	103	85	114	1050	354	201	140	22	1
77	263	312	104	189	112	182	226	67	342	113	138	407
78	75	220	17	202	213	73	624	1011	122	13	0	24
79	4	16	140	3	69	432	344	653	116	60	0	73
1880	21	133	0	7	32	330	828	153	176	0	14	75
81	7	92	204	78	53	256	860	670	73	9	0	3
82	190	107	8	66	19	106	868	374	503	0	0	2
83	236	14	71	18	108	119	447	162	544	4	99	12
84	30	68	91	24	22	296	633	507	573	63	2	1
85	292	33	28	108	268	215	394	701	95	2	0	158
86	224	21	243	14	89	444	921	394	77	102	11	44
87	99	0	11	7	2	138	568	1062	274	15	0	18
88	113	102	52	21	43	99	620	710	260	31	39	6
89	228	305	22	36	83	113	679	693	49	0	0	0
1890	396	21	79	60	40	294	905	777	68	30	43	176
91	291	98	146	41	71	35	357	601	221	74	3	0
92	49	44	10	2	71	102	775	1091	373	5	0	95
93	303	261	72	72	203	387	972	222	728	2	3	34
94	372	96	149	39	31	606	986	574	341	0	33	193
95	228	89	93	63	10	484	286	760	17	2	2	6
96	44	115	46	40	31	197	374	494	48	14	15	29
97	100	47	67	76	36	128	506	677	176	6	0	53
98	29	340	4	1	89	174	728	258	271	0	4	83
99	1	61	15	29	33	281	282	148	27	11	1	0
1900	131	37	38	113	61	56	526	790	746	10	1	127
Mean	1 20	1.03	0.92	0.58	0 73	2.24	6.60	5.63	2.60	0.35	0.14	0.57
1901	151	100	72	19	133	56	500	398	74	6	0	8
02	0	4	38	34	77	224	430	348	212	30	4	0
03	64	2	128	16	68	28	626	451	314	18	0	24
04	135	4	331	4	60	72	252	429	196	14	44	46
05	194	98	90	11	22	64	390	100	450	6	2	60
06	15	340	141	11	11	152	334	506	532	2	0	40
07	63	219	130	182	30	127	218	570	12	1	0	0
08	126	38	2	137	48	48	645	1116	338	2	4	12
09	46	82	12	185	6	242	676	362	409	6	0	138
1910	88	18	10	55	10	254	385	666	174	96	0	12
11	264	26	374	26	10	193	80	215	222	48	84	2
12	188	20	30	101	28	50	448	479	160	2	23	8
13	4	168	104	10	134	256	406	558	68	6	8	42
14	62	136	61	166	69	162	994	302	374	120	40	42
15	50	142	170	66	20	98	158	220	192	44	0	10
16	6	56	22	24	57	156	601	743	207	89	0	1
17	21	6	42	1 6	125	237	476	938	934	202	0	30
18	15	6	201	142	3	79	139	302	66	6	......	......
Mean*	0 91	0.91	1.07	0.65	0.49	1.36	4.46	4.66	2.46	0.31	0.13	0.28

* 1917 not included in these means because received after manuscript was sent to printer.

TABLE 9.—The Punjab, India. Means of twenty-five towns, 1863 to 1900. Mean of Punjab meteorological districts, 1901 to 1917.

ACTUAL OBSERVED VALUES IN INCHES.

Cycles.	Phase numbers.														
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	209	13	116	36	220	1413	658	70	179	13	59	64	108	48	175
2	152	97	553	658	190	2	0	57	128	322	263	83	49	74	344
3	344	782	518	0	7	203	178	83	32	72	26	233	765	765	695
4	55	20	0	0	34	34	87	(87)	122	170	79	79	536	834	162
5	162	3	0	52	52	89	89	188	130	143	143	48	149	149	502
6	253	253	65	44	0	0	30	139	31	31	447	13	1	135	135
7	766	188	541	56	56	0	8	6	18	154	39	39	11	303	322
8	(639)	178	16	16	0	38	20	206	5	16	16	87	499	548	208
9	115	0	0	93	140	70	86	93	226	893	671	296	6	0	56
10	44	13	48	2	174	29	855	548	224	2	64	127	86	80	26
11	342	700	353	120	0	3	6	80	1	74	626	943	1080	40	46
12	41	149	94	114	702	201	81	132	312	146	112	204	204	113	272
13	75	118	202	143	818	122	6	(24)	4	78	3	69	388	653	116
14	30	73	21	133	4	32	330	828	153	88	14	75	7	92	204
15	78	53	558	670	73	9	0	3	190	107	8	66	19	106	868
16	374	503	0	0	2	236	42	18	108	119	447	162	544	4	99
17	(12)	30	30	68	91	24	22	296	633	507	573	573	63	2	1
18	292	33	28	108	108	268	215	394	701	95	2	2	0	158	224
19	224	21	243	14	89	89	444	924	394	77	77	102	11	44	99
20	99	0	11	7	2	2	138	568	1062	274	274	15	0	18	113
21	113	102	52	21	43	43	99	620	710	260	260	31	39	6	228
22	305	305	20	36	83	113	679	(693)	49	0	0	0	36	21	79
23	60	40	294	905	777	68	30	43	234	98	146	41	71	35	357
24	601	221	74	3	0	49	44	10	2	71	102	775	1091	373	5
25	0	95	303	261	72	72	203	387	972	222	728	2	3	34	372
26	(96)	149	39	606	786	574	341	0	33	210	89	93	63	10	484
27	286	388	2	2	6	44	115	43	31	197	374	494	48	14	15
28	29	100	57	76	36	128	506	677	176	6	0	41	340	4	1
29	89	174	728	258	271	0	44	1	61	15	29	33	281	282	148
30	27	11	1	131	37	38	113	61	56	526	790	746	10	1	127
The 1901-1917 Data Begin Here.															
31	100	72	19	133	56	500	398	(74)	3	8	0	4	38	34	150
32	430	348	212	30	4	0	64	2	128	16	68	28	626	382	18
33	0	24	135	4	331	4	60	72	252	429	196	14	44	46	194
34	98	90	11	22	64	390	100	450	6	2	60	15	340	141	11
35	(11)	152	334	506	532	2	0	40	63	219	130	182	30	127	218

36	570	12	1	0	0	126	38	2	137	48	48	645	1116	338	2
37	4	12	46	82	12	185	6	459	362	409	6	0	138	88	18
38	10	55	10	254	385	666	174	96	0	12	264	26	374	26	10
39	193	80	215	222	48	84	2	188	20	30	101	28	50	448	479
40	160	2	23	6	168	104	10	(134)	256	406	558	68	6	8	40
41	62	136	61	166	69	162	994	302	374	120	40	42	50	50	142
42	170	66	20	98	158	220	192	44	0	10	6	56	22	24	57
43	156	601	743	207	89	0	1								

NORMAL VALUES IN INCHES.

1	120	103	92	58	148	660	563	260	35	14	57	120	103	92	58
2	73	224	660	563	260	35	14	57	120	103	92	58	73	224	224
3	660	563	260	35	14	57	120	103	92	58	73	224	660	660	563
4	260	35	14	57	120	103	92	(92)	58	73	224	224	660	563	260
5	260	35	14	57	57	120	120	103	92	58	58	73	224	224	660
6	563	563	260	35	14	14	57	120	103	103	92	58	73	224	224
7	660	563	260	35	35	14	57	120	103	92	58	58	73	224	660
8	(563)	260	35	35	14	57	120	103	92	58	58	73	224	660	563
9	260	35	14	57	120	103	75	73	224	660	563	260	35	14	57
10	120	103	92	58	73	224	660	563	260	24	57	120	103	75	73
11	224	660	563	260	24	57	120	98	58	124	660	563	260	24	57
12	112	92	66	224	612	260	24	88	103	75	73	442	412	35	36
13	120	98	58	148	612	260	24	(57)	120	98	58	73	442	563	260
14	24	57	120	103	75	73	224	660	563	148	14	57	120	103	92
15	56	73	442	563	260	35	4	57	120	103	92	58	73	224	660
16	563	260	35	14	57	120	98	58	73	224	660	563	260	35	14
17	(57)	120	120	103	92	58	73	224	660	563	260	260	35	14	57
18	120	103	92	58	58	73	224	660	563	260	35	35	14	57	120
19	120	103	92	58	73	73	224	660	563	260	260	35	14	57	120
20	120	103	92	58	73	73	224	660	563	260	260	35	14	57	120
21	120	103	92	58	73	73	224	660	563	260	260	35	14	57	120
22	103	103	92	58	73	224	660	(563)	260	35	14	57	120	103	92
23	58	73	224	660	563	260	35	14	88	103	92	58	73	224	660
24	563	260	35	14	57	120	103	92	58	73	224	660	563	260	35
25	14	57	120	103	92	58	73	224	660	563	260	35	14	57	120
26	(103)	92	58	148	660	563	260	35	14	88	103	92	58	73	224
27	660	412	35	14	57	120	103	75	73	224	660	563	260	35	14
28	57	120	98	58	73	224	660	563	260	35	14	88	103	92	58
29	73	224	660	563	260	35	36	120	103	92	58	73	224	660	563
30	260	35	14	120	103	92	58	73	224	660	563	260	35	14	57
31	91	107	65	49	136	446	466	(246)	22	28	91	91	107	65	92
32	446	466	246	31	13	28	91	91	107	65	49	136	446	356	31
33	13	28	91	91	107	65	49	136	446	466	246	31	13	28	91
34	91	107	65	49	136	446	466	246	31	13	28	91	91	107	65
35	(49)	136	446	466	246	31	13	28	91	91	107	65	49	136	446
36	466	246	31	13	28	91	91	107	65	49	136	446	466	246	31
37	13	28	91	91	107	65	49	291	466	246	31	13	28	91	91

TABLE No. 9—CONCLUDED.

NORMAL VALUES IN INCHES—Concluded.

CYCLES.	Phase numbers.														
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
38	107	65	49	136	446	466	246	31	13	28	91	91	107	65	49
39	136	446	466	246	31	13	28	91	91	107	65	49	136	446	466
40	246	31	13	60	91	107	65	(49)	136	446	466	246	31	13	28
41	91	91	107	65	49	136	446	466	246	31	13	28	91	91	91
42	107	65	49	136	446	466	246	31	13	28	91	91	107	65	49
43	136	446	466	246	31	13	28	......	......	......	......	......	......	......	......
Sum actual, 1-15	3305	2640	3035	2137	2470	2245	1776	2544	1755	2309	2570	2426	3908	3834	4131
Sum normal, 1-15	4077	3414	2508	1725	2178	2037	2270	2554	2143	1791	2229	2461	3535	3909	4447
Quotient	81	77	122	124	113	110	86	100	82	129	115	98	111	98	90
Smoothed	83	93	108	120	116	103	99	89	104	109	114	108	102	100	90
Sum actual, 16-30	2607	2172	1881	2496	2403	1748	3035	4735	5222	2677	3891	3095	2600	1006	2352
Sum normal, 16-30	2991	2168	1859	2087	2364	2166	3055	4681	4745	3700	3723	2849	1801	1795	2374
Quotient	87	100	101	120	102	81	99	101	110	72	105	109	144	56	99
Smoothed	95	96	107	108	101	94	94	103	94	96	95	119	103	100	81
Sum actual, 31-43	1964	1650	1830	1730	1916	2443	2039	1863	1601	1709	1477	1108	2834	1712	1341
Sum normal, 31-43	1992	2262	2185	1679	1867	2373	2284	1813	1727	1598	1414	1378	1672	1709	1530
Quotient	99	73	84	103	103	103	89	103	93	107	104	80	170	100	88
Smoothed	87	85	87	97	103	98	98	95	101	101	97	118	117	119	96
Total actual	7876	6462	6746	6363	6789	6436	6850	9142	8578	6695	7938	6629	9342	6552	7824
Total normal	9060	7844	6552	5491	6409	6576	7609	9048	8615	7089	7366	6688	7008	7413	8351
Quotient	87	82	103	116	106	98	90	101	100	95	108	99	133	88	94
Smoothed	88	91	100	108	107	98	96	97	99	103	101	113	107	105	90

TABLE 10.—Mean rainfall in inches of Ashland, Albany, Cascade Locks, Portland, Roseburg and The Dalles, in Oregon.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1879	....	....	845	281	501	83	131	107	198	302	538	779
1880	960	421	355	291	256	116	36	88	79	145	246	944
81	1080	1152	278	281	108	272	92	102	170	609	446	540
82	419	754	247	399	111	91	85	23	71	716	342	1087
83	878	157	340	519	175	2	0	12	65	344	556	(560)
84	387	540	261	337	105	164	92	15	342	352	198	883
85	346	698	50	105	345	170	9	0	242	180	784	656
86	787	275	400	305	149	38	96	2	246	278	168	996
87	1207	354	588	423	289	104	7	23	171	135	370	1024
88	732	189	284	123	102	486	104	8	67	376	427	427
89	294	98	212	266	280	62	22	60	145	399	381	549
1890	917	1038	496	133	88	209	32	29	36	233	49	383
91	387	701	320	259	211	265	58	76	174	396	539	1127
92	450	202	263	410	159	75	61	8	124	233	551	650
93	186	592	353	541	255	110	19	4	337	529	799	522
94	1040	(536)	826	266	171	236	32	2	188	434	257	473
95	770	140	336	217	343	35	44	13	204	5	360	984
96	714	393	357	446	396	94	6	71	76	208	1244	679
97	270	654	578	170	88	188	45	41	193	201	927	833
98	412	537	216	157	164	145	54	76	260	155	715	368
99	622	562	445	379	248	80	10	237	118	366	746	626
1900	472	432	372	158	273	195	16	81	176	545	427	498
01	689	652	367	249	193	99	8	30	(326)	115	482	546
02	324	784	481	600	242	69	124	50	123	134	944	927
03	801	145	289	164	116	194	48	43	132	220	993	278
04	492	1013	813	236	58	64	72	13	56	544	451	763
05	344	160	440	83	236	128	7	17	201	408	256	619
06	538	538	250	160	279	238	0	8	198	262	777	607
07	674	492	424	371	135	130	53	141	148	100	569	1064
08	402	290	419	192	276	97	14	80	32	451	295	378
09	850	632	204	92	184	44	106	18	112	289	1185	376
1910	552	590	248	245	215	116	1	4	79	322	961	401
11	680	275	98	206	300	71	16	10	378	98	406	457
12	873	492	253	272	243	254	44	231	172	302	550	629
13	663	136	409	250	190	321	86	40	204	319	541	287
14	994	376	262	305	143	172	6	0	296	414	370	217
15	461	390	230	186	326	72	103	6	50	198	981	728
16	504	588	775	277	254	135	239	38	70	98	558	432
17	340	383	444	904	200	70	10	6	114	6	506	1123
18	606	559	289	116	164	17	74	60	134	379	440	354
19	760	762	520	334	164	71	14	4	256	217	656	514
1920	375	21	415	358	90	166	62	106	409	344	592	810
21	652	645	433	262	149	115	3	22	223	279	1011	296
Mean	6.12	4.88	3.83	2.87	2.09	1.36	0.50	0.46	1.72	2.94	5.84	6.37

TABLE 11.—Mean rainfall in inches of Folsom, Hollister, Los Angeles, Marysville, Merced, Sacramento, San Francisco, San Jose, San Luis Obispo, Santa Barbara, San Bernardino, San Diego and Stockton, in California.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1878	635	769	272	174	30	3	1	0	16	47	44	(174)
79	289	246	278	184	86	7	1	1	0	79	233	383
1880	139	271	138	668	64	0	1	2	0	9	37	832
81	370	239	122	107	4	20	0	0	22	80	79	175
82	166	229	354	161	20	14	0	0	31	132	184	56
83	165	123	306	90	169	4	1	0	42	104	42	(148)
84	343	697	778	194	74	154	0	1	15	131	20	572
85	154	17	45	174	20	9	3	1	3	17	774	168
86	573	82	227	370	11	2	4	2	0	19	63	118
87	68	664	91	191	15	6	2	0	39	14	97	272
88	484	109	300	21	39	11	1	1	33	7	365	405
89	59	95	559	64	136	10	1	7	3	512	260	970
1890	574	318	247	76	86	2	1	17	74	5	24	306
91	59	594	157	160	58	10	2	7	23	5	30	363
92	147	251	309	87	209	6	0	0	6	69	375	434
93	314	287	560	86	33	0	2	0	10	34	152	208
94	284	(256)	69	35	131	35	1	2	88	113	39	672
95	681	160	208	93	61	0	1	0	49	44	118	101
96	619	12	250	280	58	0	5	31	18	117	280	210
97	304	435	187	41	19	4	0	1	7	149	40	97
98	113	60	189	25	116	6	1	0	60	43	44	109
99	333	16	421	51	38	53	0	5	0	294	269	222
1900	271	28	143	156	146	2	3	0	10	108	479	81
01	407	485	59	178	72	1	0	6	46	140	177	60
02	120	506	275	121	48	2	7	0	0	100	226	209
03	290	164	570	134	6	0	0	1	7	8	197	68
04	68	416	468	145	17	0	0	11	252	160	97	173
05	308	422	404	87	184	4	3	1	7	5	181	76
06	457	341	729	128	205	38	1	2	18	1	107	691
07	579	264	648	40	10	48	0	0	2	180	5	296
08	398	312	77	28	67	1	1	6	43	47	117	164
09	957	510	274	2	0	5	0	10	23	72	186	578
1910	280	99	274	26	2	0	1	1	41	65	39	98
11	1109	298	530	76	15	3	1	0	27	27	28	176
12	189	17	415	211	98	24	1	2	49	56	88	38
13	263	220	115	54	56	20	15	10	3	4	382	357
14	884	395	73	110	24	31	1	0	4	75	46	413
15	514	623	131	115	225	0	0	4	1	0	67	414
16	1173	253	159	18	12	0	3	8	72	135	69	410
17	217	431	82	66	26	0	2	1	14	2	46	32
18	75	482	531	51	6	9	3	6	230	34	265	182
19	136	470	230	27	20	0	0	2	74	31	32	226
1920	44	213	420	115	12	8	0	1	4	139	218	353
21	447	113	209	39	171	1	0	0	36	44	92	654
Mean	3.65	2.95	2.93	1.20	0.66	0.13	0.02	0.03	0.34	0.79	1.48	2.90

TABLE 12.—Nineteen California and Oregon stations, March 1879 to 1917. Given in inches.

SUMS OF ACTUAL VALUES OF ALL STATIONS.

Cycles.	Phase numbers.														
	(11)	(12)	(13)	(14)	(15)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	4085	4127	696	647	1191	4545	9656	7571	6041	7184	2362	700	225	563	728
2	1965	16480	11282	10024	3252	3074	707	1218	612	1302	4689	3707	5518	4668	7498
3	6084	4492	928	728	510	138	830	6014	4446	7245	7406	4280	4282	4543	109
4	20	74	936	3413	3881	(5288)	6779	6779	12309	11688	7144	1584	2982	551	100
5	2253	2253	3813	1444	12730	4083	4422	881	2897	2897	2329	1140	91	16	1494
6	1297	1297	14765	7424	12170	12170	2715	5349	6644	1041	1041	251	626	32	1480
7	1480	2304	1825	7518	8122	8122	10755	4706	5019	1937	1937	710	66	142	1540
8	1540	1001	3486	9681	10680	10680	2547	5607	1007	1121	1121	3057	629	60	835
9	835	2331	7305	7829	2523	1824	1824	8542	2436	3454	506	152	(458)	914	9043
10	5674	15902	12963	10359	6181	1784	1647	1280	204	392	1186	1471	604	4686	11934
11	3959	3628	2025	1717	370	546	1339	2445	3623	11484	4608	4468	5535	3592	3611
12	530	368	57	819	2290	8178	9541	5193	7275	9399	4362	1959	668	134	22
13	2148	3617	6774	5838	9936	(6544)	5814	2390	1878	213	34	2275	4070	2042	12521
14	2920	4672	2509	2856	217	269	970	598	3700	7224	12326	2509	5852	3135	567
15	109	825	674	2772	11112	6806	5574	8390	1550	776	1180	272	258	1244	3147
16	6084	5104	4007	3745	1265	2498	946	333	456	2332	1493	4242	8066	3583	8142
17	2942	1979	1174	58	1483	712	6024	7304	6351	2953	4087	2976	3536	1192	121
18	484	1184	4677	8789	6730	10216	2974	3810	2090	609	51	254	(2546)	3850	4056
19	3495	11185	6466	3975	1254	835	301	739	2104	8607	8287	8581	3006	9140	2725
20	770	1170	290	579	1433	8524	2546	3830	11489	10965	3297	565	385	436	215
21	3615	3543	3969	6824	6016	6445	7892	1634	3811	816	79	112	1295	2498	3877
22	4100	9175	7665	10978	2628	(4336)	1915	10	77	1422	1582	6057	12630	11570	6389
23	10959	2747	945	1405	322	851	916	2934	3480	10232	7589	5784	3509	1459	2531
24	604	93	556	760	3315	3294	4391	17675	10125	4793	571	1108	482	234	972
25	2676	9526	9747	6958	4831	504	1804	1310	699	26	35	1033	2771	6280	3774
26	18498	5517	7471	2228	2002	468	109	63	2626	938	2804	5038	7690	3177	6929
27	4380	2734	1842	277	1416	1676	2541	4385	5832	3683	3952	2198	(1867)	2189	714
28	366	1255	1963	8215	6362	17459	7381	2522	3256	1176	1440	41	1	1822	3459
29	2818	6674	9398	9398	10443	3092	2606	4883	431	618	91	309	1186	6752	9749
30	18270	6822	6717	1897	1677	813	1478	332	1562	2334	4238	7917	4861	7895	3737

SUMS OF NORMAL VALUES OF ALL STATIONS.

1	4711	2161	991	323	1455	2747	6463	8516	6739	6114	2734	991	325	321	1455
2	4034	7546	8516	6739	6114	3308	2161	991	323	1455	2747	5380	7546	8516	6739
3	6114	3308	2161	991	325	321	1455	2747	5380	7546	8516	6739	4711	2161	991
4	325	321	1455	2747	5380	(7546)	8516	8516	6739	6114	3308	2161	991	325	321
5	1455	1455	2747	5380	7546	8516	6739	6114	3308	3308	2161	991	325	321	1455

6	2747	2747	5380	7546	8516	8516	6739	6114	3308	2161	2161	991	325	321	1455
7	1455	2747	5380	7546	8516	8516	6739	6114	3308	2161	2161	991	325	321	1455
8	1455	2747	5380	7546	8516	8516	6739	6114	3308	2161	2161	991	325	321	1455
9	1455	2747	5380	7546	8516	6739	6739	6114	3308	2161	991	325	(321)	1455	2747
10	5380	7546	8516	6739	6114	3308	2161	991	325	321	1455	2747	5380	7546	7628
11	6114	3308	2161	991	325	321	1455	2717	5380	7546	8516	6739	6114	3308	2161
12	991	325	321	1455	2747	5380	7546	8516	6739	6114	3308	2161	991	325	321
13	1455	2747	5380	7546	8516	(6739)	6114	3308	1576	325	321	1455	2747	5380	7546
14	7628	6114	3308	2161	991	325	321	2101	5380	7546	8516	6739	6114	2734	991
15	325	321	1455	2747	5380	7546	8516	6739	4711	2161	991	325	321	1455	2747
16	5380	7546	7628	6114	3308	2161	991	325	321	1455	2747	5380	8031	6739	6114
17	3308	2161	991	325	321	1455	2747	5380	8031	6739	6114	3308	2161	991	325
18	321	1455	2747	5380	7546	7628	6114	3308	2161	991	325	321	(1455)	2747	6463
19	8516	6739	6114	3308	2161	658	321	1455	2747	5380	7546	8516	6739	6114	3308
20	2161	991	325	321	2101	5380	7546	8516	6739	6114	3308	2161	991	325	321
21	1455	2747	5380	7546	8516	6739	6114	3308	2161	991	325	321	1455	2747	5380
22	7546	8516	6739	6114	3308	(2161)	991	325	321	1455	2747	5380	7546	8516	6739
23	6114	3308	2161	991	325	321	1455	2747	5380	7546	8516	6739	6114	3308	2161
24	991	325	321	1455	2747	5380	7546	8516	6739	6114	3308	2161	991	323	1455
25	2747	5380	7546	8516	6739	6114	3308	2161	991	325	321	1455	2747	5380	7546
26	8516	6739	6114	3308	2161	991	325	321	1455	2747	5380	7546	8516	6739	6114
27	3308	2161	991	325	321	1455	2747	5380	7546	7628	6114	3308	(2161)	991	325
28	321	1455	2747	5380	7546	8516	6739	6114	3308	2161	991	325	321	1455	2747
29	5380	7546	8516	8516	6739	6114	3308	2161	991	325	321	1455	2747	5380	7546
30	8516	6739	6114	3308	2161	991	325	321	1455	2747	5380	7546	8516	6739	6114
Sum actual, 1–15	34899	63371	70038	85879	85165	74051	65150	66963	59645	67357	52231	28535	31864	26322	54629
Sum normal, 1–15	45674	46140	57531	68003	78957	78344	78403	75712	59832	57194	50047	39726	36861	34810	39467
Quotient	76	137	122	126	108	95	88	88	100	118	104	72	86	76	139
Smoothed	117	112	128	119	110	97	90	92	102	107	98	87	78	100	97
Sum actual, 16–30	80061	68808	68887	66086	51177	66261	43824	51991	54689	51504	39596	46215	53831	62077	57390
Sum normal, 16–30	64580	39808	64434	60907	56000	56065	50577	50338	50346	52718	53443	55922	60491	58494	62658
Quotient	124	173	104	119	91	118	87	103	109	98	74	83	89	106	92
Smoothed	130	134	132	105	109	99	103	100	103	94	85	82	93	96	107
Total sum, actual	114960	132179	136925	151965	136342	140312	108974	108954	114334	118861	91827	74750	85695	88399	112019
Total sum, normal	110254	85948	121965	128910	134957	134409	128980	126050	110178	109912	103490	95648	97352	93304	102125
Quotient	104	154	112	118	101	104	85	94	104	108	89	78	88	95	110
Smoothed	123	123	128	110	108	97	94	94	102	100	92	85	87	98	103

TABLE 13.—Per cent of normal rainfall at Chilgrove, West Sussex, England. Compiled from table of actual rainfall in "British Rainfall, 1919."

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1834	107	135	73	55	57	129	322	78	24	41	107	57
35	38	169	121	39	76	91	11	26	195	135	146	12
36	96	90	226	262	19	62	99	91	127	139	186	54
37	144	160	24	73	34	45	47	77	78	84	58	90
38	17	71	122	51	84	167	49	64	91	53	191	123
39	38	143	83	92	34	54	226	89	218	83	111	210
1840	114	100	0	21	85	78	128	71	151	45	173	19
41	128	121	96	77	143	108	79	146	157	167	156	92
42	62	126	65	44	75	22	46	73	192	37	201	67
43	81	97	66	149	298	113	87	128	22	118	104	26
44	122	125	138	26	21	57	78	99	31	120	117	19
45	105	76	48	95	113	90	92	86	94	64	113	99
46	168	88	93	80	117	45	89	173	56	156	66	48
47	47	88	46	71	82	87	40	57	58	68	77	173
48	75	232	209	185	22	191	161	182	94	96	73	124
49	94	86	57	174	145	39	90	32	168	110	63	107
1850	67	82	19	218	132	108	157	100	94	56	96	68
51	153	38	190	93	73	92	90	50	0	106	27	28
52	159	106	23	26	106	286	62	172	192	154	244	156
53	156	45	89	177	109	108	244	115	117	141	45	19
54	99	33	18	8	189	82	32	45	39	95	52	62
55	22	61	127	23	143	56	170	44	88	171	48	48
56	126	55	54	198	185	96	30	142	136	76	29	82
57	93	18	95	108	65	100	57	80	153	196	59	37
58	52	42	72	137	116	43	111	85	83	52	50	98
59	76	90	81	168	59	56	106	58	141	98	143	102
1860	136	61	94	90	186	291	109	167	125	68	102	97
61	24	85	128	39	75	101	182	24	128	43	142	55
62	100	31	172	58	172	113	103	79	73	122	41	89
63	123	38	52	29	114	195	34	66	136	103	63	93
64	64	60	146	76	77	58	14	34	138	45	123	40
65	136	106	54	22	140	98	92	182	10	236	99	85
66	150	183	77	81	69	127	75	107	262	36	59	78
67	114	109	88	106	68	80	100	113	73	67	29	44
68	136	62	89	134	58	26	35	159	111	95	46	256
69	110	119	78	56	212	84	43	51	195	55	70	120
1870	75	138	90	11	70	19	61	121	65	114	56	102
71	110	79	63	246	29	166	200	58	165	42	24	64
72	242	116	119	49	136	88	114	53	83	142	153	168
73	153	131	105	38	71	109	98	67	103	107	82	21
74	80	95	26	144	19	134	54	83	89	117	80	80
75	149	98	65	71	59	140	166	55	85	133	150	38
76	36	151	132	110	27	69	34	103	167	54	122	212
77	259	84	121	155	162	26	133	160	63	88	226	86
78	66	120	72	156	109	86	43	184	66	88	142	54
79	78	175	29	191	133	201	174	211	152	31	20	22
1880	10	128	46	100	101	101	210	34	163	208	109	122
81	48	136	91	27	74	101	133	184	100	53	135	99
82	58	82	40	197	68	153	131	76	78	222	51	81
83	94	202	35	66	101	105	130	384	133	[illegible]	153	38
84	96	106	124	80	44	61	97	44	108	33	38	116
85	62	175	99	61	234	110	22	374	171	99	101	41
86	136	42	96	91	225	28	156	75	57	133	110	171
87	93	33	49	78	50	47	38	83	136	33	148	71
88	47	34	183	86	91	158	292	95	37	48	157	65
89	30	60	92	109	232	33	92	81	27	185	43	68
1890	121	47	73	145	87	151	155	119	55	27	95	18
91	106	2	180	52	114	87	117	251	43	170	134	134
92	39	35	42	47	46	95	100	109	109	108	112	76
93	61	146	10	2	42	72	155	27	65	123	80	103
94	214	108	82	132	64	96	212	61	92	128	190	93
95	98	6	121	162	12	32	201	135	214	99	196	109
96	61	24	202	34	27	184	42	45	308	92	32	182
97	103	173	260	146	67	116	28	200	105	12	47	138
98	30	71	38	67	207	123	143	65	71	98	139	86
99	110	110	35	152	43	82	69	25	112	68	165	68

TABLE 13—CONTINUED.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1900	153	302	44	97	55	165	47	126	44	66	128	144
01	44	76	121	158	60	157	108	62	82	73	17	165
02	46	111	101	57	112	165	51	233	38	73	137	72
03	108	81	183	141	174	119	134	197	154	250	75	96
04	213	199	64	104	218	55	59	85	99	67	41	125
05	45	34	254	100	24	190	13	124	79	58	157	40
06	305	185	65	51	175	57	17	37	54	137	163	79
07	45	78	51	267	143	140	68	75	21	174	97	134
08	51	77	150	123	123	32	140	148	64	77	42	124
09	35	19	222	80	86	145	131	77	130	221	21	158
1910	107	187	71	136	56	84	85	117	4	123	126	147
11	50	96	93	80	143	103	30	18	42	147	159	256
12	126	130	213	0	57	161	80	266	108	84	58	136
13	185	64	150	183	158	23	75	66	56	140	104	55
14	31	203	222	91	75	60	126	61	58	75	108	275
15	138	222	40	75	186	84	166	52	83	96	105	297
16	50	155	148	60	93	100	39	123	89	136	140	113
17	53	53	100	107	104	170	98	200	59	108	51	52
18	138	74	69	108	85	41	168	67	224	34	98	99
19	237	133	286	129	11	25	72	133	50	8	198	199
Normal in inches.	3.20	2.45	2.32	1.95	2.07	2.31	2.65	3.02	3.08	4.22	3.53	3.51

TABLE 14.—Per cent of normal rainfall at Utrecht, Holland.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1849	73	164	64	153	91	60	136	56	47	157	85	145	103
50	115	230	84	228	117	39	64	149	43	108	118	124	118
51	57	73	138	141	102	40	146	82	42	45	187	27	90
52	162	187	94	22	160	155	45	178	135	296	147	110	141
53	145	103	52	239	80	149	105	87	132	120	7	36	105
54	122	164	26	54	132	120	63	81	87	160	123	221	113
55	80	51	64	50	76	90	182	68	34	165	44	84	82
56	113	143	33	155	218	110	66	105	112	20	192	77	112
57	120	14	77	125	13	35	96	48	104	46	51	20	62
58	85	40	41	48	71	109	142	177	39	85	32	105	144
59	47	75	209	160	34	64	79	84	130	93	88	68	94
1860	127	93	167	103	143	82	73	88	113	71	93	42	100
61	19	48	127	98	114	183	121	84	152	4	126	34	92
62	107	44	43	63	60	102	125	75	61	128	42	85	78
63	75	72	63	50	61	97	36	79	128	40	65	99	72
64	38	65	93	23	62	107	26	101	123	43	59	14	63
65	99	117	93	19	86	18	256	218	14	105	39	13	90
66	120	129	111	87	73	70	141	102	190	14	194	122	113
67	137	104	58	119	53	112	142	41	120	90	57	108	95
68	95	87	133	94	61	26	25	116	34	83	47	138	78
69	74	157	79	50	267	79	53	102	118	133	142	96	112
1870	83	20	110	39	57	40	82	210	71	149	84	164	92
71	59	50	34	161	33	133	172	28	136	101	64	75	87
72	114	92	81	65	101	90	117	86	172	176	159	158	118
73	65	72	42	89	141	95	52	84	162	95	41	22	80
74	94	55	133	39	163	71	53	61	181	76	156	83	97
75	110	77	68	37	71	85	182	185	121	56	182	42	101
76	33	156	172	109	108	79	42	66	213	61	95	85	102
77	187	208	136	68	87	43	108	152	59	92	142	92	114
78	118	54	177	80	196	49	38	120	93	91	163	72	104
79	89	120	27	194	63	118	162	118	66	83	68	28	95
1880	59	80	75	67	24	178	94	62	137	172	141	173	105
81	56	182	147	53	175	124	48	155	103	66	48	150	109
82	76	74	163	121	106	248	129	130	131	104	155	127	130
83	71	67	84	7	75	52	140	65	93	104	142	83	82
84	150	63	59	43	70	28	138	64	88	94	79	141	85
85	94	127	57	45	151	56	9	55	124	212	83	54	89
86	189	64	103	43	158	130	106	54	29	82	79	139	98
87	33	20	59	96	109	18	22	39	74	133	83	101	66
88	46	64	179	81	51	170	168	75	46	99	66	53	92
89	33	138	103	89	152	130	167	160	163	87	82	115	118
1890	160	9	100	157	68	69	172	120	41	163	200	7	106
91	141	21	113	68	154	207	120	81	67	57	77	176	107
92	142	77	64	38	47	142	51	66	187	202	87	108	101
93	81	285	51	1	42	24	122	75	147	113	131	110	98
94	98	249	106	132	67	122	188	153	112	95	115	131	131
95	108	35	162	96	72	92	104	103	34	110	138	155	101
96	91	13	116	74	14	61	75	99	219	123	96	97	90
97	35	90	144	174	86	119	42	129	144	70	68	132	103
98	80	212	97	109	162	128	109	62	174	70	118	104	119
99	146	102	49	201	174	11	73	182	207	94	55	83	115
1900	120	127	46	101	100	140	78	150	23	134	48	117	99
01	86	64	141	197	66	81	117	83	169	108	102	145	113
02	80	79	93	84	154	40	105	132	66	59	54	92	86
03	77	79	135	292	115	152	105	112	161	165	143	40	131
04	108	136	74	48	135	120	31	74	63	59	100	79	86
05	59	87	155	120	73	110	102	140	75	200	99	42	105
06	206	118	105	62	185	81	79	73	52	77	101	105	104
07	69	111	107	93	132	162	43	60	56	101	71	124	94
08	97	129	83	75	118	113	97	126	56	36	98	54	90
09	40	85	126	215	77	66	116	163	93	136	70	166	113
1910	110	173	67	162	91	132	133	82	107	27	187	126	115
11	53	101	108	67	49	183	28	196	52	157	156	110	105
12	114	126	162	90	125	208	56	265	152	89	140	140	136
13	135	73	132	45	176	189	129	21	28	65	117	115	102
14	114	72	278	93	88	90	113	45	124	52	100	166	111
15	196	201	116	99	158	91	126	115	70	28	163	160	127
16	138	182	170	186	135	190	42	119	59	129	86	119	130
17	89	15	54	120	36	161	84	230	57	215	83	54	100
18	193	111	51	74	37	87	178	62	291	103	79	154	118
19	92	92	132	150	44	77	170	58	62	87	97	167	102
1920	155	92	38	203	124	45	130	137	39	14	24	88	91
21	156	25	62	67	41	75	150	35	32	34	56	......	....
Normals,	5.44	4.30	4.98	4.33	4.93	5.89	7.58	8.36	6.51	7.27	5.96	6.89	....

TABLE 15.—Number of rainfall stations in the different counties in Denmark.

Counties.	Year.											
	1865.	1870.	1875.	1880.	1885.	1890.	1895.	1900.	1905.	1910.	1915.	1920.
Hjorring	1	1	4	5	7	8	9	9	9	11	7	8
Thisted	0	0	6	6	7	7	6	6	7	6	7	6
Ringkjobing	2	2	7	9	9	9	33	30	29	28	25	26
Ribe	0	1	4	6	8	10	18	18	18	17	15	12
Viborg	3	3	6	5	5	9	11	10	10	8	7	8
Aalborg	0	1	5	5	6	7	8	7	8	9	10	13
Randers	1	1	9	7	8	9	9	7	7	8	9	11
Aarhus	4	3	7	7	8	15	17	17	20	22	21	20
Vejle	0	1	7	7	8	9	11	10	11	9	9	10
Sonderjylland	...	...	...	...	...	...	...	...	...	...	...	25
Odense	1	1	11	12	12	17	17	18	20	20	20	20
Svendborg	1	1	9	11	10	17	16	17	17	18	16	16
Holbæk	0	0	7	10	11	11	12	10	10	11	11	11
Soro	1	2	4	5	6	9	8	11	10	9	13	14
Frederiksborg	0	1	5	8	5	5	4	5	8	6	10	11
Kjobenhavns	4	4	12	12	14	14	15	13	13	13	15	14
Præsto	0	0	13	14	14	17	14	14	13	17	22	21
Maribo	1	2	9	15	18	14	14	14	14	15	16	16
Total number	19	24	125	144	156	187	222	216	224	227	233	262

TABLE 15a.—Denmark. Observed per cent of normal rainfall of stations shown above made from manuscript copy of actual rainfall sent by Prof. Carl Ryder.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1860	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	58
61	40	113	150	77	77	163	133	92	155	12	189	37
62	87	45	79	80	97	178	117	63	108	132	71	130
63	113	83	103	114	77	151	68	76	160	62	71	104
64	54	86	126	54	82	190	57	125	149	61	88	23
65	80	86	39	17	72	43	99	126	31	112	101	29
66	150	240	55	125	118	116	101	126	144	30	150	114
67	157	166	82	193	113	99	170	31	147	110	65	70
68	115	143	158	111	31	33	49	79	123	114	80	236
69	82	139	45	37	153	81	46	75	110	114	123	116
1870	96	30	61	54	64	78	63	98	93	145	123	66
71	33	131	45	97	46	161	131	46	157	39	47	70
72	115	68	182	131	166	99	73	87	196	101	150	118
73	127	45	42	82	189	58	104	111	155	176	97	77
74	120	39	110	88	64	66	95	106	139	82	67	103
75	185	18	71	63	84	110	80	71	51	145	155	411
76	26	157	218	128	49	93	52	51	159	51	71	147
77	183	157	87	85	87	87	140	170	108	123	121	79
78	136	45	137	71	161	83	82	123	98	91	144	97
79	35	154	47	82	148	169	148	173	88	80	62	37
1880	23	166	63	114	49	116	164	43	139	171	176	116
81	42	71	87	20	87	60	121	157	118	139	105	77
82	89	74	124	131	110	178	151	114	72	121	168	79
83	75	68	34	56	46	66	145	110	113	124	170	103
84	172	134	92	45	105	52	117	44	79	130	64	137
85	92	116	39	99	130	83	41	107	149	145	54	60
86	124	50	79	94	94	75	90	44	77	88	86	139
87	21	27	66	102	133	31	82	46	129	119	101	97
88	54	135	163	122	84	153	180	84	52	82	101	87
89	28	92	79	82	46	52	117	149	96	170	54	43
1890	127	15	108	139	135	103	150	129	34	129	82	15
91	96	36	134	94	153	62	137	210	92	95	75	132
92	129	77	39	74	115	194	43	92	110	135	41	58
93	82	175	63	9	66	60	120	78	146	150	95	85
94	96	143	121	114	89	95	117	118	61	97	75	77
95	66	74	121	65	84	93	156	114	34	127	140	112
96	49	27	168	102	64	66	66	109	177	145	47	87
97	49	50	229	105	187	50	128	141	124	39	54	120
98	99	151	132	94	217	202	71	102	72	38	97	170
99	157	116	82	142	82	25	69	36	138	91	82	83
1900	148	181	50	134	79	109	115	95	78	160	69	128
01	77	53	116	162	89	190	54	58	39	53	121	130
02	(136)	30	132	63	199	66	84	146	59	83	17	77
03	103	160	84	148	84	76	128	139	92	233	93	41
04	96	160	79	160	120	78	28	75	38	82	129	110
05	80	68	150	151	87	91	85	147	125	132	75	29
06	167	(113)	108	74	115	83	57	112	51	76	146	74
07	92	80	76	57	118	194	79	103	28	82	82	132
08	99	151	121	125	146	91	85	107	88	17	84	48
09	82	45	100	139	110	107	107	79	116	110	107	163
1910	153	211	45	139	84	132	115	143	61	35	136	116
11	75	181	137	80	67	161	58	47	46	141	193	120
12	54	107	124	108	113	132	110	155	70	124	123	196
13	70	83	158	74	69	87	58	71	80	77	133	141
14	54	101	192	125	84	70	139	54	90	70	120	137
15	131	80	105	63	95	29	155	74	65	33	107	215
16	190	101	66	122	148	153	91	129	62	129	120	164
17	101	21	134	97	28	87	71	135	98	148	144	58
18	94	140	16	136	38	81	110	99	208	70	41	141
19	108	104	103	134	28	91	112	87	77	70	92	153
1920	162	143	66	256	156	58	129	88	97	21	34	104
21	218	65	82	65	77	56	49	108	64	91	.....	.....
Normals in mm.	42.6	33.7	38.0	35.2	39.1	48.4	63.4	74.7	61.2	66.2	53.6	51.7

TABLE 16.—Sweden. Observed per cent of normal. Prepared from material from "Observations Meteorologiques Suedoises L'Academie Royale des Sciences de Suede," for 1910.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1860	180	90	111	138	113	167	72	165	109	134	86	97
61	72	104	119	50	116	57	128	118	107	27	190	42
62	65	58	72	129	81	175	132	68	59	137	105	104
63	107	77	89	137	64	88	69	100	157	76	73	94
64	44	112	136	61	58	134	65	102	127	73	95	46
65	113	84	47	24	110	59	94	114	36	101	98	34
66	119	238	91	91	139	118	122	15	155	23	152	127
67	186	115	64	173	56	145	136	53	99	109	90	128
68	101	155	144	122	58	42	53	85	132	126	74	127
69	45	132	46	58	173	124	46	110	102	121	112	97
1870	140	60	48	83	102	90	92	68	108	111	189	91
71	46	52	263	58	169	58	59	24	168	41	34	45
72	108	99	120	140	162	142	70	94	181	163	157	131
73	191	72	52	49	136	107	79	105	155	152	133	76
74	84	33	93	96	48	43	76	95	106	97	77	121
75	146	34	89	65	76	97	78	78	35	57	102	77
76	72	133	134	123	55	110	70	71	216	105	82	101
77	144	149	154	78	91	82	52	123	78	93	158	93
78	84	27	122	49	156	127	63	110	100	97	151	133
79	58	131	48	132	121	121	124	94	124	98	63	44
1880	281	133	34	76	65	72	126	39	77	93	131	135
81	49	257	86	53	103	98	117	131	120	98	105	90
82	83	91	117	162	114	118	148	130	65	94	147	120
83	73	54	59	50	80	101	172	123	148	97	178	91
84	126	83	90	44	125	146	133	38	75	122	51	170
85	42	50	36	30	51	32	25	57	45	73	21	25
86	53	13	39	58	27	29	21	13	22	22	41	64
87	83	39	50	120	92	53	115	87	132	83	11	140
88	61	92	108	81	101	67	158	83	90	121	77	124
89	69	133	72	81	71	59	146	124	115	106	69	52
1890	136	256	117	242	136	122	149	137	41	152	153	81
91	103	50	100	58	125	53	113	149	99	115	110	126
92	80	84	67	108	72	172	78	127	107	110	24	80
93	88	102	83	43	90	80	103	107	153	182	78	111
94	119	108	117	102	148	96	133	125	77	91	71	119
95	70	92	152	83	70	109	178	135	66	132	117	80
96	79	48	200	115	76	124	88	126	108	164	68	99
97	92	90	173	123	119	75	106	125	135	53	83	142
98	78	160	177	88	167	158	155	115	75	50	122	188
99	151	100	87	186	78	72	84	46	185	104	90	97
1900	116	178	67	107	78	71	99	116	72	161	131	147
01	64	63	101	106	50	160	32	70	37	116	79	135
02	108	50	118	37	111	82	132	153	79	114	30	77
03	113	99	102	195	78	92	114	188	84	145	60	79
04	96	152	84	149	131	101	30	127	70	95	104	120
05	68	53	98	122	63	87	112	139	109	85	101	29
06	122	116	121	109	155	88	78	91	35	70	161	86
07	106	104	77	127	105	158	144	113	40	90	63	123
08	78	126	115	102	104	120	84	95	97	20	86	86
09	88	40	205	130	102	102	116	109	92	156	64	179
1910	125	155	52	164	130	87	131	93	95	53	252	98
Normals	3.54	3.03	3.12	2.74	3.92	4.58	6.12	6.91	5.43	5.13	4.06	3.71

TABLE 17.—Per cent of normal rainfall of Chilgrove, England; Denmark; Sweden, and Utrecht, Holland—weighted equally because of geographical distribution. The record of Sweden is not included after December, 1910.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1861	39	88	131	66	96	126	141	80	136	22	162	42
62	90	44	92	82	102	142	119	71	75	130	65	102
63	104	68	77	82	79	133	53	80	145	70	68	98
64	50	81	125	54	70	122	40	90	134	56	91	31
65	107	98	58	20	102	54	135	160	23	138	84	40
66	135	198	84	96	100	108	110	88	188	26	139	110
67	148	124	73	148	72	109	157	59	110	94	60	88
68	112	112	131	115	52	32	40	110	100	104	62	189
69	78	137	62	50	201	92	47	84	131	106	112	107
1870	98	62	77	47	73	57	74	124	84	130	113	106
71	62	78	101	140	69	130	140	39	156	56	42	64
72	145	94	126	96	141	105	94	80	158	146	155	144
73	134	80	60	64	134	92	83	92	144	132	88	49
74	94	56	90	92	165	78	70	156	129	93	95	97
75	148	57	73	59	72	108	126	97	73	98	147	50
76	42	149	164	118	60	88	50	73	189	68	92	136
77	193	150	125	96	107	60	108	151	77	99	162	88
78	101	62	127	89	156	86	56	134	89	92	150	89
79	65	145	38	150	116	152	152	149	108	73	53	33
1880	93	127	54	89	60	117	148	44	130	161	139	136
81	49	162	103	38	110	96	105	157	110	89	98	104
82	76	80	111	153	100	174	140	112	86	135	130	102
83	78	98	53	45	76	81	147	170	122	98	161	79
84	136	96	91	53	86	72	121	48	88	95	58	141
85	72	117	58	59	142	70	24	148	122	132	65	45
86	170	42	79	72	126	66	91	46	46	81	79	172
87	230	30	56	99	96	37	64	64	118	92	86	102
88	52	81	158	92	82	137	200	84	56	88	100	82
89	40	106	86	90	125	68	130	128	100	137	62	70
1890	136	82	127	171	106	111	156	126	43	118	132	30
91	112	27	132	68	136	102	122	173	75	109	99	142
92	98	68	53	67	70	151	68	98	128	139	66	80
93	78	177	52	14	60	59	125	72	128	142	96	102
94	132	152	106	120	92	102	162	114	86	103	113	105
95	86	52	139	102	60	82	160	122	87	117	148	114
96	70	28	172	81	45	109	68	95	203	131	61	116
97	70	101	202	137	115	90	76	149	127	44	63	133
98	72	148	111	90	188	153	120	86	98	64	119	137
99	141	107	63	170	94	48	74	72	160	89	98	83
1900	134	197	52	110	78	121	85	122	54	130	94	134
01	68	64	120	156	66	147	78	68	82	88	80	144
02	92	68	111	60	144	88	93	166	60	82	60	80
03	100	105	126	194	113	110	120	159	123	198	93	64
04	128	162	75	116	151	88	37	93	68	76	93	108
05	63	60	164	123	62	120	78	138	97	119	108	35
06	200	133	100	74	158	77	58	78	48	90	143	86
07	78	93	78	136	124	164	84	88	36	112	78	123
08	81	121	117	106	123	89	102	119	76	38	78	78
09	61	47	163	141	94	105	118	107	108	156	66	166
1910	124	182	59	150	90	109	118	109	67	60	176	122
11	59	126	113	76	86	149	39	87	47	148	169	162
12	98	121	166	66	98	167	82	229	77	99	107	157
13	130	73	147	101	134	100	87	53	55	94	118	104
14	66	125	231	103	83	73	126	52	91	66	109	193
15	155	167	87	79	146	68	149	80	73	52	125	224
16	123	147	128	123	125	148	57	124	70	131	115	132
17	81	30	96	108	56	139	84	188	71	157	93	55
18	142	108	45	106	53	70	152	76	241	69	73	131
19	146	110	174	138	28	64	118	93	63	55	129	173

TABLE 18.—Per cent of normal rainfall of Chilgrove, England; Denmark; Sweden and Utrecht, Holland. Begins January, 1861.

Cycles.	Phase numbers.														
	(10)	(11)	(12)	(13)	(14)	(15)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	39	88	98	96	126	141	80	79	162	42	90	44	92	82	102
2	130	71	75	130	65	102	104	68	77	82	79	92	80	145	70
3	68	98	50	81	125	54	70	122	40	90	134	56	91	31	107
4	98	58	20	102	54	135	135	160	23	138	84	40	135	198	84
5	96	100	108	110	110	88	188	26	139	110	148	124	73	(73)	148
6	72	109	109	157	59	110	110	94	60	88	88	112	112	112	131
7	115	115	52	32	32	40	110	110	100	104	62	62	189	78	137
8	137	62	50	201	92	92	47	84	131	106	106	112	107	98	62
9	77	47	47	73	57	74	(124)	84	130	130	113	106	62	78	101
10	140	140	69	130	140	39	156	56	42	64	145	94	126	118	105
11	94	80	158	146	155	144	134	80	60	64	134	92	83	92	138
12	88	49	94	56	90	128	78	70	156	111	95	97	148	57	66
13	72	117	97	73	98	98	42	156	118	74	50	131	68	114	172
14	125	102	60	130	88	162	94	62	108	156	71	112	92	(120)	65
15	145	94	116	152	150	108	73	43	93	127	54	74	117	148	44
16	130	150	136	49	162	103	38	110	96	131	110	89	98	104	76
17	80	111	153	100	174	140	112	86	135	130	102	78	98	49	76
18	81	147	170	122	98	161	(79)	136	136	96	91	53	86	72	121
19	48	88	88	95	58	141	72	117	58	59	59	142	70	24	148
20	122	132	132	65	45	170	170	42	79	72	126	126	66	91	46
21	46	46	81	79	172	230	230	30	56	99	96	96	37	64	64
22	118	118	92	86	102	52	52	81	158	92	82	82	137	200	84
23	56	56	88	100	82	40	106	106	86	90	125	68	130	(128)	100
24	137	62	70	136	82	127	171	106	111	156	126	43	118	132	30
25	70	132	68	136	102	122	173	75	109	99	142	98	68	53	67
26	70	151	68	98	128	139	66	80	78	177	52	14	60	59	125
27	72	128	142	96	102	132	(152)	106	120	97	162	114	86	103	113
28	105	69	139	102	60	82	160	122	102	148	114	70	28	172	63
29	109	68	95	203	131	61	116	70	101	170	115	90	76	149	127
30	44	63	133	110	111	90	188	153	120	86	98	64	119	139	107
31	63	170	94	48	74	72	160	89	98	108	197	52	110	78	121
32	85	122	54	130	94	134	66	120	156	66	147	78	68	(82)	88
33	112	92	68	111	60	144	90	166	60	82	60	80	100	105	126
34	194	113	110	120	159	160	93	64	128	162	75	116	151	88	37
35	93	68	76	93	108	63	60	164	123	62	120	78	138	97	119
36	108	35	200	133	100	74	(158)	77	58	78	48	90	143	86	78
37	93	78	136	124	164	84	88	36	112	78	123	81	121	117	106
38	123	89	102	119	76	38	78	78	61	47	163	141	94	105	112
39	108	156	66	166	124	182	59	150	90	109	118	109	67	60	176

40	122	59	126	113	76	86	149	39	87	47	148	169	162	98	121
41	166	66	98	167	82	229	77	99	107	157	102	147	101	(134)	100
42	87	53	55	94	118	104	66	125	231	103	82	73	126	52	91
43	66	109	193	155	155	167	87	79	146	68	149	80	73	52	125
44	224	123	147	128	123	125	148	57	124	70	131	115	132	81	30
Mean, 1-22	98	98	95	105	104	116	107	88	100	100	98	94	100	100	100
Mean, 23-44	100	89	101	117	100	107	109	93	104	98	113	85	98	94	93
Mean, 1-44	99	94	98	111	102	112	108	90	102	99	106	90	99	97	96

Means are adjusted to make their average 100.

TABLE 19.—Chile. Sums of rainfall in the following towns for years indicated: Concepcion, 1876-1887 and 1892-1915. Puerto Montt, 1862- April, 1873; 1888- July, 1895, and January, 1896-1915. Santiago, 1873-1915. Serena, 1869-1915. Valdivia, 1852-1879 and 1900-1915.

SUMS OF ACTUAL RAINFALL.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1852	......	......	......	......	......	......	......	5150	2580	620	2330	970
53	110	1420	1300	1970	5550	7500	2770	1760	2490	1260	1520	120
54	250	540	1410	2500	5490	7650	5270	2690	1310	1920	750	630
55	970	90	2080	3550	1780	4600	4610	4650	1390	990	400	2310
56	1100	500	3050	1930	1410	8340	2640	2640	1320	430	1550	1250
57	2320	1270	1650	2570	4730	6350	4220	1320	1760	1510	3220	1240
58	370	2260	560	3830	3990	2940	2240	5110	1950	580	2170	120
59	120	360	1630	2900	4750	6480	4220	1730	1650	740	660	140
1860	170	1680	890	1130	3830	2840	8630	6330	3150	910	940	280
61	120	190	1560	5310	3600	4250	4340	2570	1270	1480	640	170
62	2120	340	2770	4490	8450	13030	7170	5790	2460	4820	5520	2630
63	1490	1050	3010	6080	3960	8690	4470	4670	2210	1460	2490	3880
64	1500	800	2060	2770	8670	7630	6280	6740	3880	3040	2590	4270
65	1150	190	1560	2940	9050	6480	7320	7740	4580	6170	2170	2780
66	960	980	7900	4500	8970	2320	7640	10060	3820	2210	3500	560
67	650	1680	2820	5420	10820	6020	5390	4590	3260	1670	2470	4350
68	4220	5170	2750	3910	8880	10070	8430	4560	6640	4120	2100	6830
69	2580	1550	3210	1620	4780	4400	8720	11280	3370	3170	3260	5220
1870	2920	2130	6130	4130	8400	4380	8650	3600	1520	1600	1520	4880
71	3280	600	6860	3960	4985	4075	5470	8140	2610	4170	1190	1830
72	2060	1510	2920	3290	3680	5140	4875	8125	4850	4480	4060	3840
73	1440	566	3610	4228	3726	5890	5340	3187	3312	900	130	2210
74	250	210	1094	570	2744	6827	3598	4288	2897	2060	2068	160
75	1656	1186	2710	1204	7176	1893	3658	1250	590	960	934	2340
76	408	1466	3712	2264	5432	4155	8848	5881	3380	4726	1054	80
77	148	1279	2472	6640	3601	4109	12422	4894	5872	3888	1698	742
78	228	424	2716	5502	8897	10554	6432	2431	5051	3418	2695	474
79	446	582	1020	2138	5275	9160	11084	9804	718	938	1058	3032
1880	496	182	235	548	1436	8676	9018	4423	582	1002	126	616
81	186	304	50	2195	3773	2554	3380	2142	2969	1317	688	40
82	222	332	733	536	2248	1796	4385	3698	1031	376	877	0
83	176	38	1392	407	3349	6316	1382	836	1354	884	758	0
84	42	24	797	2920	614	2247	1722	3673	1591	1012	237	832
85	844	428	302	734	3955	757	4295	2425	1491	897	166	510
86	60	190	852	470	1512	2808	1731	1368	813	371	381	590
87	50	185	80	253	910	6643	1855	6958	2280	933	738	291
88	170	1240	750	2392	3694	4130	4111	7073	3368	3289	1522	1610
89	655	510	1520	1590	3210	1733	3870	2870	1496	740	1163	1909
1890	2162	730	805	486	1783	2841	4592	1703	1796	1133	520	2262
91	2200	1290	1930	1520	2910	6227	4654	2859	2310	3405	987	320
92	1233	2641	1535	1047	3360	2822	4080	4087	2549	2069	733	1157
93	4036	590	2270	1555	5414	3405	6648	3792	978	963	1419	1615
94	1534	1230	2326	1098	4668	3182	5181	4161	2715	3462	3574	1553
95	987	989	3222	1605	2412	4219	6826	5739	1510	1204	533	918
96	1373	410	1471	781	1942	3484	8203	4561	7270	2919	2153	603
97	313	990	2847	4587	6666	4819	3713	3491	1511	2338	2235	1894
98	1175	4251	2108	5081	5616	10006	6377	2783	3051	1733	2441	3323
99	2321	1296	2981	4380	8812	7430	13519	13047	1293	1240	2450	1150
1900	2220	3532	8567	3451	10757	10533	22182	9368	6177	6168	4155	576
01	1166	3439	1657	3639	10459	16351	13035	11198	4860	2200	5324	1578
02	1383	3495	4529	6093	15927	15389	13753	5536	5657	2392	3450	1529
03	510	501	738	2154	2864	13472	3779	3697	3019	1355	909	1445
04	679	285	1094	4784	9731	10565	17881	5736	7179	3029	1557	2132
05	369	71	3581	4011	6925	12188	9646	8120	4234	3906	450	1460
06	1421	1137	1578	4438	9484	8481	6869	5618	3916	1346	223	955
07	916	1271	558	364	5215	9114	6817	6337	5171	2866	449	2171
08	102	609	3202	6184	8909	6913	2958	6908	3144	1968	1864	879
09	484	854	265	2737	2948	5655	2865	6751	1723	2055	1967	811
1910	2756	1951	564	3678	5324	13591	9993	12160	1934	1248	3094	120
11	1092	851	644	7038	10577	5191	6221	6948	3814	917	4497	2912
12	903	3579	1443	7136	9364	8967	5405	7820	1904	3716	3192	2242
13	129	1379	2177	8693	12355	5986	15961	6161	5289	2048	349	1526
14	3242	390	1740	2024	9691	17961	13405	6552	10493	3150	5615	1564
15	192	1772	1250	9038	17618	10368	11040	8119	3291	2923	2553	1991

TABLE 19—CONTINUED.

SUMS OF NORMAL RAINFALL FOR EACH MONTH WHERE ACTUAL RAINFALL HAS BEEN USED.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1852	......	......	......	......	......	......	......	3365	2101	1417	1233	1047
53	634	738	1418	2376	3910	4457	4310	3365	2101	1417	1233	1047
54	634	738	1418	2376	3910	4457	4310	3365	2101	1417	1233	1047
55	634	738	1418	2276	3910	4457	4310	3365	2101	1417	1233	1047
56	634	738	1418	2376	3910	4457	4310	3365	2101	1417	1233	1047
57	634	738	1418	2376	3910	4457	4310	3365	2101	1417	1233	1047
58	634	738	1418	2376	3910	4457	4310	3365	2101	1417	1233	1047
59	634	738	1418	2376	3910	4457	4310	3365	2101	1417	1233	1047
1860	634	738	1418	2376	3910	4457	4310	3365	2101	1417	1233	1047
61	634	738	1418	2376	3910	4457	4310	3365	2101	1417	1233	1047
62	1846	1815	3005	4286	6788	6925	7213	5747	3748	2840	2686	2479
63	1846	1815	3005	4286	6788	6925	7213	5747	3748	2840	2686	2479
64	1846	1815	3005	4286	6788	6925	7213	5747	3748	2840	2686	2479
65	1846	1815	3005	4286	6788	6925	7213	5747	3748	2840	2686	2479
66	1846	1815	3005	4286	6788	6925	7213	5747	3748	2840	2686	2479
67	1846	1815	3005	4286	6788	6925	7213	5747	3748	2840	2686	2479
68	1846	1815	3005	4286	6788	6925	7213	5747	3748	2840	2686	2479
69	1847	1815	3013	4311	7001	7403	7554	6000	3815	2877	2693	2479
1870	1847	1815	3013	4311	7001	7403	7554	6000	3815	2877	2693	2479
71	1847	1815	3013	4311	7001	7403	7554	6000	3815	2877	2693	2479
72	1847	1815	3013	4311	7001	7403	7554	6000	3815	2877	2693	2479
73	1854	1831	3058	4466	4745	5770	5555	4239	2435	1608	1312	1105
74	642	754	1471	2556	4745	5770	5555	4239	2435	1608	1312	1105
75	642	754	1471	2556	4745	5770	5555	4239	2435	1608	1312	1105
76	819	981	2060	3436	6751	8318	8185	6131	3423	2220	1734	1368
77	819	981	2060	3436	6751	8318	8185	6131	3423	2220	1734	1368
78	819	981	2060	3436	6751	8318	8185	6131	3423	2220	1734	1368
79	819	981	2060	3436	6751	8318	8185	6131	3423	2220	1734	1368
1880	185	243	642	1060	2841	3861	3875	2766	1322	803	501	321
81	185	243	642	1060	2841	3861	3875	2766	1322	803	501	321
82	185	243	642	1060	2841	3861	3875	2766	1322	803	501	321
83	185	243	642	1060	2841	3861	3875	2766	1322	803	501	321
84	185	243	642	1060	2841	3861	3875	2766	1322	803	501	321
85	185	243	642	1060	2841	3861	3875	2766	1322	803	501	321
86	185	243	642	1060	2841	3861	3875	2766	1322	803	501	321
87	185	243	642	1060	2841	3861	3875	2766	1322	803	501	321
88	1220	1093	1640	2090	3713	3781	4148	3256	1981	1614	1532	1490
89	1220	1093	1640	2090	3713	3781	4148	3256	1981	1614	1532	1490
1890	1220	1093	1640	2090	3713	3781	4148	3256	1981	1614	1532	1490
91	1220	1093	1640	2090	3713	3781	4148	3256	1981	1614	1532	1490
92	1397	1320	2229	2970	5719	6329	6778	5149	2969	2226	1954	1753
93	1397	1320	2229	2970	5719	6329	6778	5149	2969	2226	1954	1753
94	1397	1320	2229	2970	5719	6329	6778	5149	2969	2226	1954	1753
95	1397	1320	2229	2970	5719	6329	6778	5149	2969	2226	1954	1753
96	1397	1320	2229	2970	5719	6329	6778	5149	2969	2226	1954	1753
97	1397	1320	2229	2970	5719	6329	6778	5149	2969	2226	1954	1753
98	1397	1320	2229	2970	5719	6329	6778	5149	2969	2226	1954	1753
99	1397	1320	2229	2970	5719	6329	6778	5149	2969	2226	1954	1753
1900	2031	2058	3647	5346	9629	10786	11088	8514	5070	3643	3187	2800
01	2031	2058	3647	5346	9629	10786	11088	8514	5070	3643	3187	2800
02	2031	2058	3647	5346	9629	10786	11088	8514	5070	3643	3187	2800
03	819	981	2060	3436	6751	8318	8185	6132	3423	2220	1734	1368
04	819	981	2060	3436	6751	8318	8185	6132	3423	2220	1734	1368
05	819	981	2060	3436	6751	8318	8185	6132	3423	2220	1734	1368
06	819	981	2060	3436	6751	8318	8185	6132	3423	2220	1734	1368
07	819	981	2060	3436	6751	8318	8185	6132	3423	2220	1734	1368
08	819	981	2060	3436	6751	8318	8185	6132	3423	2220	1734	1368
09	819	981	2060	3436	6751	8318	8185	6132	3423	2220	1734	1368
1910	2031	2058	3647	5346	9629	10786	11088	8514	5070	3643	3187	2800
11	2031	2058	3647	5346	9629	10786	11088	8514	5070	3643	3187	2800
12	2031	2058	3647	5346	9629	10786	11088	8514	5070	3643	3187	2800
13	2031	2058	3647	5346	9629	10786	11088	8514	5070	3643	3187	2800
14	2031	2058	3647	5346	9629	10786	11088	8514	5070	3643	3187	2800
15	819	2058	3647	5346	9629	10786	11088	8514	5070	3643	3187	2800

TABLE 20.—Chile. Table made from sums given in Table 19, beginning January, 1862.

SUMS OF ACTUAL RAINFALL.

CYCLES.	Phase numbers.														
	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(1)	(2)	(3)	(4)
1	2120	3460	2770	4490	8450	10100	5790	2460	4820	5520	2630	1490	1050	3010	6080
2	3960	6580	4670	2210	1460	2490	3880	1500	800	2060	2770	8670	7630	6280	6740
3	3880	3040	2590	4270	1150	190	1560	2940	9050	6480	7320	7320	7740	4580	6170
4	2170	2780	960	980	7900	4500	8970	2320	7640	7640	10060	3820	2210	3500	560
5	650	1680	2820	(2820)	5420	10820	6020	6020	5390	4590	3260	3260	1670	2470	4350
6	4350	4220	4220	5170	2750	3910	3910	8880	10070	10070	8430	4560	4560	6640	4120
7	2100	2100	6830	2580	1550	1550	3210	1620	4780	4400	4400	8720	11280	3370	3170
8	3170	3260	5220	2920	2130	6130	4130	4130	8400	4380	8650	(3600)	1520	1600	1600
9	1520	4880	3280	600	6860	3960	3960	4985	4075	5470	8140	2610	4170	1190	1830
10	2060	1510	2920	3485	5140	4875	8125	4850	4480	4060	3840	1440	566	3610	4228
11	3726	5890	5340	3187	2106	130	2210	250	210	1094	1657	6827	3598	4288	2478
12	2068	160	1656	1186	1957	7176	2776	1250	590	960	1687	408	2589	2264	4794
13	8848	4630	4726	567	714	2472	5120	4109	8658	4880	1698	485	424	4109	8897
14	8493	3741	3418	(1584)	446	582	1579	5275	9160	10444	718	938	2045	496	182
15	235	992	8676	9018	4423	582	564	616	186	304	50	2195	3773	2554	2761
16	2969	1317	688	40	222	332	733	536	2248	1796	4385	3698	1031	376	877
17	0	176	38	900	3349	6316	1382	836	1354	884	758	(0)	42	42	24
18	797	2920	614	2247	1722	3673	1591	1591	1012	237	832	844	428	302	734
19	734	3955	757	4295	2425	1491	897	897	166	510	60	60	190	852	470
20	1512	1512	2808	1731	1368	813	813	371	381	590	50	50	185	80	253
21	910	910	6643	1855	6958	2280	2280	933	738	291	170	170	1240	750	2392
22	3694	3694	4130	4111	7073	3368	3368	3289	1522	1610	655	510	510	1520	1590
23	3210	1733	3870	(2870)	1496	740	1163	1909	2162	730	805	486	1783	2841	4592
24	1703	1796	1133	520	2262	1745	1930	1520	2910	6227	4654	2859	2310	3405	987
25	320	1233	2641	1535	1047	3360	2822	4080	4087	2549	2069	733	1157	4036	590
26	2270	1555	5414	3405	6648	3792	978	963	1419	1615	1534	(1230)	2326	1098	3925
27	5181	4141	2715	3462	3574	1553	988	3222	1605	2412	4219	6826	5739	1357	533
28	918	1373	410	1471	1362	3484	8203	4561	7270	2919	2153	603	313	990	3717
29	6666	4819	3713	3491	1511	2338	2235	1894	2713	2108	5081	5616	10006	6377	2783
30	3051	1733	2441	2822	1296	2981	4380	8812	7430	13519	13047	1293	1240	2450	1685
31	3532	8567	3451	10757	10533	22182	9368	6177	6168	4155	576	2302	1657	3639	10457
32	16351	13035	11198	(4860)	2200	3451	1383	3495	4529	6093	15927	14571	5536	5657	2392
33	3450	1529	510	501	738	2154	2864	13472	3779	3697	2187	909	1445	679	285
34	1094	4784	9731	10565	17881	5736	7179	3029	1557	2132	369	71	3581	4011	6925
35	12188	9646	8120	4234	3906	450	1460	1421	1137	1578	4438	(9484)	8481	6869	5618
36	3916	1346	223	955	916	1271	558	364	5215	9114	6817	6337	5171	2866	449
37	2171	102	609	3202	6184	8909	6913	2958	6908	3144	1968	1864	879	484	854
38	265	2737	2948	5655	4808	1723	2055	1967	811	2756	1951	564	3673	6234	13591

39	9993	12160	1934	1248	3094	120	1092	851	644	7038	10577	5191	6221	6948	3814
40	917	4497	2912	903	3579	1443	7136	9364	8967	5405	7820	1904	3716	3192	2242
41	754	2177	8693	(12355)	5986	15961	6161	5289	2048	349	1526	3242	390	1740	2024
42	9691	17961	13405	6552	10493	3150	5615	1564	192	192	1772	1250	9038	17618	10368
43	11040	8119	3291	2923	2553	1991	......	......	......	......	......	......	......	......	......

SUMS OF NORMAL VALUES OF ALL STATIONS.

1	1846	1815	3005	4286	6788	7069	5747	3748	2840	2686	2479	1846	1815	3005	4286
2	6788	7069	5747	3748	2840	2686	2479	1846	1815	3005	4286	6788	6925	7213	5747
3	3748	2840	2686	2479	1846	1815	3005	4286	6788	6925	7213	7213	5747	3748	2840
4	2686	2479	1846	1815	3005	4286	6788	6925	7213	7213	5747	3748	2840	2686	2479
5	1846	1815	3005	(3005)	4286	6788	6925	6925	7213	5747	3748	3748	2840	2686	2479
6	2479	1846	1846	1815	3005	4286	4286	6788	6925	6925	7213	5747	5747	3748	2840
7	2686	2686	2479	1847	1815	1815	3013	4311	7001	7001	7403	7554	6000	3815	2877
8	2877	2693	2479	1847	1815	3013	4311	4311	7001	7403	7554	(6000)	3815	2877	2877
9	2693	2479	1847	1815	3013	4311	4311	7001	7403	7554	6000	3815	2877	2693	2479
10	1847	1815	3013	5665	7403	7554	6000	3815	2877	2693	2479	1854	1831	3058	4466
11	4745	5770	5555	4239	2022	1312	1105	642	754	1471	3650	5770	5555	4239	2022
12	1312	1105	642	754	2014	4745	5668	4239	2435	1608	1208	819	1520	3436	7534
13	8185	4777	2220	1551	900	2060	5094	8318	7158	2822	1734	1094	981	2748	6751
14	8252	4777	2220	(1551)	819	981	2748	6751	8318	7158	3423	2220	1551	185	243
15	642	1950	3861	3875	2766	1322	652	321	185	243	642	1060	2841	3861	3320
16	1322	803	501	321	185	243	602	1060	2841	3861	3875	2766	1322	803	501
17	321	185	243	851	2841	3861	3875	766	1322	803	501	(321	185	185	243
18	642	1060	2841	3861	3875	2766	1332	1332	803	501	321	185	243	642	1060
19	1060	2841	3861	3875	2766	1382	803	803	501	321	185	185	243	642	1060
20	2841	2841	3861	3878	2766	1322	1322	803	501	321	185	185	243	642	1060
21	2841	2841	3861	3878	2766	1322	1322	803	501	321	1220	1220	1093	1640	2090
22	3713	3713	3781	4148	3256	1981	1981	1614	1532	1490	1220	1093	1093	1640	2090
23	3713	3781	4148	(3256)	1981	1614	1532	1490	1220	1093	1640	2090	3713	3781	4148
24	3256	1981	1614	1532	1490	1156	1640	2090	3713	3781	4148	3256	1981	1614	1532
25	1490	1397	1320	2229	2970	5719	6329	6778	5149	2969	2226	1954	1753	1397	1320
26	2229	2970	5719	6329	6778	5149	2969	2226	1954	1753	1397	(1320)	2229	2970	6024
27	6778	5149	2969	2226	1954	1753	1358	2229	2970	5719	6329	6778	5149	2598	1959
28	1753	1397	1320	2229	4344	6329	6778	5149	2969	2226	1954	1753	1397	1320	2600
29	5719	6329	6778	5149	2969	2226	1954	1753	1358	2229	2970	5719	6329	6778	5149
30	2969	2226	1954	1575	1320	2229	2970	5719	6229	6778	5149	2969	2226	1954	1892
31	2058	3647	5346	9629	10786	11088	8514	5070	3643	3187	2800	2044	3647	5346	9629
32	10786	11088	8514	(5070)	3643	2994	2031	2058	3647	5346	9629	10937	8514	5070	3643
33	3187	2800	819	981	2060	3436	6751	8318	8185	6132	2822	1734	1368	819	981
34	2060	3436	6751	8318	8185	6132	3423	2220	1734	1368	819	981	2060	3436	6751
35	8318	8185	6132	3423	2220	1734	1368	819	981	2060	3436	(6751)	8318	8185	6132
36	3423	2220	1734	1368	819	981	2060	3436	6751	8318	8185	6132	3423	2220	1734
37	1368	819	981	2060	3436	6751	8318	8185	6132	3423	2220	1734	1368	819	981
38	2060	3436	6751	8318	7158	3423	2220	1734	1368	2031	2058	3647	5346	9629	10786
39	11088	8514	5070	3643	3187	2800	2031	2058	3647	5346	9629	10786	11088	8514	5070

TABLE 20—Concluded.

Sums of Normal Values of All Stations—Concluded.

Cycles.	Phase numbers.														
	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(1)	(2)	(3)	(4)
40	3643	3187	2800	2031	2058	3647	5346	9629	10786	11088	8514	5070	3643	3187	2800
41	2044	3647	5346	(9629)	10786	11088	8514	5070	3643	3187	2800	2031	2058	3647	5346
42	9629	10786	11088	8514	5070	3643	3187	2800	819	819	2058	3647	5346	9629	10786
43	11088	8514	5070	3643	3187	2800	......	......	......	......	......	......	......	......	......
Sum actual, 1-23	63176	65140	79627	63116	77135	78480	74031	61667	87892	79000	73025	63161	60231	56724	68892
Sum normal, 1-23	69085	63981	65648	64351	64753	68482	74903	80899	85216	79167	73926	67321	61019	59974	65492
Quotient	90	101	120	97	118	114	98	75	102	99	99	91	98	93	104
Sum actual, 24-43	95471	103310	85492	81414	90571	87814	73320	75003	69389	77013	88686	66849	72879	78740	73227
Sum normal, 24-43	94966	91730	88076	87896	84420	85178	77761	77361	75677	77760	79143	79243	77242	79132	85125
Quotient	104	116	100	96	110	106	97	100	95	102	115	86	97	102	89
Sum actual, 1-43	158647	168450	165119	144630	167706	166294	147351	136670	157281	156013	161711	130010	133110	135464	142119
Sum normal, 1-43	164051	155711	153724	152247	149173	153660	152664	158260	160893	156927	153069	146564	138261	139106	150617
Quotient	98	107	106	96	113	109	98	87	99	100	107	90	97	98	95

Quotients are adjusted to make their mean 100.

TABLE 21.—South Australia. Table made from data of 50 stations in South Australia— given in "Meteorological Observations of the Adelaide Observatory, 1907." Table made from January, 1861, to December, 1907, inclusive.

MEAN ACTUAL RAINFALL IN HUNDREDTHS OF AN INCH.

Cycles.	Phase numbers.														
	(10)	(11)	(12)	(13)	(14)	(15)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	70	73	183	463	330	417	197	199	63	405	33	51	44	167	440
2	347	327	200	122	68	30	92	48	138	60	530	340	402	237	400
3	101	110	100	44	6	155	227	282	260	399	142	199	25	44	2
4	27	86	86	348	174	407	407	188	210	54	26	61	64	54	68
5	80	426	214	357	357	283	220	289	120	11	28	136	60	(60)	210
6	205	228	228	447	147	460	460	314	50	44	44	146	146	7	109
7	191	191	112	456	456	316	218	218	264	128	88	88	35	67	107
8	107	141	90	222	256	256	119	161	138	162	162	177	46	296	2
9	7	190	190	202	420	254	(493)	290	396	396	87	137	113	148	83
10	72	72	290	329	311	222	184	130	315	161	207	42	100	192	333
11	503	229	130	192	252	68	107	150	97	287	272	196	207	247	191
12	99	43	151	15	151	215	226	257	338	214	46	52	50	138	140
13	374	318	361	117	199	222	23	67	206	178	252	148	159	74	106
14	406	298	146	130	238	48	16	80	220	109	346	168	136	(64)	7
15	22	116	374	160	266	228	143	178	41	73	248	244	228	191	290
16	254	129	42	201	22	34	114	240	450	182	149	126	65	49	27
17	3	35	175	227	185	295	284	91	183	121	42	21	89	132	521
18	342	306	287	211	144	139	(82)	180	150	13	157	142	399	400	88
19	189	302	302	142	53	134	59	139	69	133	133	171	330	190	232
20	176	116	116	23	127	93	93	38	11	128	109	109	69	288	434
21	174	174	215	103	73	52	52	51	44	160	236	236	496	298	195
22	255	255	218	230	102	56	56	17	48	42	222	222	311	370	178
23	144	144	35	44	47	199	54	54	58	687	331	466	141	(393)	236
24	270	160	32	198	102	67	127	176	430	450	394	200	248	234	38
25	36	68	140	64	178	275	186	150	240	101	138	96	39	64	142
26	172	226	238	304	254	349	90	141	26	2	38	275	571	369	220
27	272	346	151	146	52	52	(8)	174	198	206	367	318	180	340	20
28	269	53	140	349	82	281	389	277	108	40	92	178	50	92	213
29	267	207	164	98	39	31	138	49	81	66	216	193	241	345	210
30	74	46	4	54	44	252	223	426	469	234	110	159	97	70	115
31	89	137	226	342	84	124	199	98	150	67	14	207	281	206	331
32	146	412	184	84	56	61	46	50	198	121	401	246	155	(212)	221
33	64	39	73	132	26	88	249	151	157	188	50	283	78	131	146
34	276	162	329	260	248	184	264	120	209	95	49	140	216	300	280
35	198	78	204	66	11	118	34	21	307	395	343	382	182	205	218
36	25	7	7	28	232	70	(177)	432	371	300	320	166	247	87	9
37	22	44	298	175	238	300	263	118	145	182	85	....	....	....	....

MEAN NORMAL VALUES OF ALL STATIONS.

1	84	60	139	257	304	284	257	192	106	90	84	60	98	180	257
2	294	257	206	179	106	90	84	60	98	180	257	294	257	206	179
3	106	90	84	60	98	180	257	304	284	257	206	179	106	90	84
4	60	98	180	257	304	284	284	257	206	179	106	90	84	60	98
5	180	257	304	284	284	257	206	179	106	90	84	60	98	(98)	180
6	257	304	304	284	257	206	206	179	106	90	90	84	84	60	98
7	180	180	257	304	304	284	257	257	206	179	106	106	90	84	60
8	60	98	180	257	304	304	284	257	206	179	179	106	90	84	60
9	98	180	180	257	304	284	(257)	206	179	179	106	90	84	60	98
10	180	180	257	304	284	257	206	179	106	90	84	60	98	218	304
11	284	257	206	179	106	90	84	60	98	180	257	304	284	257	192
12	106	90	84	60	98	218	304	284	257	192	106	90	84	60	98
13	218	294	257	206	179	98	84	79	180	280	284	232	179	98	72
14	98	218	294	257	192	106	87	60	139	257	294	232	179	(98)	84
15	60	139	257	304	270	206	179	98	84	60	98	218	304	284	257
16	206	142	90	84	60	98	180	257	304	270	206	179	106	90	84
17	60	98	180	257	304	284	257	206	179	106	90	84	60	139	257
18	304	284	257	206	179	106	(90)	84	84	60	98	180	257	304	284
19	257	206	206	179	106	90	84	60	98	180	180	257	304	284	257
20	206	179	179	106	90	84	84	60	98	180	257	257	304	284	257
21	206	206	179	106	90	84	84	60	98	180	257	257	304	284	257
22	206	206	179	106	90	84	84	60	98	180	257	257	304	284	257
23	206	206	179	106	90	84	60	60	98	180	257	304	284	(257)	206
24	179	106	90	84	60	98	180	257	304	284	257	206	179	106	90
25	72	98	180	257	304	284	257	206	179	106	90	84	60	98	180
26	257	304	284	257	206	179	106	90	84	60	98	180	257	304	284
27	257	206	179	106	90	84	(60)	98	180	280	284	257	206	179	106
28	90	72	98	180	257	304	284	257	192	106	90	84	60	98	218
29	304	284	257	206	179	106	90	84	60	139	257	304	284	257	206
30	179	106	90	72	98	180	257	304	284	257	206	179	106	87	60
31	98	180	257	304	284	257	206	179	106	87	60	98	180	257	304
32	284	257	206	179	106	90	72	98	180	257	304	284	257	(206)	179
33	98	84	60	98	180	257	294	257	206	179	106	90	84	60	98
34	180	257	304	284	257	192	106	90	84	60	98	180	257	304	284
35	257	206	179	106	90	84	60	98	180	257	304	284	257	206	179
36	106	90	84	60	98	180	(257)	304	284	257	206	179	106	90	84
37	60	98	180	257	304	284	257	206	179	106	90	......	......	......	......
Sum actual, 1–18	3210	3348	3359	4213	3984	4049	3612	3332	3639	2097	2859	2474	2368	2567	3124
Sum normal, 1–18	2835	3226	3716	3996	3937	3636	3563	3198	2928	2918	2735	2648	2542	2470	2746
Quotient	109	100	86	102	97	107	97	100	119	99	100	89	89	100	109
Sum actual, 19–37	3118	2976	3078	2842	2048	2786	2707	2687	3316	3497	3648	3997	3932	4194	3538
Sum normal, 19–37	3502	3351	3370	3053	2979	3005	2882	2828	2992	3335	3658	3741	3793	3645	3506
Quotient	92	92	94	96	72	96	97	98	114	106	103	110	107	118	104
Actual total	6328	6324	6437	7085	6032	6835	6319	6019	6955	6494	6507	6471	6300	6761	6662
Normal total	6337	6576	7086	7049	6916	6641	6445	6026	5920	6253	6393	6389	6335	6115	6252
Quotient	99	95	90	99	86	102	97	99	116	103	101	100	99	110	106

Quotients are adjusted to make their means 100.

TABLE 22.—Jamaica. Observed per cent of normal rainfall. Prepared from table given by W. H. Pickering in "The Relation of Prolonged Tropical Droughts to Sun Spots," in the *Monthly Weather Review* for October, 1920.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1870	102	158	96	61	190	55	92	84	109	165	163	136
71	59	58	71	76	71	30	80	51	77	88	77	83
72	77	103	95	45	57	37	61	77	62	60	41	93
73	207	71	170	25	55	40	54	111	145	85	46	115
74	88	80	19	96	116	61	54	141	93	115	136	49
75	66	24	80	67	94	57	82	75	103	55	30	133
76	154	29	51	102	88	83	172	74	70	112	117	113
77	152	43	167	64	165	99	99	26	68	44	100	155
78	162	102	87	15	53	101	123	158	101	111	96	190
79	72	193	202	159	100	162	94	180	100	158	69	35
1880	111	29	34	61	127	47	81	140	54	39	29	157
81	31	146	40	101	112	85	100	91	104	120	99	66
82	74	70	110	73	90	36	79	70	119	89	70	78
83	140	127	127	73	58	76	66	79	106	80	67	58
84	121	125	80	40	74	105	53	74	84	94	65	48
85	44	54	46	103	54	51	64	91	84	63	62	307
86	136	166	83	139	58	355	131	198	80	79	48	111
87	154	84	74	98	102	129	151	101	78	84	106	15
88	35	69	53	79	232	103	56	80	110	43	60	203
89	122	33	130	147	86	191	128	75	111	104	57	59
1890	133	106	182	74	61	63	105	101	89	70	85	106
91	88	82	26	186	135	151	117	109	86	152	100	101
92	102	50	70	62	94	112	93	112	121	120	130	71
93	88	118	60	119	119	110	192	99	108	102	132	212
94	52	92	103	128	183	59	125	61	95	123	66	129
95	34	182	68	134	108	56	105	119	93	118	101	75
96	134	177	133	80	109	74	106	69	112	75	60	111
97	23	28	57	155	119	75	125	96	137	190	75	72
98	45	143	139	89	183	116	137	101	96	102	62	54
99	101	103	117	105	46	71	82	62	101	235	196	145
1900	133	151	76	124	85	94	151	79	110	64	68	116
01	100	43	103	56	67	214	159	95	144	96	131	106
02	145	111	132	118	98	157	72	79	80	71	73	163
03	49	51	99	107	116	91	91	186	73	72	75	95
04	87	169	213	130	83	232	90	80	88	163	102	78
05	200	108	232	113	90	154	58	90	112	122	88	141
06	86	187	172	176	145	175	88	102	145	83	99	41
07	66	136	10	27	56	91	90	68	73	104	56	90
08	111	184	106	76	54	178	88	102	82	109	86	138
09	111	59	89	80	75	98	116	119	216	117	276	34
1910	135	80	138	78	57	88	117	110	118	145	100	238
11	111	52	63	88	113	57	68	64	78	82	64	167
12	112	85	152	48	50	37	90	93	85	81	350	69
13	93	41	118	174	88	58	94	80	94	69	113	68
14	68	75	127	104	73	80	62	62	51	63	127	98
15	162	105	100	192	70	182	122	206	225	106	144	119
16	91	191	83	178	170	97	159	202	104	160	233	32
17	81	119	78	155	80	127	110	110	209	68	123	97
18	23	123	182	139	137	77	76	106	74	89	66	91
19	160	91	60	163	159	53	91	52	84	76	67	127
1920	72	87	106	6	90	......	......	......	......	......	......	......
Normals in inches,	3.92	2.75	3.21	4.56	9.13	6.53	4.75	6.82	7.38	10.16	7.64	5.07

TABLE 23.—Jamaica. Observed per cent of normal is tabulated, beginning January, 1870.

Cycles.	Phase numbers.														
	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	102	158	96	61	61	190	55	92	(84)	109	165	165	163	136	59
2	58	71	76	76	71	30	80	51	77	88	77	83	77	103	95
3	51	37	61	77	62	60	41	93	207	71	170	25	55	40	54
4	111	115	46	115	88	80	19	106	61	54	141	104	136	49	66
5	24	74	94	70	75	103	55	82	154	40	102	86	176	72	112
6	115	98	167	114	99	62	56	100	158	102	51	53	112	130	111
7	(143)	72	193	180	100	162	137	100	158	52	100	29	34	94	47
8	81	140	54	34	157	31	146	40	101	112	85	96	104	120	99
9	66	74	70	110	73	90	36	79	70	119	89	70	78	140	127
10	100	58	76	66	79	106	80	67	(58)	121	121	125	80	40	74
11	105	53	74	84	84	94	65	48	44	54	46	103	103	54	51
12	64	91	84	63	63	62	307	136	136	166	83	139	58	58	355
13	131	198	80	80	79	48	111	154	154	84	74	98	102	102	120
14	151	101	78	28	84	106	15	35	35	69	53	79	232	232	103
15	56	80	110	110	43	60	203	122	33	33	130	147	86	191	128
16	(75)	111	104	57	59	133	106	182	74	61	63	105	101	89	70
17	85	106	85	26	186	135	151	117	109	86	152	100	101	102	50
18	70	62	94	112	93	112	121	120	130	71	88	118	60	119	119
19	110	192	99	108	102	132	212	52	(92)	103	128	121	125	61	95
20	123	66	129	108	68	134	108	56	105	119	106	101	75	134	177
21	133	94	74	106	69	112	75	60	111	23	28	106	119	75	125
22	96	137	190	75	72	94	39	89	183	116	137	101	96	102	62
23	78	103	117	105	46	71	82	62	101	235	196	139	151	76	124
24	85	94	151	79	110	64	68	116	72	103	56	67	214	159	95
25	(144)	96	118	145	111	132	118	98	114	79	80	71	73	163	49
26	51	99	107	116	91	91	180	72	75	95	87	169	213	130	83
27	232	90	80	88	163	102	78	200	108	232	113	90	154	58	90
28	112	122	88	141	86	187	172	176	(145)	175	88	102	145	83	99
29	41	66	136	10	27	56	91	90	68	73	104	56	90	111	184
30	106	76	54	178	88	102	82	109	86	138	111	59	89	80	75
31	98	118	216	117	276	34	135	80	138	78	57	88	117	110	118
32	145	100	238	111	52	63	88	113	57	68	64	78	82	64	167
33	112	85	152	48	50	37	90	93	85	81	350	69	67	118	174
34	(88)	58	94	80	94	69	117	68	68	75	127	104	73	80	62
35	62	51	63	127	98	162	162	105	100	192	70	182	122	206	225
36	106	144	119	91	191	83	178	170	97	159	202	104	160	233	32
Mean, 1–18	93	99	96	88	91	97	104	101	107	87	104	101	108	109	108
Smoothed	100	96	94	92	92	97	101	104	98	99	97	104	106	108	103
Mean, 19–36	99	91	114	94	92	88	107	93	92	110	108	92	111	104	104
Smoothed	98	101	100	100	91	96	96	97	98	103	103	103	104	106	106
Mean, 1–36	96	95	105	91	92	92	106	97	100	98	106	96	110	106	106
Smoothed	99	99	97	96	92	97	98	101	98	101	100	104	104	107	103

TABLE 24.—Tananarive, Madagascar. Rainfall in mm.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1890.......	18880	15270	12380	13100	0	1302	240	58	58	15403	23901	29955	129747
91.......	11700	23843	35133	4528	469	224	557	534	1982	28173	3635	18389	129167
92.......	36374	33996	3007	5064	574	665	442	1175	424	5611	7517	28113	122962
93.......	25853	24182	18607	10001	4131	1412	1460	887	237	8219	1616	50343	146948
94.......	47306	21811	22957	1844	3496	597	849	3307	6244	1902	10327	40132	160772
95.......	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
96.......	16820	41155	6490	12505	630	1040	100	933	393	7320	15605	15455	118446
97.......	46065	15095	27500	4480	1108	100	170	55	690	7770	7960	44647	155640
98.......	41699	11800	13820	2785	472	1009	535	1650	380	3263	7385	36816	121614
99.......	23470	30281	37733	12616	2783	232	802	1056	91	14746	14009	10116	147936
1900.......	41449	33277	14280	2060	310	82	439	1112	4128	2709	3249	15104	118199
01.......	41200	23627	22918	894	294	1213	162	799	386	991	4068	37217	133769
02.......	12200	30358	21516	9423	1431	420	364	113	2096	5506	11549	18439	113415
03.......	44565	23840	25840	1852	700	631	756	836	1190	7226	19729	24218	151383
04.......	31777	24842	17356	697	905	2548	943	1717	1271	2680	3262	36547	124545
05.......	40502	53237	11665	8039	1140	215	756	1901	2381	6829	31347	35541	193553
06.......	4945	66995	24004	13270	320	225	670	70	3220	13825	10090	24760	166494
07.......	19105	16710	34655	3765	0	1685	1790	105	5155	7055	16425	54770	161220
08.......	20940	47040	18115	3740	3245	114	859	0	720	5310	8172	45237	153492
09.......	13099	20183	1675	6120	600	480	25	3135	4565	4663	6102	8565	69212
1910.......	21162	22798	26092	180	11	231	57	70	2[illegible]	1950	14984	31284	120576
11.......	32681	27787	25301	3828	1322	1426	703	667	481	1617	16374	13227	125474
12.......	23301	15071	12141	7299	189	485	934	110	2325	2443	943	25459	90700
13.......	49075	44162	6064	1928	3770	273	463	419	4953	5238	16571	24286	157202
14.......	61814	46426	7412	5354	833	130	1579	328	80	5648	11917	7549	149070
15.......	27781	27075	22142	8352	3200	309	113	212	214	2464	15922	15098	122882
16.......	29355	24652	21576	5774	3132	593	613	571	661	5185	39063	44902	176077
17.......	20533	23850	8596	6541	263	154	1077	2391	864	1662	17139	52281	135351
18.......	19572	15787	11486	2159	2007	928	600	315	359	1963	13011	26605	94792
19.......	27480	28110	24442	1018	1261	2057	402	313	2538	3590	11537	33782	136530
1920.......	38211	51067	8087	4344	692	720	1069	312	247	605	14821	10635	130810
21.......	58273	24303	11229	513	4077	179	462	508	104	2624	20389	37662	160323
Mean.	305.28	293.10	178.80	53.45	14.02	6.99	6.45	8.27	15.34	61.03	128.58	289.40	1360.74

TABLE 25.—Tananarive, Madagascar, beginning January, 1890.

Cycles.	Phase numbers.														
	(13)	(14)	(15)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	18080	15270	12380	13100	0	1302	240	58	58	15403	23901	20828	23843	35133	4528
2	469	224	557	534	1982	28173	3635	18389	6374	33996	3007	5064	574	665	442
3	1175	424	5611	7517	28113	25853	24182	18607	10004	4131	1412	1460	887	237	8219
4	1616	50343	47306	(21811)	22957	2670	597	849	3307	6244	1902	10327	40132		
5									16820	41155	9498	630	1040	100	933
6	393	7320	15605	15455	46065	21298	4480	1108	100	170	55	690	7770	7960	43173
7	11800	13820	2785	472	1009	535	1650	380	3263	22100	23470	30281	37733	12616	2783
8	233	802	1056	91	14746	12062	41449	33277	14280	2060	310	82	439	1112	4128
9	2709	3249	28151	23627	22918	894	294	1213	162	799	(386)	2580	37217	12200	30358
10	21516	9423	926	364	113	2096	5506	11549	18439	44565	23840	25840	1852	700	631
11	756	1013	7226	19729	24218	31777	24842	17356	697	905	2548	943	1717	1271	2680
12	3262	36547	40502	53237	11665	8039	1140	215	756	1901	2381	6829	31347	35541	4945
13	66995	24004	13270	(320)	225	670	70	3220	18825	10090	24760	19105	16710	34655	3765
14	0	1685	1790	105	5155	7055	16425	54770	20940	47040	18115	3740	3245	114	859
15	0	720	5310	8172	45237	13099	20183	1675	6120	600	252	3135	4565	4663	6102
16	8565	21162	22798	26092	1805	115	234	57	70	25	1950	14984	31284	32681	27787
17	25361	3828	1322	1426	703	667	481	1617	16374	13227	23301	15071	12141	7299	189
18	485	934	110	2325	2443	943	37367	44162	6064	1928	(3770)	273	463	419	4953
19	5238	16571	24286	61814	46426	7412	5354	833	130	1579	328	80	5648	11917	7549
20	27781	27781	27075	22142	8352	3200	309	113	212	214	26164	15922	15098	29355	24652
21	21576	5774	3132	593	613	571	661	5185	39063	44902	20533	23850	8596	8541	263

NORMAL VALUES IN HUNDREDTHS OF MM.

Cycles.	(13)	(14)	(15)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	30528	29310	17880	5345	1402	699	645	827	1534	6103	12858	29734	29310	17880	5345
2	1402	699	645	827	1534	6103	12858	28940	30528	29310	17880	5345	1402	699	645
3	827	1534	6103	12858	28940	30528	29310	17880	5345	1402	699	645	827	1534	6103
4	12858	28940	30528	(29310)	17880	3374	694	645	827	1534	6103	12858	28940		
5									30528	29310	11612	1402	699	645	827
6	1534	6103	12858	28940	30528	23645	5345	1402	699	645	827	1534	6103	12858	29734
7	29310	17880	5345	1402	699	645	827	1534	6103	20899	30528	29310	17880	5345	1402
8	699	645	827	1534	6103	20899	30528	29310	17880	5345	1402	699	645	827	1534
9	6103	12858	29734	29310	17880	5345	1402	699	645	827	(1534)	6924	28940	30528	29310
10	17880	5345	1050	645	827	1534	6103	12858	28940	30528	29310	17880	5345	1402	699
11	645	1180	6103	12858	28940	30528	29310	17880	5345	1402	699	645	827	1534	6103
12	12558	28940	30528	29310	17880	5345	1402	699	645	827	1534	6103	12858	28940	30528
13	29310	17880	5345	(1402)	699	645	827	1534	6103	12858	28940	30528	29310	17880	5345
14	1402	699	645	827	1534	6103	12858	28940	30528	29310	17880	5345	1402	699	645
15	827	1534	6103	12858	28940	30528	29310	17880	5345	1402	672	827	1594	6103	12858
16	28940	30528	29310	17880	5345	1402	699	645	827	1534	6103	12858	28940	30528	29310

17	17880	5345	1402	699	645	827	1534	6103	12858	28940	50328	29310	17880	5345	1402
18	699	645	827	1534	6103	12858	29734	29310	17880	5345	(1402)	699	645	827	1534
19	6103	12858	28940	30528	29310	17880	5345	1402	699	645	827	1534	6103	12858	28940
20	30528	30528	29310	17880	5345	1402	699	645	827	1534	6103	12858	28940	30528	29310
21	17880	5345	1402	699	645	827	1534	6103	12858	28940	30528	29310	17880	5345	1402
Sum actual, 1–11	88747	101888	121603	102700	162123	126660	106875	102786	103501	171528	90630	98675	153204	71994	70575
Sum normal, 1–11	101786	104494	111073	123029	134733	123300	117027	111975	128374	127305	113452	107076	120918	67907	81702
Quotient	87	99	111	85	121	104	93	93	82	136	81	93	128	107	87
Smoothed	91	99	98	106	103	106	97	89	104	100	103	101	109	107	94
Sum actual, 12–21	129283	139006	139595	176226	122622	41771	82754	111847	109154	121506	97553	102989	129097	165185	108364
Sum normal, 12–21	146427	134302	133800	113588	96446	77817	83942	93261	88571	111335	144287	129272	145492	144398	141274
Quotient	88	103	103	153	126	53	97	119	122	108	67	79	88	114	76
Smoothed	89	98	120	127	111	92	90	113	116	99	85	78	94	93	93
Total sum, actual	218030	240894	261198	278926	284745	168431	189629	214633	212655	293034	188183	201664	282301	237179	178939
Total sum, normal	248213	238796	244873	236617	231179	201117	200969	205236	216944	238640	257739	236348	266410	212305	222976
Quotient	88	101	107	118	123	84	94	105	98	123	73	85	106	112	80
Smoothed	90	99	109	116	108	100	94	99	109	98	94	88	101	99	93

SUPPLEMENTARY TABLES.

Data collected during the investigation, but not used, published to make available for other problems. All this information was obtained in manuscript form with the exception of that from India, which was collected from the large annual volumes of "India Rainfall," 1901-1918.

SUPPLEMENTARY TABLE No. 1.—Showing total monthly and annual rainfall recorded at Alexandria and the normal for 1891-1920 in mm.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1891.........	9	9	7	0	0	0	0	0	6	4	2	76	113
92.........	51	11	13	2	2	0	0	0	0	11	85	23	198
93.........	89	27	53	2	3	drops	0	0	drops	6	11	107	298
94.........	52	17	40	drops	6	0	0	0	0	0	102	30	247
95.........	1	0	4	16	0	0	0	0	0	0	46	100	167
96.........	69	45	19	2	0	0	0	0	1	1	41	27	205
97.........	126	12	14	0	0	0	0	0	0	14	1	107	274
98.........	57	4	1	0	0	0	0	0	0	0	60	144	266
99.........	73	23	2	0	0	0	0	0	0	58	25	64	245
1900.........	14	33	16	0	2	0	0	0	0	0	10	125	200
01.........	83	0	4	0	0	0	0	0	14	0	30	57	188
02.........	104	8	4	6	1	0	0	0	drops	5	36	92	256
03.........	90	34	14	1	drops	drops	0	drops	0	drops	10	24	173
04.........	63	12	drops	2	drops	0	0	1	drops	3	65	50	196
05.........	46	16	14	drops	0	0	0	0	0	28	7	159	270
06.........	32	43	6	3	9	drops	0	drops	0	19	64	31	207
07.........	25	13	38	7	0	0	0	2	drops	0	50	25	160
08.........	80	47	14	3	0	1	0	0	drops	0	39	76	260
09.........	43	41	0	51	drops	0	0	0	0	21	22	31	209
1910.........	86	8	19	2	3	0	0	drops	4	0	30	28	180
11.........	28	42	12	2	drops	0	0	0	drops	8	17	79	188
12.........	21	24	9	0	2	0	0	0	0	drops	10	27	93
13.........	12	36	21	drops	drops	0	drops	0	drops	14	79	98	260
14.........	28	31	7	8	0	drops	0	drops	drops	drops	29	103	206
15.........	19	19	19	1	drops	0	0	0	drops	0	14	10	82
16.........	109	14	8	2	drops	0	0	drops	drops	0	21	45	199
17.........	66	39	13	1	drops	0	0	0	drops	8	8	65	200
18.........	39	31	6	drops	0	0	0	0	0	drops	53	50	179
19.........	36	4	1	drops	drops	0	0	0	0	3	54	126	224
1920.........	35	42	11	drops	drops	drops	drops	0	0	0	6	39	133
Normal.......	53	24	13	4	1	0	0	0	1	7	34	67	204

NOTE.—"Drops" indicate that rain was too small to measure.

SUPPLEMENTARY TABLE No. 2.—Showing total monthly and annual rainfall recorded at Khartoum (Gordon College) and the normal for 1899-1920 in mm.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1899	0	0	0	0	0	1	13	12	......	6	0	0	[32]
1900	0	0	0	drops	0	23	80	47	23	8	drops	0	181
01	0	0	0	0	6	16	24	16	d ops	8	0	0	64
02	0	0	0	0	0	0	116	5	2	drops	0	0	123
03	0	0	0	0	24	0	18	12	14	drops	0	0	68
04	0	0	drops	0	drops	0	34	76	20	drops	0	0	130
05	0	0	drops	0	6	16	8	75	4	50	0	0	159
06	0	0	0	0	0	4	90	96	24	13	0	0	227
07	0	0	0	0	0	drops	14	163	12	0	0	0	189
08	0	0	drops	0	0	1	64	44	31	12	0	0	152
09	0	0	drops	drops	1	drops	71	26	11	3	0	0	112
1910	0	0	0	0	0	35	38	15	22	drops	0	0	110
11	0	0	0	0	7	drops	55	12	2	1	0	0	77
12	drops	0	drops	0	drop	drops	drops	98	18	0	0	0	116
13	0	0	0	drops	drops	0	7	70	22	2	0	0	101
14	0	0	drops	0	drops	1	30	54	11	5	0	0	101
15	0	0	0	0	9	8	19	63	77	0	0	0	176
16	0	0	0	drops	14	22	33	57	20	0	0	0	146
17	0	0	0	0	drops	34	0	24	18	0	0	0	76
18	0	0	0	0	drops	14	30	50	drops	drops	0	0	94
19	drops	0	0	drops	7	drops	38	23	7	drops	0	0	75
1920	0	0	drops	drops	4	0	103	185	49	drops	0	0	341
Normal	0	0	0	0	3	8	40	56	18	5	0	0	130

NOTE.—"Drops" indicate that rain was too small to measure. Brackets [ ] are used to denote that the observations are incomplete.

SUPPLEMENTARY TABLE No. 3.—Showing total monthly and annual rainfall recorded at Adis Ababa and the normal for 1898-1920 in mm.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1898	8	15	105	73	41	121	352	290	151	18	10	0	1184
99	2	11	......	......	......	......	......	......	......	......	......	......	......
1900	......	......	......	......	......	[108]	283	328	194	0	13	5	[931]
01	16	54	124	100	36	222	277	250	128	21	0	13	1241
02	1	76	49	89	42	172	236	291	184	0	11	1	1152
03	29	25	83	88	268	191	269	267	224	20	0	8	1472
04	0	37	136	57	58	124	350	196	176	40	0	0	1170
05	5	7	48	88	41	94	294	352	113	1	45	0	1000
06	9	156	189	103	60	132	380	358	119	16	28	0	1550
07	0	20	11	140	36	61	176	284	108	14	83	drops	933
08	38	7	10	70	5	91	284	365	220	28	8	0	1126
09	48	0	18	133	130	208	210	364	174	0	10	drops	1295
1910	0	1	25	48	66	147	268	334	226	20	0	14	1149
11	7	4	67	38	31	140	306	230	155	46	64	0	1088
12	53	139	51	43	20	182	286	319	111	0	0	0	1204
13	0	65	66	102	108	104	192	311	134	0	0	0	1082
14	10	94	77	125	18	68	288	323	308	100	0	32	1443
15	2	23	105	126	133	121	345	378	570	59	27	11	1900
16	64	57	91	74	148	294	248	418	321	5	drops	7	1727
17	28	39	10	115	194	279	281	287	270	53	0	34	1590
18	0	84	70	104	74	106	208	264	51	drops	drops	0	961
19	11	47	66	32	43	90	316	253	133	0	0	0	991
1920	2	10	61	74	26	151	280	300	165	5	3	0	1077
Normal	15	48	70	87	75	146	279	307	192	20	14	6	1259

NOTE.—"Drops" indicate that rain was too small to measure. Brackets [ ] are used to denote that the observations are incomplete.

SUPPLEMENTARY TABLE No. 4.—Copenhagen. Rainfall in mm.

From Meteorological Institute, Copenhagen. Sent by Prof. Carl Ryder.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1820	.....	.....	.....	.....	.....	.....	.....	.....	55	50	60	23	.....
21	64	5	22	25	74	4	21	31	63	42	81	67	499
22	44	17	63	15	3	2	138	116	41	28	33	12	512
23	39	85	33	44	36	76	66	45	50	32	45	69	620
24	26	26	43	27	40	38	34	76	53	56	150	119	688
25	40	45	23	100	41	70	27	99	83	51	131	40	750
26	10	71	41	44	7	22	41	25	34	87	54	51	487
27	97	5	93	45	55	39	56	48	40	53	40	70	641
28	28	32	64	54	24	54	145	88	70	38	38	58	693
29	22	90	21	27	34	43	126	81	61	107	83	7	702
1830	35	70	38	103	60	107	56	100	72	28	9	27	705
31	45	61	49	19	40	130	18	52	27	34	61	21	557
32	18	1	36	2	40	47	71	73	50	28	35	34	435
33	19	58	67	29	19	61	30	87	43	73	50	204	740
34	79	29	40	14	39	29	3	43	68	49	78	32	503
35	23	56	24	55	82	15	2	40	56	45	43	29	470
36	103	53	67	31	15	27	91	30	70	32	62	70	651
37	15	50	33	36	38	28	20	57	54	38	51	31	451
38	38	12	59	93	20	30	44	133	33	53	25	16	533
39	48	22	13	43	43	56	55	36	73	10	43	27	469
1840	74	29	5	5	60	31	63	66	59	58	54	13	517
41	71	11	25	29	30	99	96	48	76	171	62	51	769
42	17	0	66	0	24	94	36	3	58	26	48	27	399
43	125	61	18	50	14	104	69	47	26	100	54	17	685
44	121	61	44	15	21	34	54	123	27	90	57	17	664
45	35	21	34	17	122	16	75	105	63	104	49	83	724
46	58	55	83	37	22	28	74	22	12	34	26	36	487
47	32	37	39	43	62	51	39	26	66	34	24	16	469
48	9	55	38	63	10	97	38	110	36	104	56	19	635
49	50	44	34	19	9	104	121	45	48	95	27	35	631
1850	17	53	12	54	38	37	117	61	57	54	79	21	600
51	32	30	63	86	48	68	46	28	27	45	85	14	572
52	55	62	11	22	52	80	5	68	69	74	101	81	680
53	56	42	22	51	36	37	75	64	46	34	17	7	487
54	45	30	20	21	47	46	27	134	67	39	36	70	582
55	30	8	35	41	60	55	74	76	30	80	6	35	530
56	44	41	3	66	49	57	63	40	57	23	67	64	574
57	40	18	32	57	10	15	32	43	28	38	27	19	359
58	29	9	19	17	93	27	51	55	14	31	23	35	403
59	29	57	38	52	13	51	34	52	107	45	61	65	604
1860	34	36	33	51	40	93	23	132	51	55	24	25	597
61	20	48	62	13	28	76	106	51	73	6	84	29	596
62	34	24	24	20	28	86	80	34	89	79	31	68	597
63	42	35	49	47	25	60	65	64	75	27	23	78	590
64	23	23	47	15	28	119	43	152	86	41	61	6	644
65	28	12	13	7	16	29	55	57	31	56	48	4	356
66	44	93	32	72	91	44	53	77	65	26	77	55	729
67	68	68	16	74	48	55	125	18	76	65	54	34	701
68	27	53	58	52	7	3	8	60	64	61	25	100	518
69	25	30	14	10	74	32	23	63	42	59	37	32	441
1870	32	6	9	16	19	33	12	60	65	99	47	33	431
71	84	21	19	21	16	75	80	26	84	16	25	20	487
72	35	18	57	45	86	51	61	30	89	90	56	64	682
73	36	11	9	28	73	56	114	84	69	99	55	33	667
74	40	7	45	31	15	25	87	68	67	33	60	43	521
75	66	2	31	10	24	68	50	46	38	62	72	18	482
76	12	51	69	29	40	54	45	34	76	34	21	50	515
77	79	54	24	19	44	39	100	123	43	70	40	38	673
78	48	15	36	21	57	58	35	46	49	41	93	29	528
79	17	42	8	49	39	57	108	111	29	40	17	5	522
1880	8	41	14	31	13	41	92	8	59	123	105	53	588
81	6	20	26	3	47	20	93	66	72	61	52	35	501
82	24	16	45	40	18	81	46	88	46	53	67	29	553
83	22	10	5	17	22	37	87	55	54	67	84	46	506
84	78	49	49	19	30	27	75	44	35	102	36	55	599
85	3	36	22	17	49	78	15	83	92	99	18	20	552
86	40	7	16	28	37	42	50	29	46	73	24	59	451
87	5	10	23	41	69	24	44	43	52	49	45	54	459
88	29	26	71	19	44	54	96	48	22	43	45	56	553
89	15	31	26	34	43	25	60	107	88	72	15	14	530

TABLE 4—CONCLUDED.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1890.........	42	3	31	47	23	45	91	93	15	74	33	2	499
91.........	36	13	51	21	73	69	97	170	42	61	38	60	731
92.........	56	12	25	37	36	89	26	94	50	90	7	37	559
93.........	22	72	30	6	32	19	51	57	68	141	63	38	599
94.........	34	50	40	62	46	34	136	65	35	93	42	34	671
95.........	17	11	40	16	38	48	86	87	14	63	78	66	564
96.........	22	8	78	42	30	42	32	81	100	84	31	40	590
97.........	9	12	93	52	47	33	43	68	94	9	32	41	533
98.........	46	42	46	51	101	96	59	51	67	11	39	76	685
99.........	68	38	37	54	23	15	32	16	97	43	55	39	517
1900.........	54	45	27	29	27	34	93	69	63	132	36	71	680
01.........	29	13	49	56	44	150	27	52	36	23	74	62	615
02.........	48	11	56	18	86	36	51	69	39	43	5	52	514
03.........	47	48	18	74	10	60	54	90	61	133	61	20	676
04.........	37	44	38	53	66	42	23	36	12	51	78	50	530
05.........	32	40	47	64	14	47	56	170	64	78	30	7	649
06.........	62	41	34	21	30	52	43	85	44	32	80	26	550
07.........	32	25	25	35	45	90	65	63	10	20	40	86	536
08.........	23	50	34	52	80	56	50	72	61	9	34	20	541
09.........	33	19	31	39	32	64	46	40	45	46	62	87	544
1910.........	54	93	12	54	61	40	89	64	46	14	76	57	660
11.........	22	64	31	35	58	70	57	38	21	85	78	58	617
12.........	28	34	41	39	27	49	46	135	28	67	73	93	660
13.........	26	21	44	20	13	28	50	56	51	62	76	76	523
14.........	31	34	80	60	30	15	77	39	57	35	57	67	582
15.........	66	35	23	32	42	10	72	43	36	16	38	109	522
16.........	87	38	25	38	37	86	43	128	45	77	61	92	737
17.........	45	9	34	41	10	19	40	88	50	111	95	22	564
18.........	29	41	3	28	18	47	88	76	67	32	25	77	531
19.........	38	32	29	53	7	40	60	57	48	31	40	90	525
1920.........	60	28	19	102	100	38	81	95	34	2	10	54	623
21.........	77	15	20	22	34	48	36	101	35	53	51	......	......
Means........	40.6	34.2	35.8	37.4	39.7	51.1	60.0	67.7	54.3	58.4	51.1	46.2	576.5

SUPPLEMENTARY TABLE No. 5.—Rainfall of agricultural districts of the state of South Australia. All stations used.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1908.........	50	47	123	64	246	269	99	198	263	215	32	42	1648
09.........	47	34	51	168	247	266	258	379	108	145	100	27	1830
1910.........	43	18	276	18	330	231	328	154	268	158	119	73	2016
11.........	29	192	56	27	208	208	174	135	171	69	21	159	1449
12.........	03	68	122	46	41	268	206	172	210	105	163	79	1483
13.........	13	129	173	42	(90)	33	94	182	215	182	83	98	1334
14.........	31	28	98	132	106	61	105	26	49	51	147	98	932
1915.........	42	19	20	119	188	268	186	290	239	80	21	34	1506
16.........	50	12	25	75	115	414	343	277	202	176	195	88	1972
17.........	123	149	105	47	301	245	314	249	282	187	101	89	2192
18.........	34	22	53	90	200	186	160	240	40	157	19	38	1239
19.........	30	237	22	56	153	106	109	129	169	95	39	148	1293
1920.........	32	04	44	76	158	375	197	281	231	158	218	94	1868
Means........	.41	.74	.90	.74	1.83	2.25	1.98	2.09	1.88	1.37	.97	.82	......

CORRELATION OF OLD AND NEW METEOROLOGICAL DISTRICTS OF INDIA.

Old No.	Old Name.	New No.*	Old No.	Old Name.	New No.*
1	Tenasserim	2	31	N. W Frontier Province	14
2	Lower Burma, Deltaic	2	32	West Punjab	12
3	Central Burma, Deltaic	2	33	Malabar	30
4	Upper Burma, Deltaic	3	33*a*	Travancore	30
5	Arakan	3	34	Madras, South Central	31
6	East Bengal	5	35	Coorg	29
7	Assam Surma	4	36	Mysore	29
8	Assam Hills	4	37	Konkan	25
9	Assam Brahmaputra	4	38	Bombay, Deccan	26
10	Deltaic Bengal	5	39	Hyderabad, North	28
11	Central Bengal	5	40	Kkandesh	26
12	North Bengal	5	41	Berar	22
13	Bengal Hills	5	42	Central Province, West	23
14	Orissa	6	43	Central Province, Central	23
15	Chota Nagpur	7	44	Central Province, East	24
16	South Bihar	8	45	Gujarat	19
17	North Bihar	8	46	Kathiawar and Cutch	19
18	United Provinces, East	9	47	Sind	16
19	South Oudh	9	48	Baluchistan Hills	15
20	North Oudh	9	49	Central India, East	20
21	United Provinces. Central	10	49*a*	Central India. East	21
22	United Provinces, West	10	50	Rajputana, E. Central India W	18
23	United Provinces, East Sub	9	51	West Rajputana	17
24	United Provinces, West Sub	10	52	Madras, East Coast North	33
25	United Provinces, Hills	10	52*a*	Madras, East Coast North	33
26	Southeast Punjab	11	53	Hyderabad, South	28
27	South Punjab	11	54	Madras Central	32
28	Central Punjab	12	55	Madras, East Coast Central	33
29	Punjab, Submontane	11	56	Madras, East Coast South	31
30	Punjab Hills	13	57	Madras, South	31
31	North Punjab	14			

*New number, as used in these tables and "India Rainfall." Names of each district will be found at head of its part of table.

SUPPLEMENTARY TABLE No. 6.—The rainfall of the thirty-three districts of India, in inches, 1901-1918.

No. 1.—Bay Isles.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907	322	0	345	43	1329	970	1397	1457	546	1061	1885	1198
08	41	168	0	70	1504	2327	1525	2246	1260	625	475	5
09	5	211	137	395	1324	1794	1901	1027	1469	1453	852	733
1910	53	45	453	356	612	1267	1025	1007	2197	1064	677	361
11	14	17	0	348	859	1679	1125	713	2216	1023	193	513
12	1925	1	0	43	629	2206	1726	1167	1221	981	457	55
13	171	1	3	5	559	1724	1375	731	1489	1123	847	572
14	0	0	0	85	895	1576	2182	1619	1119	353	667	793
15	89	111	65	81	917	999	1077	917	1311	1266	826	1083
16	0	0	0	2	1919	1772	1249	1673	1629	1187	649	401
17	24	7	273	9	976	938	1208	1352	1373	665	671	792
18	125	9	17	33	1715	1549	592	1462	839	585	......	......

TABLE 6—Continued.

No. 2.—Lower Burma.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	0	196	22	46	859	2059	2400	3951	1438	1240	165	7
02		29	39	80	1809	1987	2938	2130	1925	419	47	67
03	0		6	41	931	2264	2691	2408	1884	998	196	28
04	0	16	50	349	1083	3055	3244	2612	3039	396	552	21
05	2	15	20	10	1234	2933	3148	2134	2049	710	73	66
06	22	0	3	38	1148	2063	2571	1494	2047	667	220	3
07	35	3	204	28	1785	2649	2541	3600	1677	1017	73	151
08	3	2	14	101	1013	2769	2795	3113	1399	840	705	1
09	4	42	44	100	1324	2512	3452	2364	1960	926	514	16
1910	12	35	338	299	1627	1719	1830	2701	2215	697	299	9
11	5	6	20	392	950	2765	2950	3258	1561	908	13	3
12	122	6	10	45	1439	2326	2866	2656	1437	749	322	5
13	8	14	47	2	952	2270	3271	2817	1657	654	778	6
14	2	9	6	153	1001	3237	4027	3186	1278	724	282	187
15	21	8	42	146	1771	2306	3066	2687	1400	1201	216	319
16	0	3	15	114	1114	3635	1768	2435	2135	795	500	47
17	10	11	100	92	771	2988	3110	2462	1953	1223	197	66
18	12	0	48	127	2700	2524	2766	3343	2349	620		

No. 3.—Upper Burma.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	6	80	4	50	718	2316	2504	2610	1724	978	248	20
02		4	4	170	685	2178	3750	1615	1606	434	20	8
03	4		36	16	608	2116	1850	2815	1594	933	334	2
04	0	10	9	358	706	3056	3358	2211	1392	338	514	26
05	9	30	256	76	1004	2267	3352	2656	1760	658	34	146
06	6	54	8	32	852	2674	2802	1524	1713	568	102	4
07	38	4	83	64	498	558	434	534	581	460	9	126
08	17	3	6	88	467	644	529	857	635	328	834	0
09	5	3	1	167	763	653	697	888	592	601	284	67
1910	6	15	114	290	716	682	624	659	857	710	176	0
11	14	3	41	347	579	877	555	646	680	564	23	1
12	12	9	19	74	553	751	648	914	598	652	127	10
13	9	19	39	31	413	770	722	813	649	655	206	21
14	1	15	17	92	656	1200	691	698	656	593	135	200
15	1	11	63	139	1037	890	661	661	641	533	125	100
16	5	8	4	126	442	811	719	926	963	624	307	63
17	2	57	8	126	399	787	450	1023	1008	723	226	4
18	3	2	35	110	1033	624	583	827	680	528		

No. 4.—Assam.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	68	52	115	1039	726	2125	1779	2005	1335	819	413	3
02	32	36	377	1475	149	2397	2184	2130	1652	363	35	8
03	47	100	426	574	847	2564	1855	2525	1398	683	294	3
04	41	251	235	2020	1467	1785	2292	1916	1138	475	268	17
05	51	82	760	842	1070	3308	2090	2839	1279	1251	25	100
06	36	254	339	1235	1304	1743	2416	2710	1295	643	185	4
07	236	128	364	1028	799	1928	2155	1221	1585	170	17	50
08	70	144	106	776	1217	1472	1880	1396	1459	401	30	0
09	87	33	16	803	1196	2154	1331	1742	915	499	111	39
1910	47	110	541	789	985	2147	2374	1530	993	933	49	22
11	304	81	358	917	1714	1858	2293	1600	1530	943	103	13
12	40	241	481	1194	943	1685	2065	1664	952	643	188	32
13	53	338	476	1321	1443	1724	1767	1403	1019	822	48	175
14	26	322	309	854	1087	1175	1520	1826	1215	279	39	51
15	34	204	293	792	2300	1852	2468	1815	997	411	40	16
16	77	118	437	921	1117	1337	1816	1614	1197	899	120	23
17	47	381	128	723	715	2100	1838	1388	1313	715	138	6
18	16	65	563	622	1100	2200	2649	2108	1386	283		

TABLE 6—Continued.

No. 5.—Bengal.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	91	94	48	260	646	1547	1646	1392	1169	285	252	10
02	4	4	242	642	913	1442	2060	1524	1914	275	24	10
03	44	82	162	97	512	1667	1076	1836	1226	656	54	0
04	18	97	76	433	1154	781	1882	1346	820	374	65	5
05	78	140	380	422	938	967	2137	2186	1540	546	2	51
06	88	320	180	68	657	1190	1866	2149	1000	538	67	0
07	6	83	322	348	612	1358	1549	927	979	124	4	58
08	80	58	32	160	662	1408	1546	882	938	152	36	0
09	22	21	3	558	596	1904	1052	2380	972	532	72	78
1910	60	44	112	241	687	1544	1908	1388	961	734	13	0
11	37	10	186	338	1052	1686	1410	1286	1138	608	45	0
12	6	64	306	624	784	1384	1688	1365	771	619	365	0
13	4	283	113	160	1017	2477	1473	1451	1147	618	80	73
14	1	212	101	534	1031	885	1655	1388	885	147	12	88
15	17	81	325	247	1115	1607	1427	1537	1023	527	100	0
16	5	44	18	587	388	1798	1478	1708	1441	1165	191	1
17	2	122	71	312	701	1572	1651	1192	1020	1357	52	0
18	3	1	160	411	1062	2045	1475	1970	963	108	.....	.....

No. 6.—Orissa.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	180	254	44	173	298	309	1258	1002	837	346	549	0
02	23	1	92	313	322	515	1952	1264	679	119	22	170
03	34	106	69	83	254	641	1410	1116	1124	1117	122	6
04	1	49	86	19	361	1192	1010	1216	917	434	2	16
05	123	61	300	195	429	375	1057	787	1087	292	2	3
06	113	389	132	12	241	804	1152	825	1041	501	40	25
07	1	95	224	456	208	941	689	2354	648	103	13	96
08	144	4	63	23	193	1139	1212	1974	799	191	0	0
09	24	64	16	520	247	1184	1570	962	980	173	2	228
1910	67	4	9	148	257	932	1318	1211	1042	940	0	0
11	0	38	135	128	234	1350	621	1110	988	356	24	1
12	4	229	109	198	150	480	1368	1384	812	319	354	0
13	7	249	65	28	427	1056	2010	1126	581	458	110	6
14	0	134	49	213	772	860	1569	1072	1418	66	0	27
15	54	95	173	98	289	624	934	1060	1066	645	843	0
16	0	19	2	77	180	1458	883	1193	718	975	261	0
17	1	385	123	83	457	1292	1226	1263	958	1517	67	0
18	19	1	85	126	514	1336	694	1102	722	20	.....	.....

No. 7.—Chota Nagpur.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	359	282	45	62	145	293	1018	1623	1050	129	39	0
02	19	40	51	95	231	308	1721	833	1185	54	31	14
03	87	66	38	129	229	533	874	1112	831	886	3	0
04	5	71	168	37	454	1263	1963	1502	405	106	6	1
05	171	217	200	147	230	158	1781	962	1360	83	0	11
06	188	533	141	5	107	644	1461	937	749	307	30	6
07	9	227	313	95	74	1289	742	1917	875	2	0	108
08	65	160	17	1	186	813	1316	1451	610	108	0	1
09	114	47	5	332	109	1067	1055	1415	1218	84	0	61
1910	85	29	15	136	177	954	977	1101	969	320	25	0
11	5	0	123	29	141	1482	602	1544	1028	336	163	0
12	11	97	82	95	135	466	1430	1396	450	92	227	0
13	11	527	187	4	286	1425	1289	1498	650	316	80	51
14	0	85	97	80	514	408	1129	1258	631	80	0	29
15	39	155	106	35	184	433	973	820	800	207	178	0
16	0	64	1	67	86	1006	841	1173	785	923	67	0
17	6	170	64	28	375	1155	1272	1645	900	1016	4	4
18	16	4	16	47	251	1253	500	1526	680	0	.....	

TABLE 6—Continued.

No. 8.—Bihar.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	220	79	46	5	243	264	864	1230	562	32	28	0
02	12	2	96	64	224	433	1375	842	1331	106	4	9
03	18	21	8	15	78	678	364	1240	664	567	0	0
04	34	8	12	14	446	697	1599	1416	313	394	37	10
05	58	112	132	88	303	178	1566	1928	1398	42	0	2
06	59	224	34	4	165	730	1388	1602	462	132	1	0
07	5	236	152	83	134	894	966	929	871	12	0	7
08	60	161	23	7	133	337	737	644	591	85	0	1
09	24	26	0	270	91	1666	1049	1361	699	132	0	19
1910	10	18	21	41	190	971	1273	1368	982	317	100	0
11	31	0	86	52	167	1313	719	1683	1240	532	71	0
12	19	19	98	101	250	559	1382	1203	379	42	289	0
13	0	148	78	5	407	1542	992	1414	1028	274	15	140
14	0	84	33	127	396	375	1163	1812	398	38	0	4
15	31	195	106	23	378	575	1194	1492	737	276	154	3
16	1	63	0	90	71	1112	1554	1284	1088	602	10	0
17	11	75	37	27	432	928	1338	878	1078	561	0	1
18	25	0	8	106	356	957	885	1990	937	29	......	......

No. 9.—United Provinces, East.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	245	125	36	4	61	186	862	1064	2434	19	0	6
02	16	6	10	10	94	133	1676	626	1011	54	3	0
03	30	1	4	2	55	202	628	1690	1065	1323	0	10
04	32	6	24	1	104	587	1350	1236	343	248	67	101
05	57	90	82	19	70	63	1294	1342	687	18	0	6
06	22	226	23	0	58	534	1366	1171	437	23	0	0
07	7	292	60	72	35	162	707	1164	73	0	0	0
08	75	1	22	6	18	206	1022	1254	295	38	0	2
09	33	23	0	259	20	930	1588	719	524	23	0	85
1910	16	1	1	5	92	605	774	1295	860	377	123	0
11	168	0	117	8	12	380	321	1149	1555	334	148	1
12	57	20	23	17	57	188	1279	1046	540	4	110	3
13	1	138	122	2	242	627	783	703	328	47	0	46
14	5	54	76	38	179	140	1642	1262	389	13	3	1
15	46	167	90	23	56	418	1091	1628	1439	383	4	7
16	0	72	0	24	26	1043	1129	1467	711	216	29	0
17	28	105	26	13	163	628	1324	918	1190	221	0	19
18	1	1	19	13	60	493	380	1006	355	0	......	......

No. 10.—United Provinces, West.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	278	162	67	4	81	102	783	1800	414	42	0	49
02	11	24	31	64	105	254	1473	917	1364	56	3	0
03	104	8	63	10	62	194	658	1349	740	594	0	17
04	63	6	160	12	144	410	1515	1439	501	18	87	70
05	206	168	125	30	85	178	778	703	414	1	2	28
06	37	367	92	8	55	794	1130	1020	732	14	0	31
07	83	287	103	114	56	68	774	1083	9	0	0	0
08	102	87	5	11	60	223	1414	1685	138	1	4	8
09	80	35	0	275	14	702	1534	957	452	5	0	148
1910	62	18	0	8	58	379	755	1379	893	690	16	1
11	329	6	182	7	3	315	263	643	1306	62	193	2
12	144	35	48	21	28	132	991	1067	981	0	31	7
13	2	188	124	7	229	572	611	457	84	11	6	39
14	0	63	101	88	135	241	1369	860	1051	56	25	0
15	103	274	222	33	58	239	954	1184	589	49	0	11
16	2	77	0	13	49	621	1362	1414	981	240	14	0
17	37	117	62	96	204	466	1428	1017	1281	357	0	25
18	36	2	64	46	34	470	409	723	115	2	......	......

TABLE 6—CONTINUED.

No. 11.—PUNJAB, EAST AND NORTH.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	194	142	76	2	66	52	628	612	77	10	0	15
02	0	3	37	39	91	245	593	415	254	34	9	0
03	91	3	120	6	52	29	744	548	426	27	0	29
04	92	6	296	6	93	94	395	624	351	21	47	53
05	205	99	97	8	29	81	443	163	429	3	0	38
06	25	320	170	9	12	207	478	607	755	2	0	27
07	109	330	191	200	27	120	319	819	21	2	0	0
08	162	54	2	130	52	60	869	1622	257	5	7	21
09	84	98	9	232	11	359	902	658	638	12	0	176
1910	125	32	9	28	12	363	567	944	346	189	0	16
11	396	29	425	19	7	237	124	351	403	44	127	2
12	209	35	43	80	30	61	671	790	250	1	46	9
13	8	213	142	7	226	386	511	624	80	7	8	59
14	57	140	65	179	95	205	1240	368	608	146	36	50
15	93	238	228	62	24	116	260	373	369	72	0	12
16	7	86	21	20	54	219	914	907	332	127	0	2
17	31	13	40	213	134	345	714	992	1259	402	0	44
18	26	4	224	157	5	131	151	518	55	3	.....	.....

No. 12.—PUNJAB, SOUTHWEST.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	108	58	68	36	200	59	372	184	72	2	0	0
02	0	4	39	30	63	202	268	262	171	27	0	0
03	36	2	135	26	85	27	509	354	202	10	1	18
04	188	2	366	2	26	49	108	234	42	6	40	38
05	182	98	82	14	16	48	338	37	471	8	3	82
06	5	360	112	13	10	98	190	404	309	1	0	52
07	17	108	69	163	32	134	117	320	2	0	0	0
08	90	21	2	144	45	35	421	609	418	0	0	3
09	9	66	14	138	1	126	449	67	180	1	0	100
1910	70	5	10	82	9	144	203	389	2	4	0	8
11	131	23	324	34	14	149	37	79	40	53	42	2
12	168	6	16	122	26	38	226	168	69	4	0	8
13	0	124	66	13	43	125	300	493	57	6	8	24
14	66	133	57	154	43	118	748	236	141	93	45	33
15	8	45	112	71	15	79	57	68	16	17	0	7
16	6	27	22	28	60	92	288	579	82	51	0	0
17	13	0	44	96	116	129	237	883	609	1	0	16
18	4	8	178	126	1	27	127	97	77	10	.....	.....

No. 13.—KASHMIR.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	589	725	315	61	335	152	1335	2363	277	19	0	65
02	23	72	382	291	232	354	1138	917	563	92	17	0
03	344	85	656	73	227	171	959	1851	694	34	0	263
04	333	97	557	111	250	191	1712	1297	302	142	79	171
05	438	448	607	95	208	206	1308	1034	229	2	2	139
06	209	747	468	31	67	778	1261	3172	1069	6	0	103
07	294	441	339	372	213	308	213	435	54	52	8	2
08	236	156	61	617	167	56	328	652	255	58	4	291
09	274	407	155	102	100	127	543	441	481	105	5	225
1910	348	272	200	309	113	257	366	528	68	2	0	173
11	839	172	702	174	59	124	190	252	148	39	168	76
12	413	127	272	244	230	47	343	302	12	14	40	119
13	210	342	223	340	145	251	291	445	65	29	82	138
14	139	654	393	487	262	327	1474	615	347	512	165	287
15	151	592	371	546	54	185	365	718	253	67	1	45
16	145	402	200	148	169	349	1043	1030	214	109	13	24
17	171	72	256	391	204	632	768	1086	906	417	1	257
18	81	89	854	661	16	244	370	517	75	53	.....	.....

TABLE 6—Continued.

No. 14.—Northwest Frontier Province.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	316	179	268	128	633	92	209	356	286	67	0	0
02	15	8	169	189	112	230	411	383	257	139	25	2
03	110	6	364	117	186	32	215	338	224	15	6	74
04	313	6	621	43	48	18	290	437	117	93	48	46
05	271	197	397	56	88	20	246	194	198	15	3	250
06	32	543	223	82	57	113	286	459	221	22	0	172
07	159	299	262	381	49	123	159	358	49	12	0	0
08	320	111	33	584	28	32	434	638	447	40	0	94
09	29	211	65	112	23	99	541	493	93	12	1	186
1910	380	90	50	219	50	207	584	644	32	0	0	39
11	383	38	707	95	28	114	47	227	124	92	95	50
12	253	103	26	222	44	38	418	381	59	23	2	9
13	16	229	135	62	56	164	205	392	96	14	37	60
14	61	334	171	328	139	204	675	358	170	368	69	153
15	2	232	202	438	39	88	122	196	147	70	0	8
16	47	171	92	151	160	66	301	794	179	57	1	9
17	70	4	218	89	102	152	242	714	279	20	0	131
18	10	26	454	285	5	117	146	198	74	7	.....	.....

No. 15.—Baluchistan.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	174	15	89	16	162	0	106	22	6	0	0	0
02	2	2	26	20	10	47	28	63	60	17	22	28
03	70	72	282	160	73	11	81	36	11	0	11	13
04	269	49	335	7	0	2	6	9	9	0	20	7
05	388	191	172	20	10	4	43	0	9	2	3	263
06	39	391	294	16	3	26	30	99	30	0	10	12
07	1	330	108	113	2	118	42	191	0	0	0	6
08	123	11	104	93	3	3	177	108	1	0	0	67
09	71	172	83	72	4	21	98	12	41	0	0	142
1910	191	24	62	48	9	42	200	78	0	0	0	109
11	385	56	381	62	1	2	7	42	9	47	99	26
12	350	19	15	90	13	17	166	52	15	0	2	100
13	46	234	178	8	2	71	80	145	4	36	61	106
14	114	347	78	71	4	85	281	29	50	153	189	60
15	42	18	131	257	1	5	31	19	10	12	0	1
16	168	91	29	91	26	22	48	391	7	1	0	6
17	118	5	161	15	47	1	35	341	141	0	24	53
18	12	107	380	71	2	2	32	16	19	1	.....	.....

No. 16.—Sind.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	0	11	14	2	35	0	112	21	0	0	0	4
02	0	0	1	1	98	231	24	244	319	0	0	0
03	11	5	17	7	7	1	301	11	27	0	0	0
04	47	29	112	0	1	2	49	4	7	0	4	10
05	27	71	3	15	0	0	138	0	10	0	0	9
06	6	201	51	0	0	96	48	170	65	4	0	0
07	1	131	21	16	1	228	16	374	2	0	0	0
08	77	0	1	20	1	7	834	278	0	0	0	0
09	18	7	0	15	0	9	441	65	53	0	0	20
1910	47	0	0	9	3	118	566	156	1	0	0	0
11	6	0	59	0	0	10	0	15	7	1	5	0
12	35	0	0	6	5	27	238	189	12	0	0	0
13	0	65	17	0	0	36	939	517	228	3	1	73
14	0	80	3	4	23	154	274	3	45	16	6	2
15	0	7	40	35	0	0	31	1	42	38	0	0
16	8	0	0	0	9	49	191	698	139	5	0	0
17	3	2	17	12	124	31	88	442	569	124	0	0
18	0	0	33	5	0	0	0	92	7	0	.....	.....

TABLE 6—CONTINUED.

No. 17.—RAJPUTANA, WEST.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	34	0	3	0	15	12	333	237	6	14	0	
02	0	0	0	3	16	177	152	312	196	6	0	0
03	5	7	29	0	20	4	689	379	205	0	0	0
04	9	12	50	3	61	58	200	215	60	6	11	24
05	12	20	4	6	1	19	145	3	273	0	0	2
06	0	128	27	0	1	67	253	280	351	3	0	7
07	4	130	26	12	26	34	212	1089	1	0	0	0
08	38	1	0	6	22	124	940	1190	306	1	4	0
09	13	8	0	104	11	106	727	344	449	2	0	65
1910	8	0	0	17	1	302	231	632	41	3	0	0
11	5	0	119	1	0	113	11	62	240	25	8	0
12	35	0	0	7	21	102	519	457	73	27	12	0
13	0	24	8	0	60	217	232	309	126	1	0	33
14	8	8	0	29	16	204	503	238	210	24	14	0
15	30	91	64	1	2	71	95	93	51	122	0	0
16	5	1	1	7	65	86	271	808	403	76	0	0
17	6	5	7	51	229	305	441	971	860	308	0	3
18	2	0	14	3	4	25	23	189	22	1	......	......

No. 18.—RAJPUTANA, EAST.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	103	51	11	2	16	65	693	755	30	34	0	3
02	16	3	0	5	27	154	1102	428	496	46	0	7
03	11	2	6	0	45	82	738	917	537	114	0	0
04	14	18	92	1	104	168	1167	1079	223	3	30	76
05	27	45	14	7	6	53	398	114	300	0	0	4
06	1	98	40	0	9	259	853	291	763	5	0	13
07	37	176	42	61	45	68	451	1252	11	0	0	0
08	69	4	6	2	31	174	1679	1435	269	1	5	0
09	29	6	0	203	24	424	1133	665	319	4	0	105
1910	42	11	0	7	9	384	412	908	754	341	4	0
11	74	3	69	3	1	273	168	337	781	23	96	1
12	45	17	11	14	13	98	1202	996	317	5	14	7
13	0	62	7	2	195	347	465	307	97	6	2	75
14	0	3	4	15	39	334	1247	478	454	59	17	0
15	68	123	190	14	16	129	312	498	131	156	0	4
16	1	28	0	2	37	311	669	1701	497	99	11	0
17	16	37	21	46	290	461	1218	1556	1206	354	0	1
18	25	0	14	5	5	103	189	623	97	0	......	......

No. 19.—GUJARAT.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	0	0	2	6	21	214	886	652	76	48	0	0
02	10	0	0	2	4	106	830	1130	1048	12	4	42
03	0	0	1	0	34	94	1740	692	605	20	0	0
04	2	48	78	0	10	157	685	194	382	16	1	3
05	2	3	2	2	0	70	2100	116	257	6	0	0
06	0	46	0	0	0	688	1200	874	400	40	0	1
07	1	38	1	8	3	284	1276	1721	43	0	0	0
08	17	0	0	0	0	246	1880	1268	85	4	0	0
09	0	6	0	26	9	638	1473	712	588	8	0	26
1910	3	0	0	1	1	1041	1088	1177	170	78	23	0
11	10	0	84	0	3	554	223	297	193	1	7	1
12	0	0	0	2	3	406	2401	1067	150	33	127	0
13	0	0	0	0	32	1493	1463	632	505	4	0	1
14	0	15	0	1	27	927	1493	414	1035	38	23	0
15	21	6	52	7	6	445	476	306	184	380	2	0
16	0	0	0	0	30	400	687	1318	617	146	6	0
17	3	20	0	20	387	526	1129	1207	1158	954	0	0
18	2	0	1	0	43	139	393	561	50	2	......	......

TABLE 6—Continued.

No. 20.—Central India, West.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	112	62	19	10	10	102	965	1724	349	17	0	9
02	80	37	1	6	19	109	1659	685	792	79	25	22
03	15	1	1	0	43	174	947	1178	1008	458	0	0
04	13	48	99	0	49	348	1573	1041	449	55	14	53
05	48	15	34	12	13	97	1081	594	574	0	0	4
06	1	67	31	0	5	592	1494	672	1525	14	0	0
07	15	67	4	33	8	164	836	1343	122	0	26	0
08	57	2	28	4	4	343	1485	1159	178	0	3	1
09	12	5	0	106	29	599	1109	1083	388	8	0	69
1910	8	0	0	2	2	763	735	980	1019	173	103	0
11	70	5	12	0	2	487	475	569	798	46	118	0
12	16	22	2	1	10	199	1376	1064	329	11	234	7
13	0	35	5	0	124	665	1127	779	237	0	2	48
14	0	5	17	7	62	514	1483	557	578	26	45	0
15	47	106	106	23	22	359	595	850	288	273	12	16
16	0	28	0	1	68	742	911	2177	482	204	78	0
17	51	84	5	9	278	690	1192	1319	1063	345	0	0
18	3	3	10	0	34	354	461	876	261	1	......	......

No. 21.—Central India, East.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907	19	469	20	79	23	158	763	1875	27	0	14	0
08	78	58	15	1	28	141	2068	2328	314	55	1	21
09	87	46	8	250	10	951	1518	544	478	0	0	82
1910	24	1	1	12	58	692	560	1421	970	188	214	0
11	125	9	79	0	22	500	396	1365	1552	283	153	0
12	10	33	5	11	17	107	1790	1074	540	0	142	4
13	2	312	77	0	166	818	792	635	273	3	0	38
14	1	23	114	58	68	271	2095	972	310	9	1	0
15	60	117	96	29	28	499	800	1547	457	222	1	4
16	0	40	0	2	12	1012	927	1819	569	359	95	0
17	15	78	78	4	249	660	1571	1624	920	234	5	10
18	1	11	5	2	35	275	332	978	301	0	......	......

No. 22.—Berar.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	211	16	65	48	21	578	942	1235	280	206	0	0
02	13	0	0	31	5	154	1087	681	401	197	92	155
03	31	4	0	6	183	374	1469	859	532	303	0	0
04	22	7	39	0	29	486	553	387	849	213	0	7
05	13	32	10	9	23	256	879	499	899	27	1	0
06	52	4	10	0	10	1019	1163	1130	305	24	37	86
07	5	317	4	129	2	646	884	878	98	2	63	1
08	2	9	94	33	4	780	990	991	660	1	0	8
09	7	37	14	38	84	535	889	517	684	26	0	292
1910	0	0	0	0	29	931	725	937	971	249	217	0
11	98	0	4	0	8	545	548	645	287	25	218	0
12	0	91	1	10	9	309	938	895	258	30	48	4
13	0	49	5	6	84	710	1208	622	537	44	1	127
14	0	55	42	45	73	1137	804	700	1100	19	37	63
15	120	22	283	83	32	729	901	413	657	411	29	124
16	0	29	2	7	119	922	1246	821	1081	345	145	0
17	4	212	76	16	170	789	884	639	1008	358	8	0
18	4	11	7	0	304	527	462	361	104	26	......	......

TABLE 6—CONTINUED.

No. 23.—CENTRAL PROVINCES, WEST.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	170	122	104	64	28	368	1395	2052	523	32	0	0
02	30	8	0	16	12	138	1238	867	827	106	116	66
03	24	14	0	6	185	413	1508	1458	976	400	2	0
04	6	72	130	0	37	584	984	784	650	157	0	32
05	36	37	40	50	37	255	1389	1010	1384	14	0	2
06	32	60	108	0	26	1208	1619	1146	874	19	18	44
07	30	330	7	135	21	497	889	1738	139	0	76	5
08	47	36	77	21	3	634	1541	1599	572	35	4	28
09	34	59	17	182	67	640	1233	965	553	4	0	237
1910	21	0	0	2	23	916	940	1319	1103	208	227	0
11	70	0	40	0	5	777	643	1092	1056	149	238	0
12	21	194	0	11	7	165	1489	1412	550	7	227	7
13	4	155	59	1	90	790	1289	1192	315	14	3	86
14	0	33	192	78	53	537	1607	1047	783	37	17	31
15	45	100	234	47	45	746	1449	1339	634	432	26	19
16	0	85	0	6	74	1058	1080	1523	1057	720	137	0
17	18	213	76	17	242	914	1284	1518	1411	313	0	6
18	4	28	11	2	162	941	809	984	295	5	......	......

No. 24.—CENTRAL PROVINCES, EAST.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	167	418	112	42	50	269	1397	1755	762	110	8	0
02	2	3	3	113	48	143	1679	1183	691	39	10	26
03	20	53	3	25	156	382	1453	1519	924	524	1	0
04	0	57	119	2	260	1455	1121	1618	419	268	4	0
05	210	107	84	104	104	135	1513	1062	1329	53	0	0
06	96	357	270	0	18	587	1803	985	971	148	23	41
07	20	146	83	238	12	803	1069	1797	427	0	36	60
08	36	185	9	2	18	910	1812	2202	714	51	0	10
09	20	38	26	376	25	823	2048	860	517	25	0	281
1910	11	1	4	26	42	1048	1340	1539	1132	248	255	0
11	21	0	49	0	12	1191	1037	1873	907	341	65	0
12	16	346	0	73	29	201	1910	2067	754	22	55	0
13	4	248	78	5	76	952	1365	1338	554	67	14	71
14	0	40	58	219	134	634	2046	1360	928	17	2	17
15	118	100	127	58	65	535	1485	1525	940	525	61	2
16	0	101	5	12	61	1114	1155	1442	783	637	107	0
17	4	330	103	44	164	1132	1542	1461	1120	560	3	3
18	43	16	11	15	225	2015	948	1481	498	2	......	......

No. 25.—KONKAN.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	......	1	10	103	97	2687	4111	2820	426	211	37	9
02	1	0	3	9	50	1606	3789	2023	2422	378	128	250
03	0	0	1	5	767	1696	5135	2565	1125	514	64	9
04	0	1	25	25	65	3537	2955	1407	837	359	1	0
05	0	1	0	10	4	1156	3120	1341	770	366	70	0
06	35	4	6	1	10	2072	4171	1936	876	173	37	61
07	6	4	2	118	12	2336	4626	3301	678	93	38	5
08	3	4	1	44	25	1746	5560	2594	819	109	8	0
09	1	0	10	8	111	2911	5062	1418	1461	108	49	1
1910	0	0	6	1	35	3119	1729	2964	1418	562	148	0
11	1	0	8	4	62	2032	2289	2825	631	192	89	17
12	0	0	0	38	116	2321	5083	2253	559	330	390	0
13	0	1	1	10	65	3467	4207	1345	730	569	4	0
14	0	3	0	12	31	2610	5753	3064	2024	107	94	22
15	1	18	25	71	74	3092	2788	1414	1465	573	78	5
16	0	0	1	30	146	3067	2768	3270	2251	837	485	0
17	0	76	10	8	93	3113	2711	3463	2380	1628	123	0
18	3	0	15	12	1269	1284	1588	2207	424	59	......	......

TABLE 6—CONTINUED.

No. 26.—BOMBAY DECCAN.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	......	15	28	140	154	426	782	701	356	296	20	2
02	26	0	0	32	72	399	806	420	592	288	148	268
03	26	0	0	14	303	342	1036	596	548	316	44	18
04	1	20	12	22	104	456	522	258	706	343	0	1
05	0	6	1	18	118	266	953	338	223	199	32	0
06	40	3	16	3	54	668	765	758	375	126	55	84
07	3	11	8	233	15	423	919	914	503	37	32	9
08	1	0	16	47	49	321	938	576	642	74	14	0
09	5	0	15	10	168	620	886	430	517	165	30	19
1910	0	0	11	4	83	660	663	901	691	351	123	0
11	6	0	14	6	97	511	503	521	132	165	145	27
12	0	3	0	80	109	326	1185	559	255	400	219	1
13	0	1	0	52	199	878	761	310	349	230	5	17
14	0	2	2	32	95	593	1333	853	733	96	156	43
15	40	19	64	105	93	719	869	310	819	284	122	57
16	0	1	2	44	248	485	911	616	748	576	465	0
17	0	70	28	32	64	609	402	651	904	634	191	0
18	23	1	12	27	372	211	226	394	269	73	......	......

No. 27.—HYDERABAD, NORTH.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	38	......	......	......	......	......	......	......	......	281	2	......
02	......	......	......	......	......	......	......	650	......	......	......	......
03	......	......	0	......	......	376	......	1054	735	......	......	37
04	0	......	......	......	46	452	568	268	1166	327	0	0
05	2	28	23	72	......	352	28	929	795	......	......	0
06	130	1	34	0	14	1002	927	637	406	92	64	86
07	4	19	12	287	0	558	695	861	299	1	11	36
08	6	5	35	9	13	355	681	658	1523	1	0	1
09	16	10	18	81	65	669	872	590	586	46	1	48
1910	0	0	2	0	69	851	727	663	1593	270	149	0
11	15	0	10	1	9	415	789	765	383	23	90	3
12	0	93	0	47	36	201	902	640	262	78	80	0
13	0	38	0	64	106	550	1105	329	320	154	0	44
14	0	20	3	14	42	1117	1003	771	1132	54	43	71
15	103	6	259	62	35	775	509	574	1055	392	59	32
16	0	31	6	14	135	637	1261	544	1106	486	228	0
17	1	284	88	69	123	692	937	927	1313	356	134	0
18	34	1	14	17	405	324	457	423	465	11	......	......

No. 28.—HYDERABAD, SOUTH.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	26	167	14	168	291	430	625	347	289	248	71	......
02	......	......	......	......	......	......	......	576	......	......	......	......
03	......	......	0	......	......	234	......	1037	851	......	......	43
04	1	......	......	......	106	460	524	167	180	279	0	0
05	0	24	29	75	......	438	219	843	330	......	......	0
06	156	0	8	12	27	706	570	808	490	238	47	214
07	4	6	69	504	13	522	509	687	347	4	26	48
08	57	15	14	15	10	369	495	573	1849	18	0	0
09	3	0	4	151	58	553	702	624	676	31	0	0
1910	0	0	5	37	65	582	412	754	766	339	175	0
11	0	0	1	18	106	336	655	448	385	83	61	18
12	0	140	0	103	35	121	837	690	347	92	140	0
13	0	12	0	19	192	205	836	236	235	240	1	0
14	0	0	9	48	121	717	1068	850	945	54	35	24
15	59	33	250	56	101	575	600	749	886	746	94	1
16	0	10	0	115	111	682	1107	433	1105	1097	406	14
17	0	130	160	88	191	529	595	769	946	510	75	0
18	56	0	76	71	367	163	319	269	693	18	......	......

TABLE 6—Continued.

No. 29.—Mysore.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	29	116	30	212	392	1236	2136	839	634	840	456	76
02	0	24	77	308	458	758	2386	604	940	848	234	580
03	2	0	11	68	602	832	2839	1062	798	777	856	198
04	6	10	40	268	601	1650	1888	632	604	550	12	3
05	4	41	58	95	560	1078	1476	818	358	726	127	1
06	90	9	9	50	300	832	2165	1610	505	818	103	192
07	19	0	45	349	192	459	785	699	586	225	210	54
08	54	13	34	172	367	320	840	384	290	266	6	2
09	86	4	22	174	638	464	862	788	403	487	146	40
1910	0	3	30	95	359	433	972	848	416	901	328	0
11	2	1	22	109	519	574	821	298	213	668	142	28
12	3	18	12	160	276	476	1065	673	716	762	241	0
13	0	0	5	77	365	442	893	350	604	484	5	15
14	0	3	8	70	247	226	1092	539	391	456	261	95
15	40	9	134	169	264	829	655	263	687	409	348	37
16	0	0	0	87	572	623	747	783	544	660	613	27
17	1	144	60	73	227	603	369	660	1040	588	367	5
18	48	4	63	187	402	239	184	378	378	161	......	......

No. 30.—Malabar.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	113	121	198	538	526	3146	2692	1346	660	880	1354	162
02	58	10	180	285	459	1574	4242	1147	1914	1296	620	483
03	12	54	20	312	858	2084	3703	1458	1168	1207	552	262
04	96	12	104	258	758	3941	2733	1130	806	1068	83	37
05	6	72	26	388	910	3111	2031	1178	702	1388	316	2
06	96	28	48	48	540	1614	3380	1588	526	966	640	316
07	28	1	83	509	256	3634	3940	4873	643	803	680	150
08	4	50	57	317	394	2931	5925	2296	452	621	57	20
09	165	13	35	188	2026	3775	4412	1142	899	590	467	88
1910	3	17	36	250	487	3753	2229	2305	1248	1103	747	0
11	4	8	22	98	562	4281	3284	1361	252	992	395	183
12	7	5	6	513	654	4141	4272	3055	561	1513	373	14
13	0	9	11	121	613	2800	3652	1206	814	1705	147	83
14	0	0	7	10	356	2696	4876	2476	979	1296	364	344
15	26	21	110	262	428	3128	3382	1487	1329	770	983	26
16	0	8	12	191	702	4493	2403	1996	1629	1135	516	29
17	0	194	119	84	401	3885	2089	1636	1914	1301	636	60
18	18	10	61	75	3109	2327	986	1674	481	622	......	......

No. 31.—Madras, Southeast.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	89	152	84	136	272	117	146	242	861	449	540	329
02	289	39	71	82	505	137	143	472	300	1139	740	429
03	82	32	6	69	473	205	212	408	792	547	783	768
04	135	0	2	68	457	95	294	133	281	613	102	16
05	24	26	69	253	310	158	123	367	234	941	587	16
06	202	50	59	31	139	154	247	714	234	657	753	505
07	31	5	80	297	188	1463	237	189	455	633	892	268
08	57	143	86	73	241	121	130	181	659	1091	174	108
09	457	38	19	243	447	93	118	853	469	511	281	86
1910	35	81	5	91	202	171	582	578	203	1072	615	2
11	16	3	17	111	251	204	160	128	496	490	777	569
12	29	10	10	42	215	139	107	280	435	987	1117	110
13	14	13	19	75	218	94	177	237	500	865	832	545
14	26	8	16	142	191	138	99	395	492	1200	529	557
15	152	90	173	133	193	206	447	311	515	334	997	269
16	0	13	13	70	204	89	634	450	368	786	633	143
17	70	135	117	35	278	245	172	622	584	499	707	209
18	405	28	86	31	286	138	145	198	189	257	......	......

TABLE 6—CONTINUED.

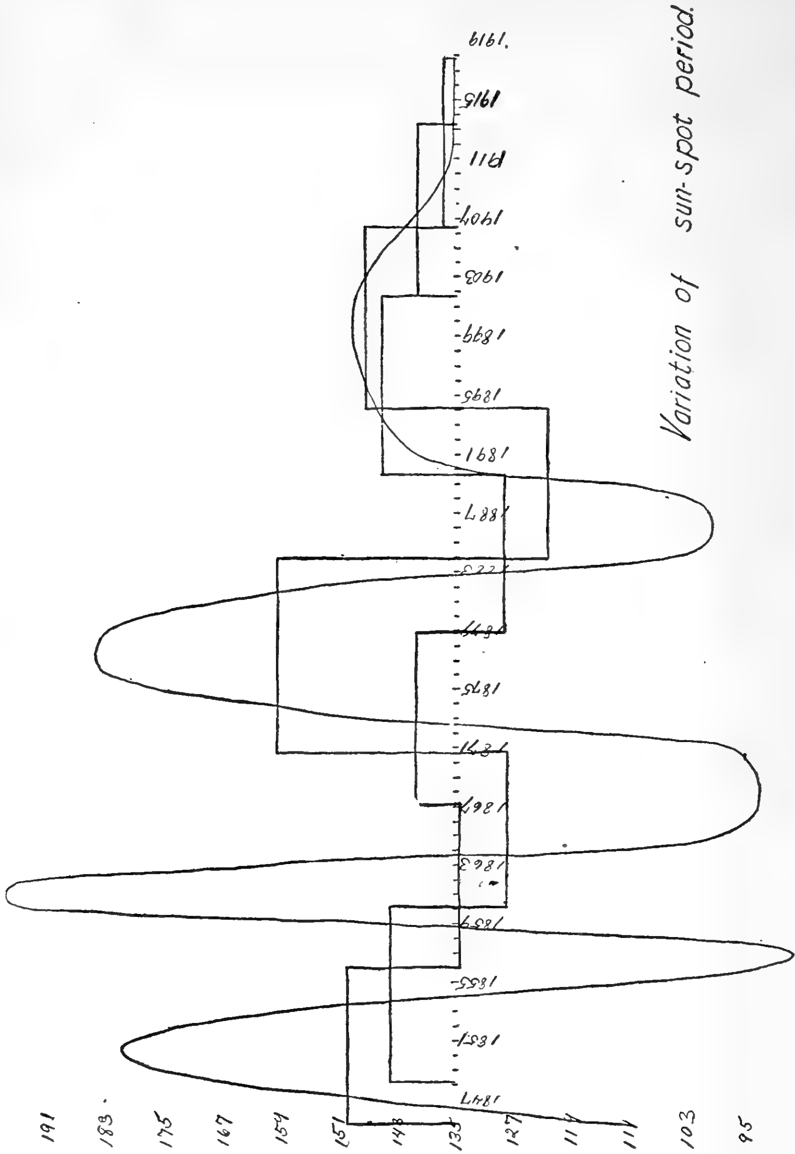
No. 32.—MADRAS, DECCAN.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	25	193	1	58	254	242	262	208	403	271	275	61
02	15	0	3	79	154	321	161	354	653	626	126	76
03	36	0	0	30	225	266	461	479	803	408	790	96
04	26	0	11	49	248	184	248	98	318	472	0	12
05	5	19	50	53	147	300	161	867	483	486	219	1
06	113	2	4	3	50	351	456	532	551	376	59	395
07	2	0	16	258	10	213	477	153	379	89	281	73
08	21	66	36	25	147	146	287	163	886	249	8	2
09	159	1	3	145	250	162	242	883	731	82	25	1
1910	0	0	5	36	153	173	600	668	865	516	339	0
11	0	0	3	53	202	234	309	239	382	285	124	35
12	0	20	2	56	72	139	299	453	659	419	468	0
13	0	0	0	30	249	191	404	94	474	531	1	78
14	0	0	2	59	175	190	338	517	621	132	133	25
15	109	14	212	52	185	227	502	213	774	277	529	6
16	0	2	0	34	218	228	828	623	716	1027	340	1
17	5	227	35	24	172	360	185	605	851	635	313	10
18	61	1	17	40	294	86	85	238	607	19	......	......

No. 33.—MADRAS, COAST NORTH.

YEARS.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901	47	304	15	1	189	210	453	468	450	460	970	224
02	8	0	10	102	84	247	463	770	680	1208	610	400
03	48	23	3	20	368	410	762	731	722	558	1389	274
04	216	4	15	11	416	308	402	386	420	685	18	114
05	16	50	45	104	180	308	302	624	596	368	568	6
06	335	61	55	10	45	583	574	692	413	428	157	869
07	5	9	3	284	86	788	515	615	362	209	331	206
08	197	168	11	34	156	280	528	795	1073	465	85	8
09	113	13	6	438	156	460	828	739	690	96	26	263
1910	4	6	2	119	95	707	909	848	788	1149	336	0
11	0	1	35	55	109	579	571	480	719	522	427	127
12	5	62	16	79	127	219	872	993	774	473	388	3
13	0	47	4	31	251	448	787	529	507	904	79	104
14	4	21	22	273	367	688	728	778	1129	143	131	18
15	169	66	228	119	197	615	574	903	685	793	972	6
16	1	10	2	81	152	576	1027	886	641	1358	532	8
17	7	116	41	97	353	825	609	816	944	1080	491	51
18	151	17	40	53	331	475	462	599	595	88	......	......

FIGURE 1.



RAINFALL PERIOD.
Dinsmore Alter.

RAINFALL PERIOD.
Dinsmore Alter.

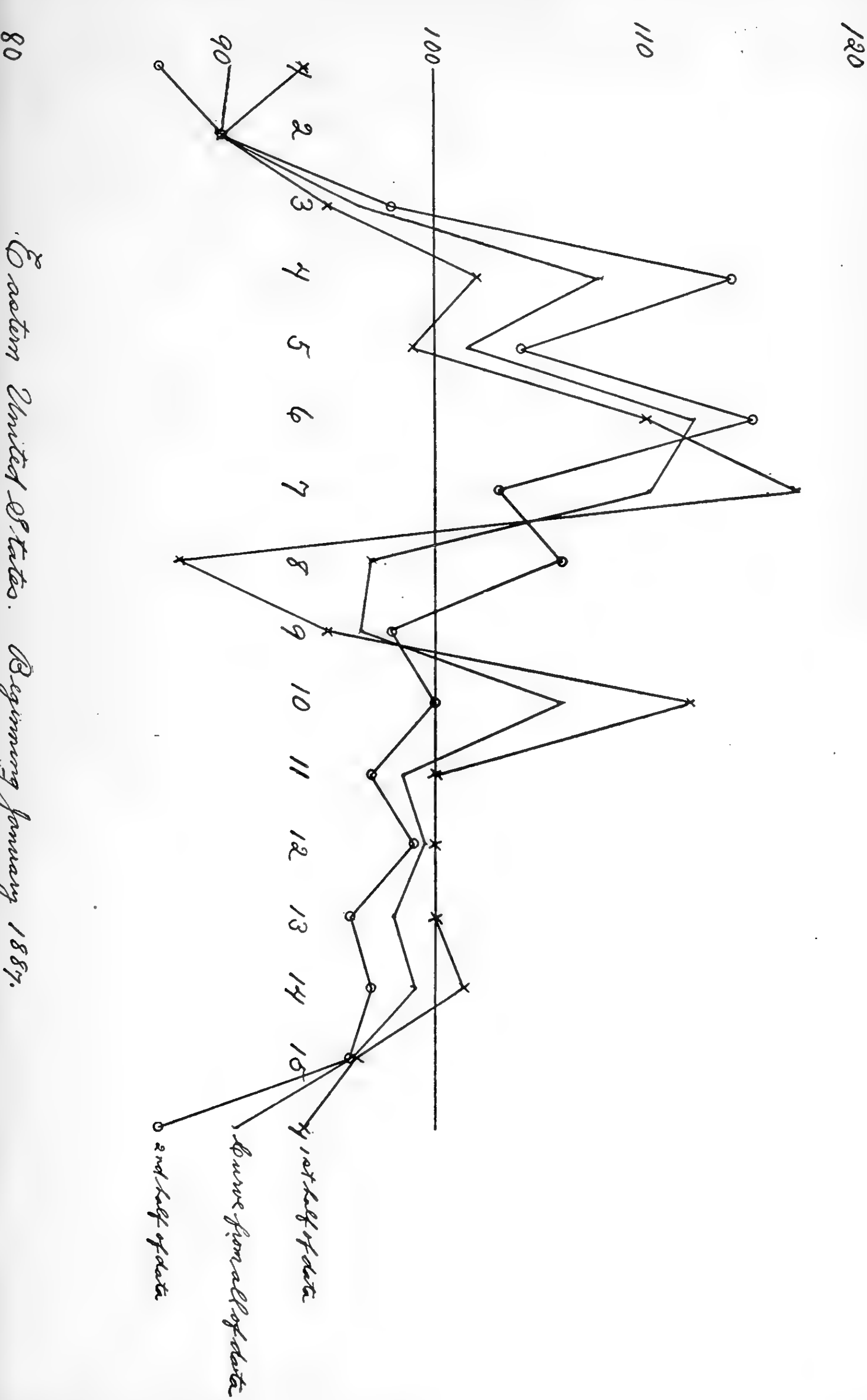
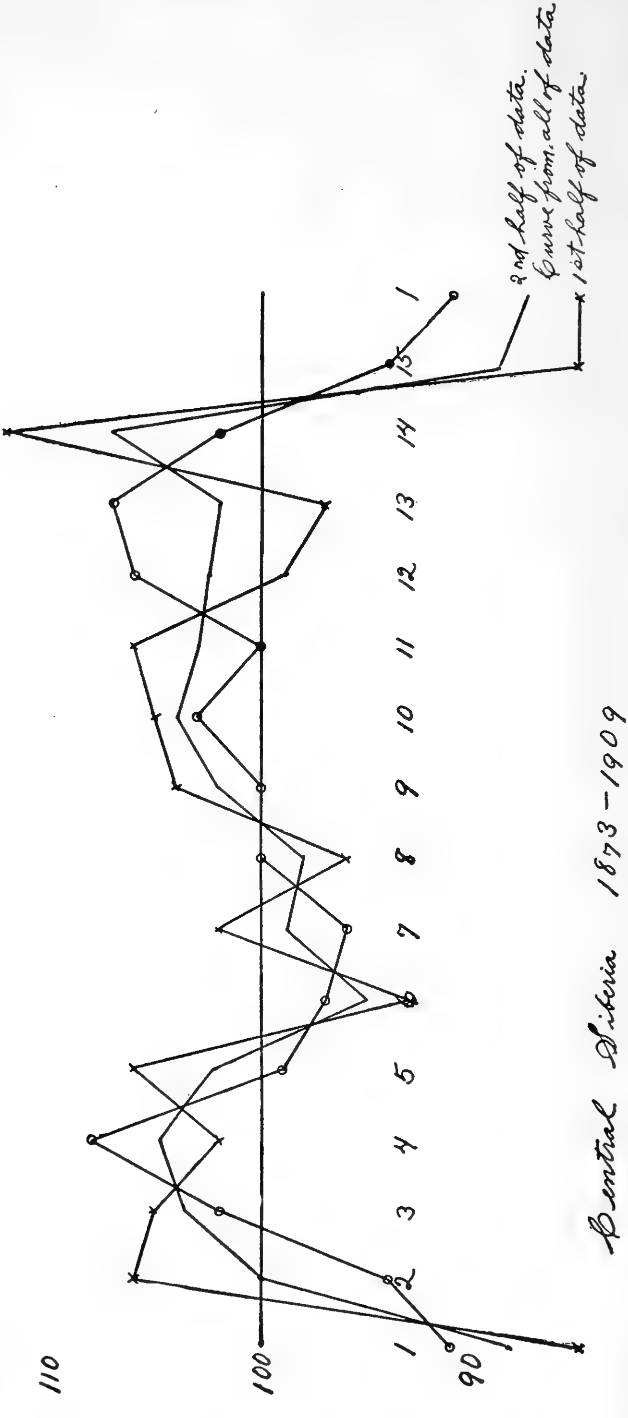


FIGURE 2.

RAINFALL PERIOD.
Dinsmore Alter.

FIGURE 3.



RAINFALL PERIOD.
Dinsmore Alter.

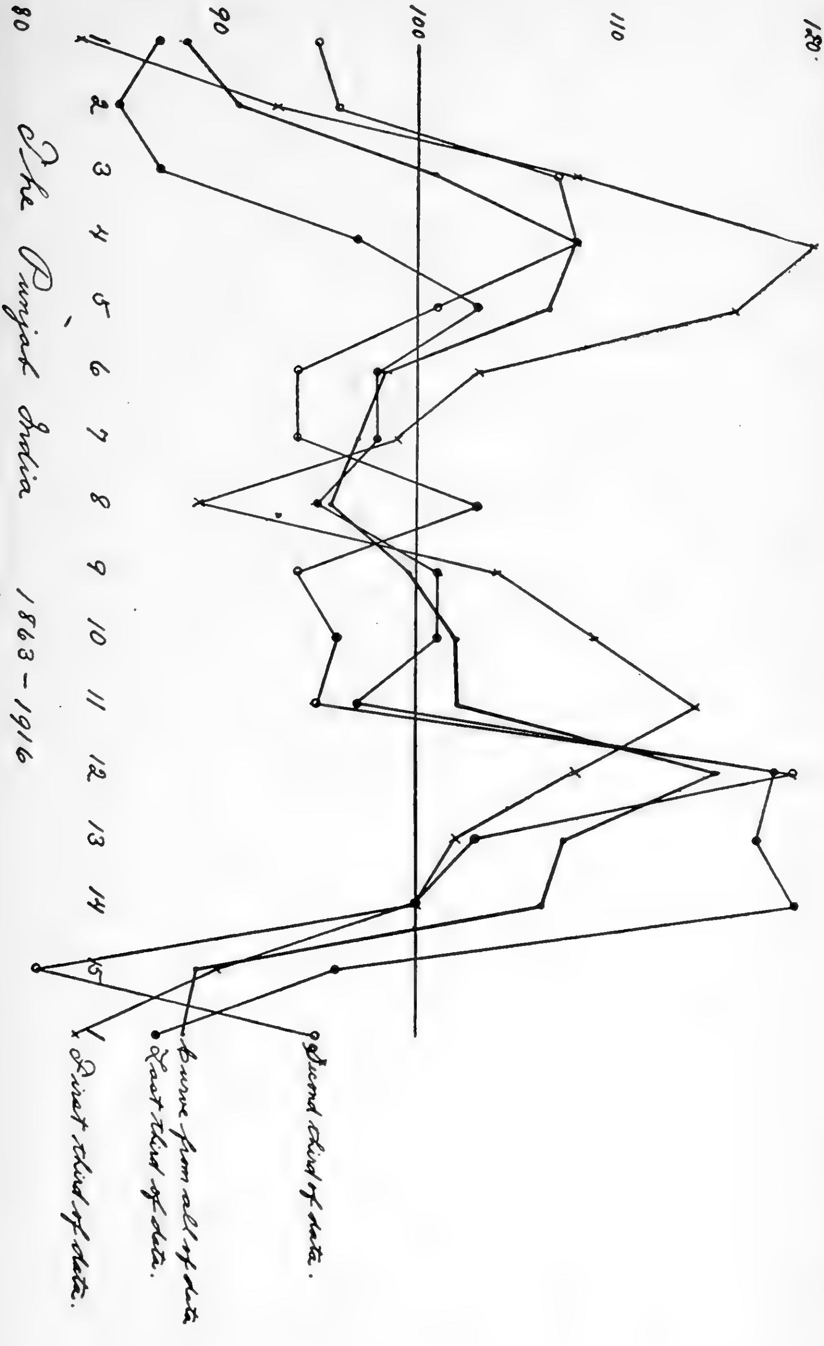


FIGURE 4.

FIGURE 5.

RAINFALL PERIOD.
Dinsmore Alter.

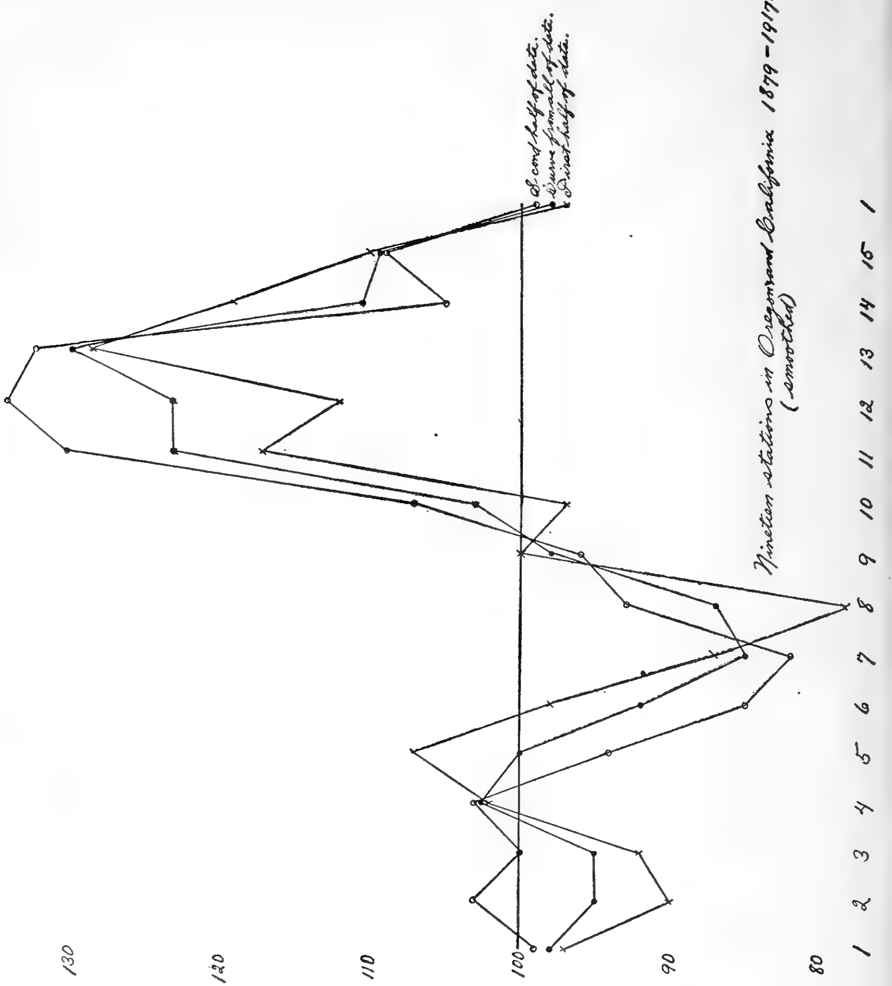


FIGURE 6.

RAINFALL PERIOD.
Dinsmore Alter.

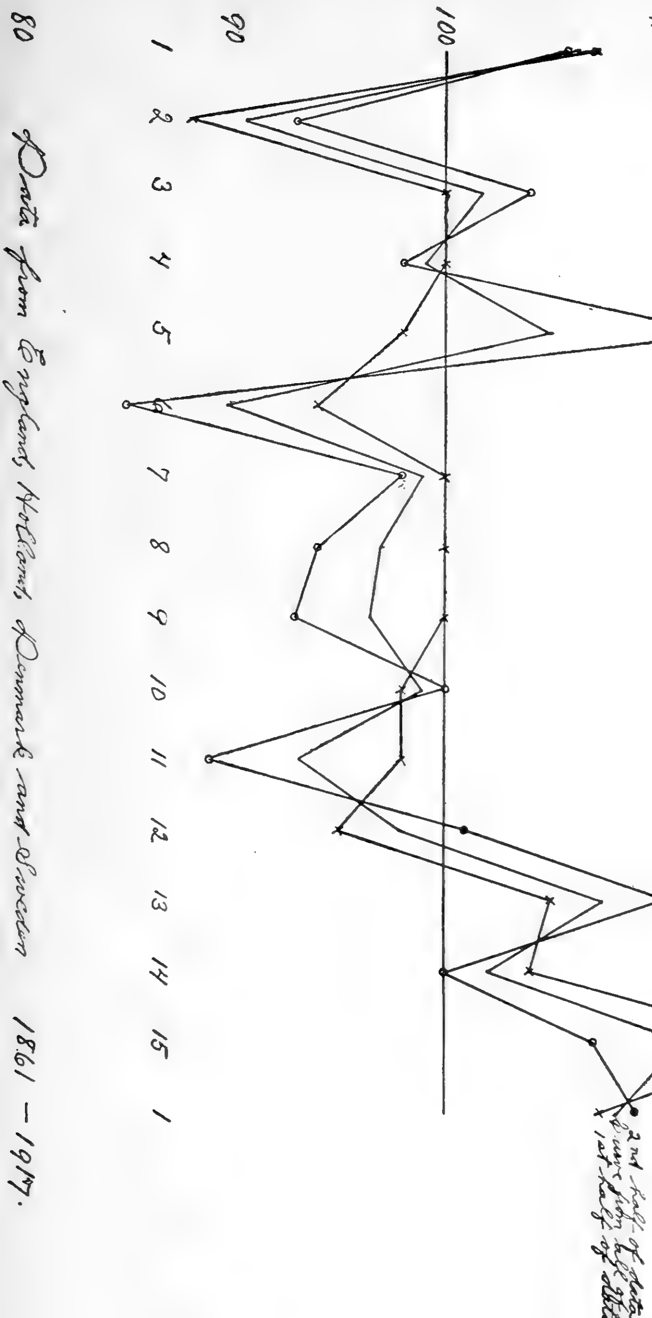
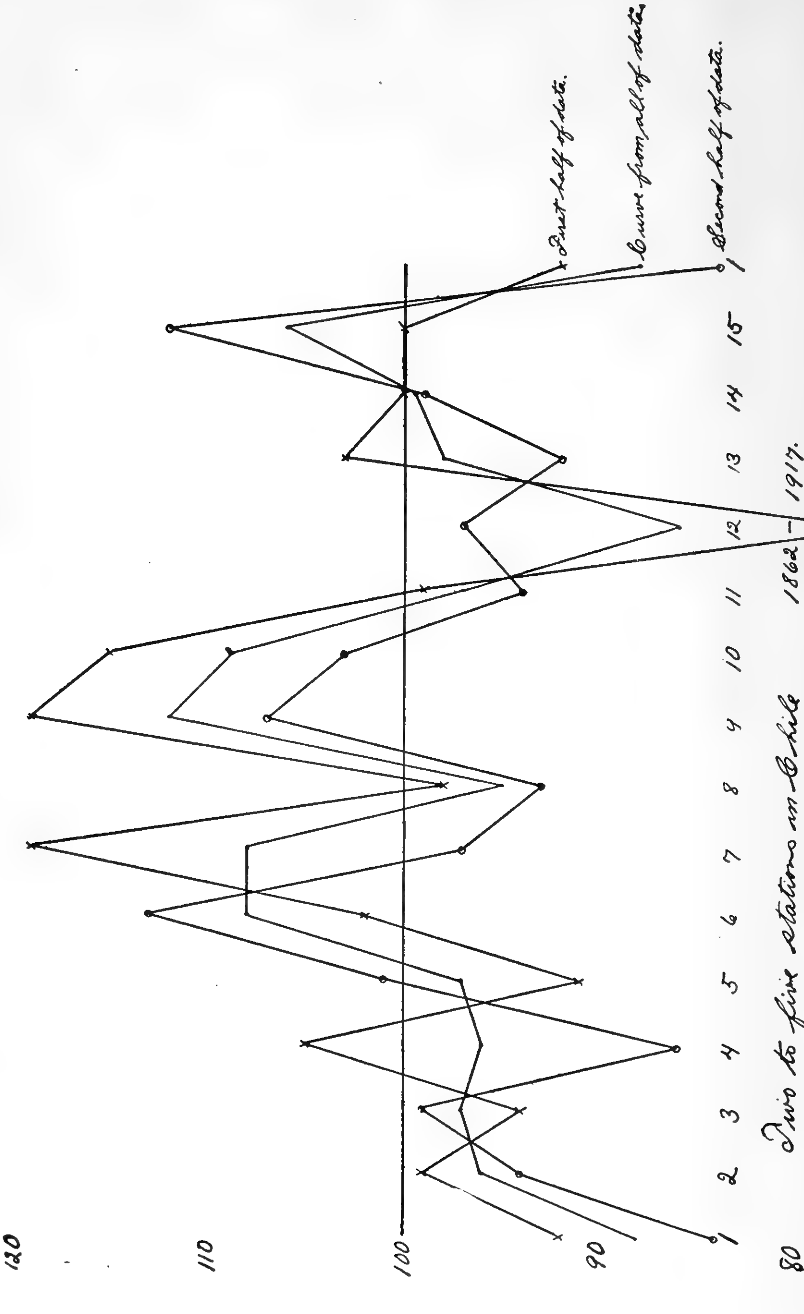


FIGURE 7.

RAINFALL PERIOD.
Dinsmore Alter.



RAINFALL PERIOD.
Dinsmore Alter.

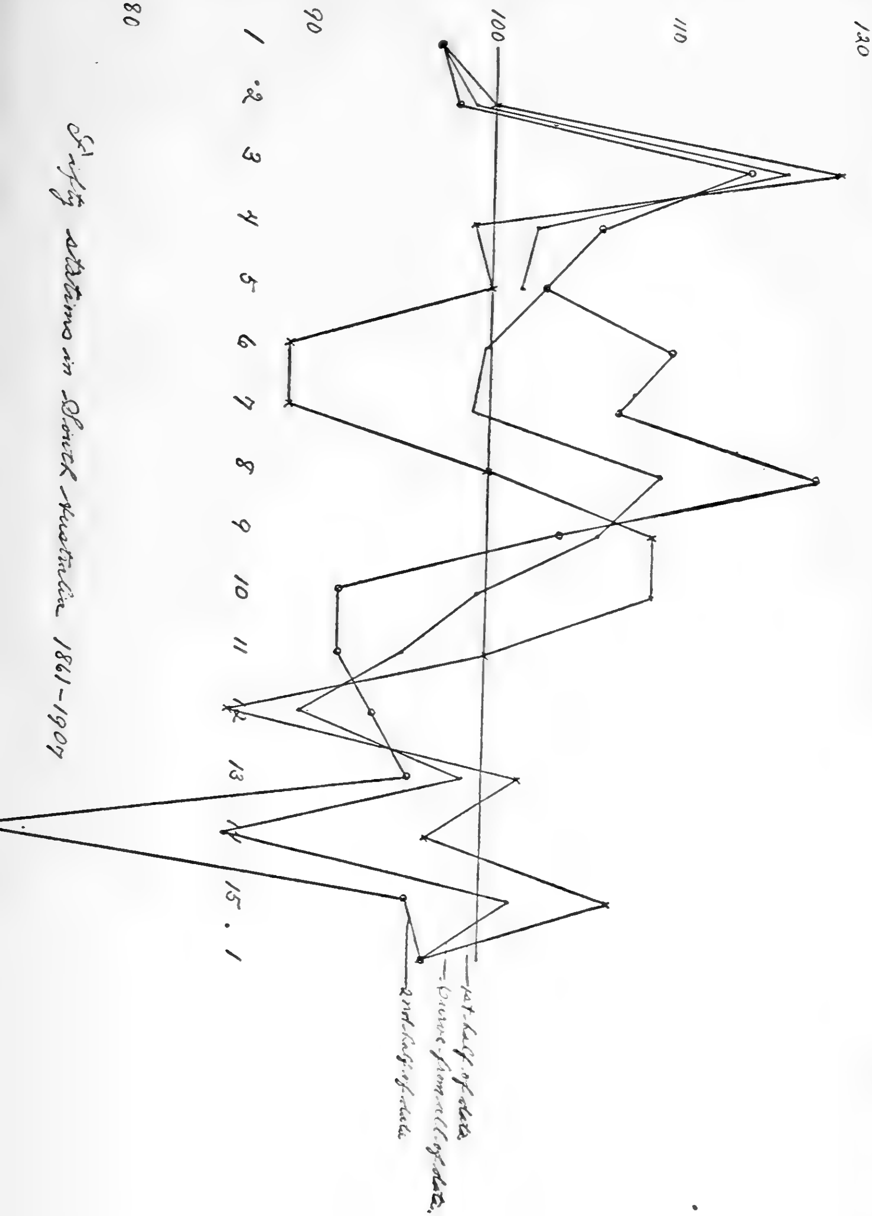
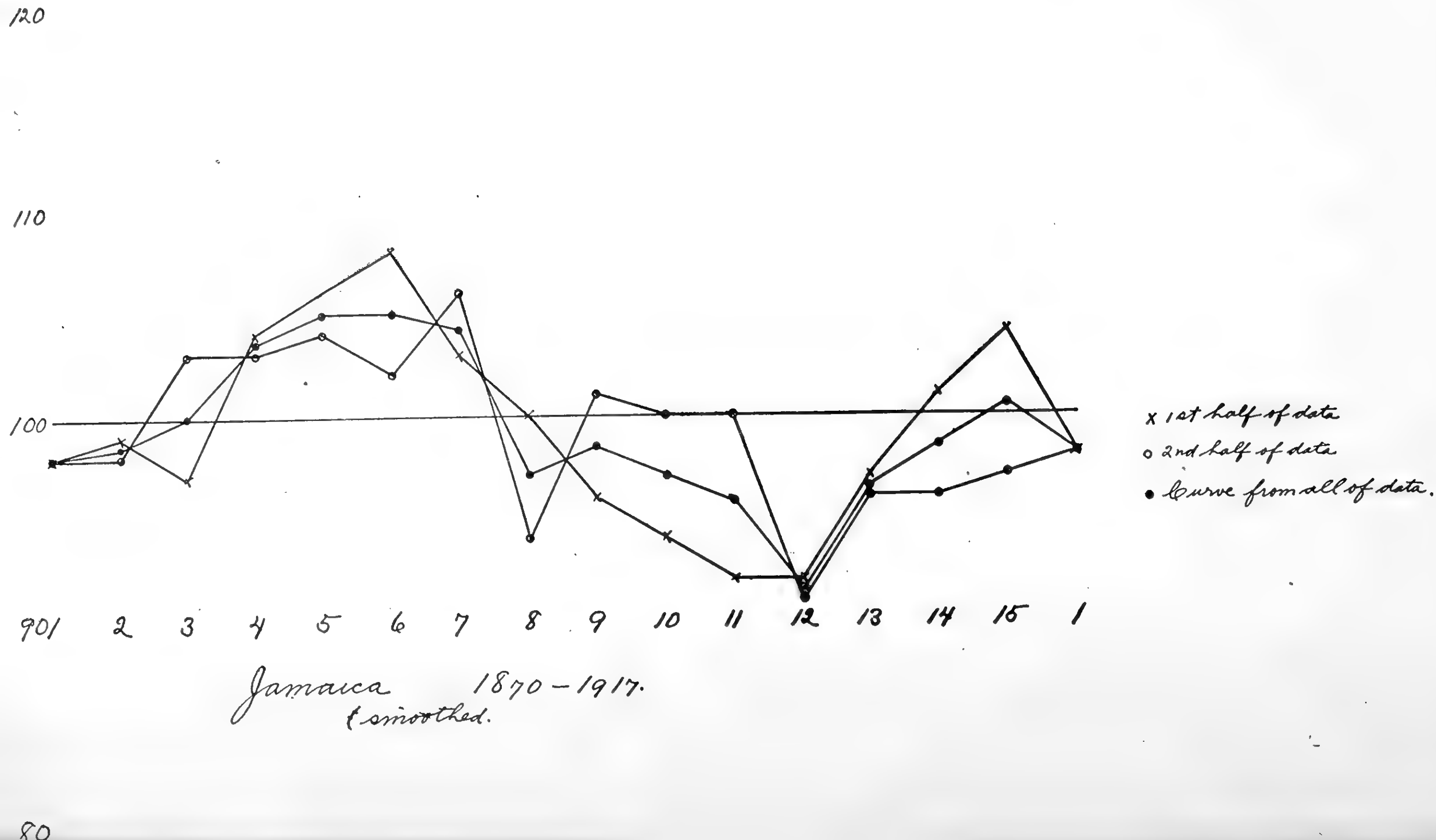


FIGURE 8.

FIGURE 9.


120
110
100
80
901
2
3
4
5
6
7
8
9
10
11
12
13
14
15
1
x 1st half of data
o 2nd half of data
• Curve from all of data.
Jamaica 1870 – 1917.
(smoothed.

RAINFALL PERIOD.
Dinsmore Alter.

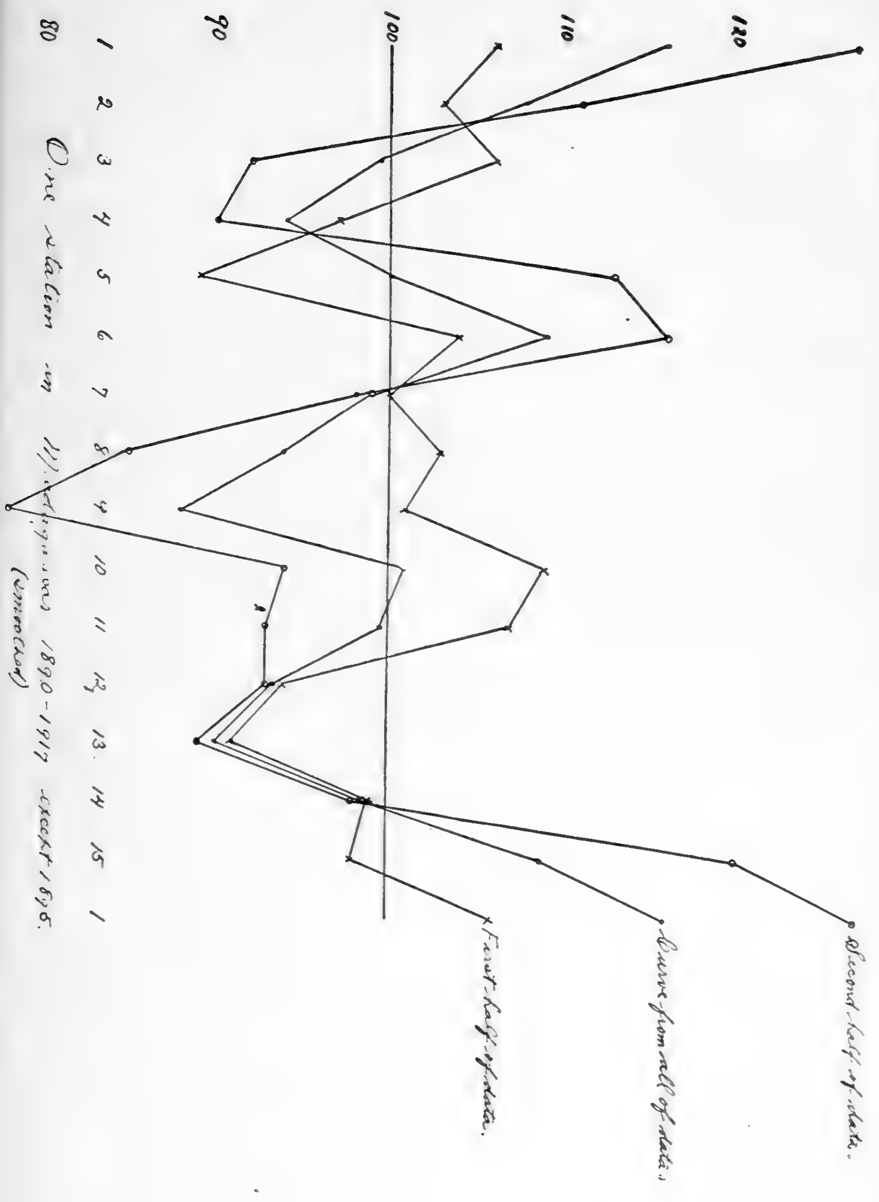


FIGURE 10.

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THE KANSAS UNIVERSITY SCIENCE BULLETIN.

VOL. XIII.] JULY, 1922. [NO. 12.

Indications of a Gigantic Amphibian in the Coal Measures of Kansas.

By H. T. MARTIN,

Associate Curator, Paleontological Museum, University of Kansas.

INTRODUCTION.

IN the summer of 1919, Robert and James Coghill, students of the University of Kansas, discovered in the sandstone cliffs bordering the Wakarusa creek, five miles east of Lawrence, what to them appeared to be the footprints of some large animal impressed in the hard, sandy bottom of a small, narrow ravine that empties into Wakarusa creek from the east near Dightman bridge. The writer's attention was called to the find, and a visit to the locality revealed three or four tracks exposed to view. Unfavorable weather conditions prevented the removal of the tracks at the time, and the subsequent rains covered them with silty mud. It was not until the spring rains of 1921 had again washed them clear that work on their removal could be carried on. By this time additional tracks were exposed, and in a distance of thirty-nine feet, where the animal had traveled in a nearly direct line, nine very fine impressions of his huge feet were recorded.

The impressions, although in a nearly straight line, were not in consecutive order. As shown in the diagram (plate I, figs. 1 to 9), one space of twelve feet from the first track to the second was eroded and no impressions remained. Midway between the third and the fourth, a distance of eight feet, there is an indication of a track, but with no character. From track four to track five the bottom of the ravine is still covered with mud, and it is possible that more tracks will be found here. Eight of the tracks have been safely removed and placed in the museum. The first in the series yet remains *in situ*, but will be removed in the spring. The first impression in the series occurs at the mouth of the small ravine, where it empties over the edge of the deeply undercut, rocky, shelving bank into the Wakarusa. At this point the smooth, level bed of the creek is composed of the same sandy formation (plate II) as that in which the tracks appear. From the bed of the creek to the level of the first track there is an elevation of fourteen feet. This track, like several others in the set, shows the imprint of more than one foot. It also shows plainly that the animal must have been of great size and weight, for from the marks made by the claws (plate I, fig. 10) of the front foot, at the extreme upper edge of the basinlike cavity each impression has made, to the level of the superimposed impression of the hind foot there is a depth of over fifteen inches. It may be doubted if an animal of less than from 400 to 500 pounds weight could possibly have left as deep an imprint as is here shown. From the first track to the second, a distance of twelve feet, there is an elevation of three feet.

There is no doubt that the animal was well adapted for traveling on land, as well as for life in the wet and swampy marshes, and that its body was carried clear of the ground, requiring relatively long limbs. The imprints also indicate that an upright position was maintained, the toes of the feet being planted in a straight line parallel to the body and to the line of travel. The footprints suggest that the animal was of very robust build, possibly not unlike that of *Eryops* from the Permian of Texas, but probably of longer limb. It may well be that the form described herewith as *Onychopus gigas* is a Carboniferous representative of this well-known fossil amphibian, or some similar animal with a longer length of limb.

Onychopus gigas gen. et sp. nov.

An entirely new form of amphibian is indicated by the present series of footprints, for which the term *Onychopus gigas* is proposed. The generic term refers to the presence of claws, apparently for both fore and hind feet. Claws are known among previously described Paleozoic vertebrates, particularly among the Permian reptiles, but are here regarded as a generic character. Their presence is indicated in the long, sharply marked grooves on the edges of the footprints, where the sluggish animal lazily dragged his feet from the soft sand. Another new character is an apparent presence of heel pads (plate I, figs. 2-10), which are represented in the footprints as depressions at the base of the footprint. Further discoveries may locate the form in a genus of reptiles or amphibians already known, but for the present the footprints indicate an unknown animal.

Additional characters are indicated in the apparent presence of webs between the toes, extending a short distance on the phalanges. The body and the tail were carried clear of the ground, as there is no evidence of dragging. This is all the more unusual in view of the great depth of the impressions. The length of his sluggish stride was 450 mm.; the manus was 90 mm. in length and the pes 104 mm. Other detailed measurements are given in the description of the plate.

The most nearly related form is *Baropus lentus*, described by Marsh, from the Coal Measures of Osage county, Kansas (1). The present form differs from *Baropus* in being somewhat larger, and especially in the indications of the heel pads and claws. None of the other Coal Measures footprints from Kansas approach the present footprints in size save *Dromopus agilis* Marsh (2), from which it is clearly separated by a number of characters.

The present series of footprints have been compared with the descriptions of Coal Measures footprints given by King, Leidy, Lea, Butts, Marsh, Mudge, Dawson, Moore, Cox, Moodie and Woodsworth, a list of whose writings relating to this subject is to be found in Moodie's memoir (2) on "The Coal Measures Amphibia of North America." The present form is widely separated from the footprints recently described by Lull (3) as *Dromopus (?) woodworthi*, from the Coal Measures of Massachusetts.

It has been assumed, on account of the indications of four toes on the manus and five on the pes, that *Onychopus gigas* was an amphibian, though the discovery of skeleton material may make this assumption unwarranted. In view of the possibility of its being reptilian, the present footprints have been carefully compared with those described by Hitchcock (4), but none similar in form are found.

FORMATION.

The massive reddish-brown sandstone in which the tracks were found contains abundant flaky scales of mica. There are no perceptible lines of stratification and no lines of cleavage. The rocks are split up by horizontal, perpendicular and oblique cracks and fissures into sections of erratic shapes and sizes (plate II). A careful examination failed to reveal any invertebrates or other fossil forms in the sandstone bluffs, although remains of Coal Measures plants have been found elsewhere in this horizon.

The bottom of the ravine containing the tracks scales off more readily than the surrounding bluffs and is consequently rapidly eroding away. The banks of the ravine are very steep, the average width at the bottom being about 3 feet, with a width at the top of 25 feet, while the depth from the level of the banks above to the level of the tracks is 25 feet.

CORRELATION OF FORMATION.

The heavy sandstone rocks in which the impressions appear are exposed in a sharp escarpment on the south side of the Wakarusa creek for a distance of 1½ to 2 miles, in varying heights ranging from a thin feathering edge to 40 feet. The highest point is attained in close proximity to and just above the small ravine in which the tracks were discovered.

A short distance southwest, at the extreme eastern end of Blue Mound, and just above these exposures, an outcrop of the Iatan limestone occurs, thus definitely placing the sandy exposures in the division which composes the lowest member of the Douglas formation, and as it occurs immediately below the Iatan limestone constitutes a part of the uppermost strata of the Weston shales.

The inclusion of this heavy sandstone in the Weston shales will be better understood by referring to the description of the Douglas formation by Moore (5):

> "The shale members of the Douglas are variable in composition and texture, changing markedly from point to point. In the north there is a predominance of clay shales, which is sufficiently pure for use in brick manufacture, but towards the south the proportion of sand is notably increased. In places here the shale is replaced by thick, massive sandstones. Coal occurs at one or two horizons in the formation, but is not of great thickness and has been worked only locally."

DESCRIPTION OF TRACKS.

Track No. 1, the first in the series, shows clearly where the front foot had pressed down in the soft, plastic mud to a depth of eight inches, leaving at this level a well-defined ledge. Immediately behind this narrow ledge the superimposed hind foot had pressed down to a depth of another seven inches, plainly indicating that the animal was of large size and great weight. This impression represents the tracks of the front and the hind foot of the left side.

Track No. 2. (Plate I, fig. 2.) This track was located 12 feet from No. 1 and is one of the finest in the set, showing distinctly the impressions of five bluntly pointed toes. Between the toes the weight of the animal has caused the mud to ooze up, not in sharp ridges as one would expect if the animal had separate unwebbed phalanges, but in a smooth, rounding ridge, indicating that either a fleshy pad, or more likely a thick web, extended to the base of the short, blunt claws. The hinder part of the impression has unfortunately eroded away, so that no imprint of the heel is retained. Both the manus and the pes are represented here, and naturally that of the pes shows most distinctly. Towards the hinder part of the impression there is a small, round indentation, as if caused by a conical protuberance beneath the pad of the foot, as indicated in other tracks of the series. The elevation from the first track to the second is three feet.

TRACK No. 3. (Plate I, fig. 3.) This track was exactly two feet from its predecessor, measurements in each instance being made from the centers of the impressions. There are four distinct toe marks in this track, evidently a left manus. This track, like No. 2, was in a shelving, badly eroded place, leaving no imprint of the palm. From this track to No. 9, the last in the series, there is an elevation of 3 feet.

TRACK No. 4. (Plate I, fig. 4.) This impression was separated by eight feet of clear space from No. 3, and it has the least character of any in the set. There are four light toe marks, and two of the small, round depressions at the base of the palm. These were made, no doubt, by round, warty tubercles beneath the foot. The relative position of the toe imprints to each other indicates a right manus, but so indistinct are the surface toe marks that it is doubtful if they do not belong to the left instead of the right.

TRACK No. 5. (Plate I, fig. 5.) From the fourth to the fifth track there is a space of ten feet, covered to a depth of several inches with soft mud and yet unexplored. Future rains will doubtless disclose more impressions. Track No. 5 shows deep scoring on the edges of the depressions by the slipping of the claws. The four grooves thus made end with the same number of round pits, pressed a half inch or more below the level of the palm, while at the base of the palm one of the small circular pits occurs. These small pits appear at the base of each palm and sole wherever the conditions are favorable enough to retain the imprint of the hinder part of the foot. There is no doubt but that this track represents the impression of the left manus.

TRACK No. 6. (Plate 1, fig. 6.) Impression No. 6, two feet six inches from No. 5, is similar in all respects to others already described, and is the left pes.

Tracks Nos. 7 and 8. (Plate 1, figs. 7 and 8.) These two tracks were removed in one block. The distance of stride from No. 6 to No. 7 was two feet six inches. Here the animal changed its course and turned sharply to the left, making a short step of only twelve inches from track seven to track eight. Each of these tracks were pressed firmly into the sandy matrix, making a bowl-shaped depression, with sloping sides, twelve inches in diameter and six inches deep. Grooves in the sides of the depressions show distinctly where the toes and the pad of the front foot have pressed down to a depth of four inches. At this level there is a slight ledge left where the overlapping hind foot pressed still deeper down for another three inches, leaving a well-defined imprint of the short claws and the circular pits similar to those found at the base of the palm and sole of the other tracks collected.

Track No. 9. (Plate 1, fig. 9.) This, the last track of the series, was situated two feet three inches from the preceding track, and six inches higher in elevation. This probably is of the left side, but whether of the manus or pes is rather doubtful. The imprint, being on higher and drier ground, was less distinct and showed less character than those made in more plastic material. The bank rises rapidly from the last track found, and although the overlying soil was cleared away for quite a space around, no other indications of tracks could be found.

The finding of these scarce footprints in the Coal Measures of Kansas will be welcomed because they may shed some light on the ancestors of the later Permo-Carboniferous amphibians, or possibly reptilian fauna of that age.

Thanks are here expressed to the finders of these rare tracks for their generosity in presenting them to the paleontological department of the University of Kansas.

I wish to express my thanks to Dr. Roy L. Moodie, College of Medicine of the University of Illinois, to whom I am under obligations for assistance in the preparation of this paper.

CONCLUSIONS.

The present series of footprints referred to under the new term of *Onychopus gigas* indicates one of the largest, if not actually the largest, pre-Triassic vertebrate thus far known from the geological horizons of the world. A short-bodied, long-limbed vertebrate with well-developed feet left these impressions, of whose bodily structure nothing whatever is known. So deeply marked are the footprints in the sandstone that it looks as if an elephant had recently waded through. A curious consistency of the sandy shale is indicated in the well-preserved indications of foot structure of *Onychopus gigas* as he trailed through the sandy mud many millions of years ago. It is extremely interesting to note the change in elevation between track one and track nine. While this may be due to the dip of the strata, it may also indicate the shelving bank of a Coal Measures stream which has again been exposed by the gradual erosion of the present Wakarusa creek.

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4. Hitchcock, Edward. 1858. Ichnology of New England, Boston.
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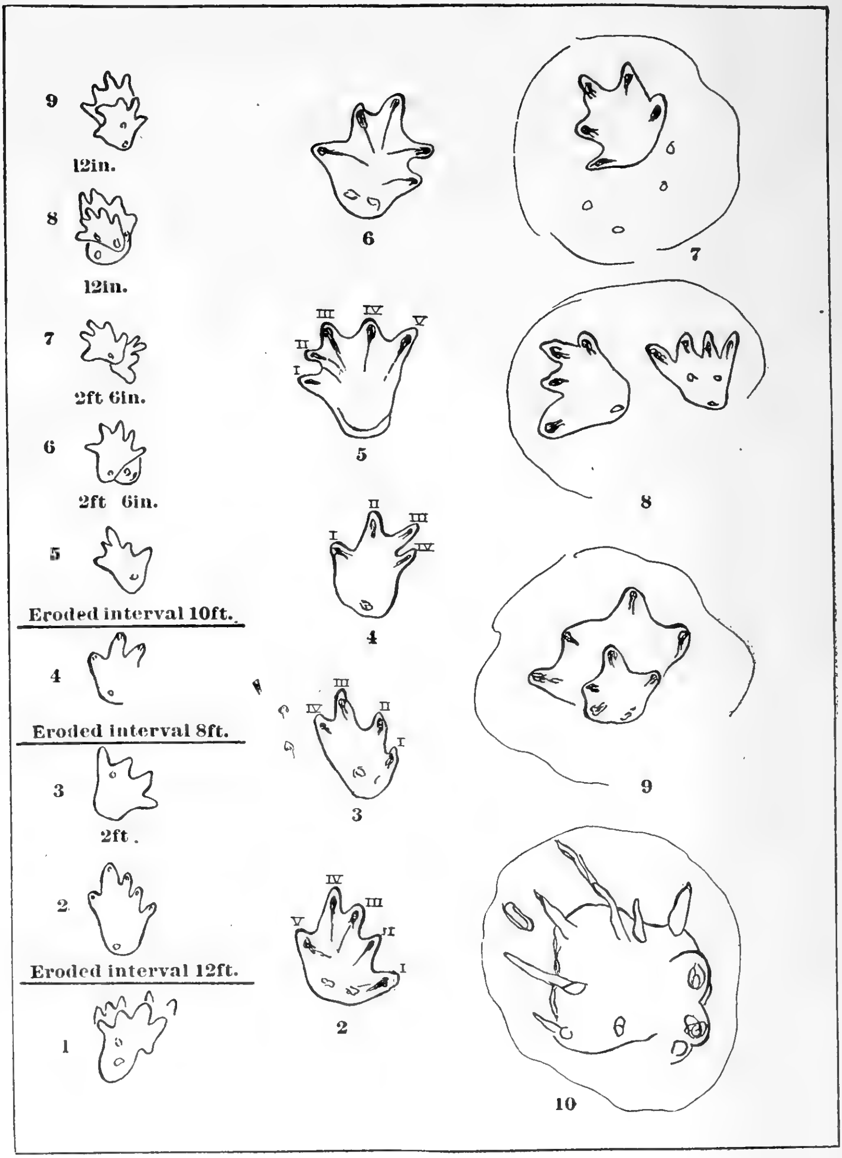
Footprints of a Gigantic Amphibian.
H. T. Martin.

PLATE I.



EXPLANATION OF PLATE I.

The small figures on the left, from 1 to 9, indicate the series of amphibian footprints in the sandstone ledge of the Upper Coal Measures. After making the sixth impression the animal turned sharply to the left, so that the drawing does not represent exactly the manner of occurrence. It shows, however, the distance between impressions. No. 1 is possibly a fore-foot impression, with portions of another; No. 2, the left pes; No. 3, the left manus; No. 4, indefinite; No. 5, left pes; No. 6, left pes, part manus; No. 7, left pes, part left manus; No. 8, left pes, part manus; No. 9, undecided.

The figures 2 to 10 on the right of the plate are detailed studies of the best-preserved tracks.

No. 2, left pes with a distance of 130 mm. across the heel impressions at the level of digit I. The distance between the tips of digits I and II, II and III, III and IV is in each case 40 mm.; between IV and V is 80 mm. Small pits in the heel impression indicate heel pads.

No. 3, left manus. The small pits to the left indicate toe marks of another foot. The greatest width of this foot is 105 mm. The distance between the tips of digits I and II, II and III is in each case 50 mm.; between III and IV is 40 mm.

No. 4, right manus. The distance from the tip of digit III to the posterior edge of the heel pad is 95 mm.; between II and III, 45 mm.; between I and II, 48 mm.

No. 5, right pes. The greatest length is 110 mm.; the greatest width 120 mm.

No. 6, undoubtedly a pes, with well-marked heel pads. The greatest length is 140 mm., the greatest width 144 mm.

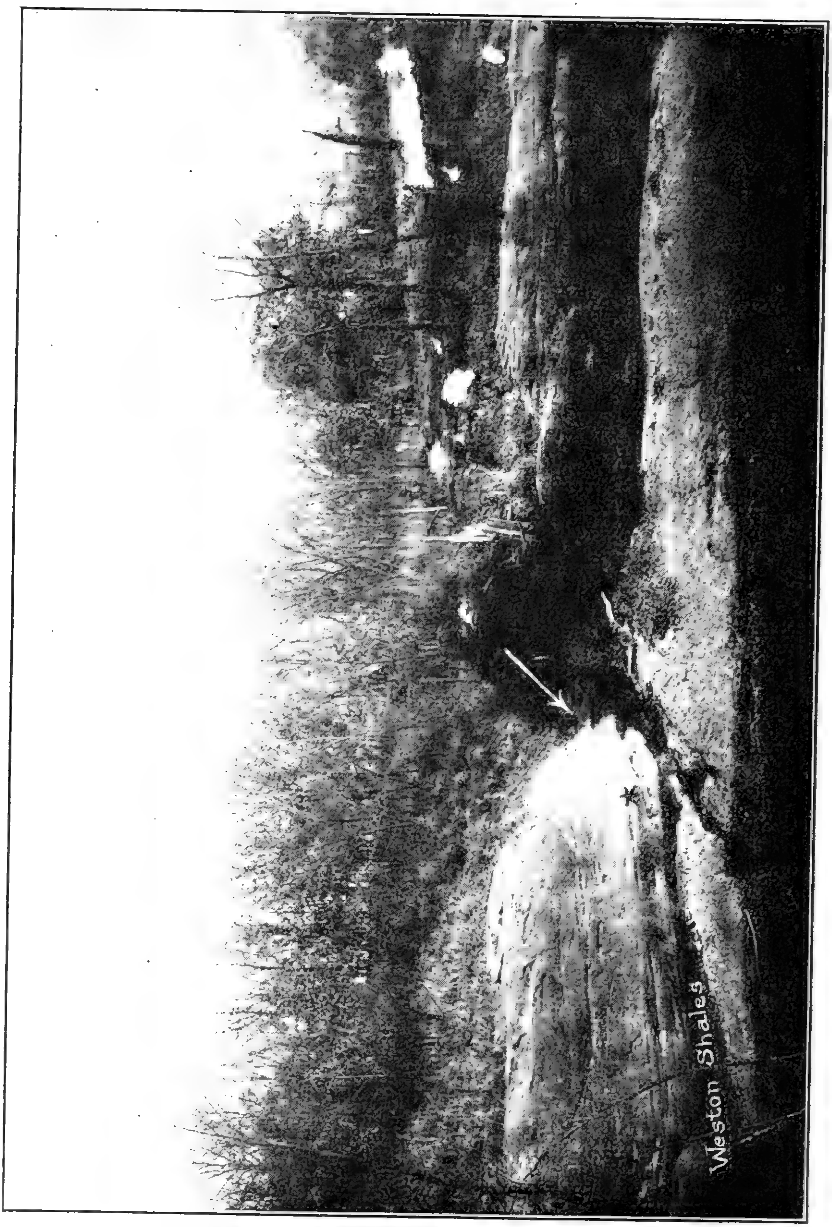
No. 7, a pes. The impressions below the pes represent a second impression, which was probably obliterated by the hind foot. The circle surrounding the footprints represents the edge of a three-inch depression in which the footprints occurred. This indicates both the great weight of the animal and the softness of the ground.

No. 8, a part of pes and manus, also occur in a depression three inches deep.

No. 9 shows two superimposed impressions of a fore and a hind foot. The greatest width of the hind foot is 135 mm.

No. 10 is a sketch of the appearance of the depression, showing the shape of the depression and the long furrows made by dragging blunt claws along a moist surface. Claws have been previously indicated in the remains of the larger Permian and Triassic amphibians, in the presence of blunt terminal rugose phalanges, but so far as I am aware no impressions of them have been so clearly recorded in the rocks of the Coal Measures.

PLATE II.



FOOTPRINTS OF A GIGANTIC AMPHIBIAN.
H. T. Martin.

EXPLANATION OF PLATE II.

Photograph of the east bank of the Wakarusa creek at Dightman's crossing, five miles southeast of Lawrence, Kan., showing the relation of the heavily bedded sandstone, in which the amphibian footprints were found, to the Weston shales which outcrop immediately at the edge of the water. The ravine in the center of the picture has a depth from the surface of twenty feet, and in this depression, on the ledge indicated at the point of the arrow, was found the series of footprints shown in the plate. This ledge at the position of the first track lies fourteen feet above the creek, but the stratum rises three feet between the first and the second impressions, between which there is an eroded interval of twelve feet. A further inclination of the stratum is indicated in the fact that there is a rise of four feet between the second and the last impressions, a distance of twenty-seven feet. The ledge on which the impressions were found is continued into the sandstone cliff immediately above the star (*).

FOOTPRINTS OF A GIGANTIC AMPHIBIAN.
H. T. Martin.

PLATE III.

Photographs of tracks Nos. 8 and 9, showing the imprint of both the front and the supraimposed hind foot on each impression.

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VOL. XIII.] JULY, 1922. [No. 13.

On Some Isothiourea Ethers.[1]

(Contribution from the Chemical Laboratory, University of Kansas.)

BY F. B. DAINS AND W. C. THOMPSON.

ONE of the characteristic reactions of the substituted thioureas is their ability to add directly alkyl halides, with the formation of halogen halide salts of bases, in which the alkyl group is joined to sulfur.[2]

$$RNHCSNHR + R'X = RNHC(SR')NR,HX.$$

From these salts, the free thiourea ethers can be obtained by the action of alkalies. As part of an investigation now in progress, it was deemed advisable to synthesize the n-propyl and n-butyl ethers of certain thioureas and, owing to the departure of one of the authors from this laboratory, to record these preliminary results at this time.

EXPERIMENTAL.

γ-PROPYL-α, β-DIPHENYL THIOUREA. $C_6H_5NHC(SC_3H_7)NC_6H_5$.

(n-Propyl ester of phenylimino-phenyl thiocarbamic acid.)

A mixture of thiocarbanilide (15 gms.) and normal propyl iodide (10 gms.) was heated on the water bath for an hour. The light-brown viscous liquid solidified on cooling. After crystallization from alcohol the hydrogen iodide salt was obtained in the form of colorless rhombic crystals, which melted at 103°. The salt was slightly soluble in ether, cold water and cold alcohol, but readily soluble in hot water, hot alcohol and acetone. The yield was 80 per cent.

Calc. for $C_{16}H_{18}N_2S,HI$: N, 6.93. Found: 7.09, 6.79.

The free base, which was insoluble in water, was obtained by

1. The authors wish to express their thanks to the research committee of the University for a grant which was of assistance in the prosecution of this work.

2. Ber. 14, 1490 (1881); 15, 1314 (1882); 21, 962, 1857 (1888).

neutralizing an aqueous solution of the salt with sodium hydroxide. The white needles, which separated from alcohol, melted at 61.5°.

Calc. for $C_{16}H_{18}N_2S$: N, 10.39. Found: 10.10, 10.16.

γ-n-Butyl-α, β-Diphenyl Thiourea. $C_6H_5NHC(SC_4H_9)NC_6H_5$.

The mixture of normal butyl iodide and diphenyl thiourea was heated on the steam bath for an hour. The salt, which solidified on cooling, could not be purified by crystallization. It was therefore ground up and thoroughly washed with ether, in which it was insoluble. The yield of the hydroiodide, which melted at 122°, was 83 per cent.

Calc. for $C_{17}H_{20}N_2S,HI$: N, 6.78. Found: 6.66, 6.68.

An aqueous solution of the salt was treated with sodium carbonate. The free base was obtained a heavy, colorless, noncrystallizable oil, which was readily soluble in the ordinary organic solvents.

Calc. for $C_{17}H_{20}N_2S$: N, 9.85. Found: 9.92, 9.95.

γ-n-Propyl-α, β-Di-p-Tolyl Thiourea. $C_7H_7NHC(SC_3H_7)NC_7H_7$.

Di-p-tolyl thiourea and normal propyl iodide reacted readily on warming and the resulting hydrogen iodide salt was purified by washing with cold alcohol. It then melted at 165°. The yield was 88 per cent.

Calc. for $C_{18}H_{22}N_2S,HI$: N, 6.57. Found: 6.29, 6.51.

The salt was freely soluble in water and the thio ether, precipitated by the addition of alkali, crystallized from alcohol in fine, white needles which had a melting point of 99°.

Calc. for $C_{18}H_{22}N_2S$: N, 9.36. Found: 9.18, 9.35.

γ-n-Butyl-α, β-Di-p-Tolyl Thiourea. $C_7H_7NHC(SC_4H_9)NC_7H_7$.

The hydrogen iodide salt, which was obtained in a 95 per cent yield from the normal butyl iodide and the thiourea, melted at 145°.

Calc. for $C_{19}H_{24}N_2S,HI$; N, 6.36. Found: 6.35, 6.35.

The free base formed by neutralizing an alcoholic solution of the salt was a thick, colorless liquid, insoluble in water but soluble in organic solvents.

Calc. for $C_{19}H_{24}N_2S$: N, 8.97. Found: 9.12, 9.33.

γ-n-Propyl-α, β-Di-2, 4-Dimethyl-Phenyl Thiourea.
$(CH_3)_2C_6H_3NHC(SC_3H_7)NC_6H_3(CH_3)_2$.

Di-m-xylyl thiourea and normal propyl iodide reacted easily on warming, but the product, which was obtained in 87 per cent yield, proved to be the free base and not its salt. This when purified from alcohol melted at 113.5°.

Calc. for $C_{22}H_{28}N_2S$: N, 8.58. Found: 8.46, 8.46.

THIOETHERS FROM UREAS CONTAINING TWO DIFFERENT GROUPS.

γ-Methyl-α-p-Bromophenyl-β-Phenyl Thiourea.

$C_6H_5NHC(SCH_3)NC_6H_4Br$ or $C_6H_5NC(SCH_3)NHC_6H_4Br$.

The unsymmetrical nature of the mol did not prevent the addition of the alkyl iodide, since when methyl iodide and phenyl-p-bromophenyl thiourea were heated under the usual conditions a yield of 69 per cent of the hydrogen iodide salt was obtained. It melted at 152°.

Calc. for $C_{14}H_{13}N_2SBr,HI$; N, 6.24. Found: 6.04, 6.27.

The thioether was preciptated when an alcoholic solution of the salt was made alkaline with sodium carbonate and then diluted with water. When purified, the white needles melted at 79°.

Calc. for $C_{14}H_{13}N_2SBr$; N, 8.72. Found: 8.54, 8.77.

γ-n-Propyl-α-p-Bromophenyl-β-Phenyl Thiourea.

$C_6H_5NHC(SC_3H_7)NC_6H_4Br$.

Normal propyl iodide and the thiourea united to form a salt, which, however, failed to crystallize, but remained as a heavy, red oil.

Calc. for $C_{16}H_{17}N_2SBr,HI$; N, 5.88. Found: 5.46.

The thioether, which was isolated in a 70 per cent yield, melted at 84°, after purification from alcohol.

Calc. for $C_{16}H_{17}N_2SBr$; N, 8.02. Found: 8.09, 8.07.

γ-n-Butyl-α-p-Bromophenyl-β-Phenyl Thiourea.

$C_6H_5NHC(SC_4H_9)NC_6H_4Br$.

The hydrogen iodide salt from the thiourea and the normal butyl iodide separated in this case also as a thick noncrystallizable oil.

Calc. for $C_{17}H_{19}N_2SBr,HI$; N, 5.70. Found: 5.37, 5.62.

The free base obtained in the usual manner was a viscid oil, soluble in alcohol and ether.

Calc. for $C_{17}H_{19}N_2SBr$; N, 7.71. Found: 7.72, 7.52.

γ-n-Butyl-Monophenyl Thiourea. $C_6H_5NHC(SC_4H_9)NH$.

When monophenyl thiourea and normal butyl iodide were warmed on the water bath, a gummy mass was obtained. This was dissolved in hot alcohol and neutralized with sodium carbonate. On dilution with water the thiourea was precipitated as a heavy oil, which failed to crystallize.

Calc. for $C_{11}H_{16}N_2S$; N, 12.72. Found: 13.03, 13.05.

SUMMARY.

A number of new alkyl ethers of substituted thioureas have been prepared. While usually these ethers are solid crystalline compounds, the normal butyl derivatives thus far isolated are basic oils. The di-m-xylyl thiourea gave the free base and not the hydrogen iodide salt with normal propyl iodide.

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The Size of the Thymus Gland in Relation to the Size and Development of the Foetal Pig as Studied in a Varied Range of Stages.

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INTRODUCTION.

THE thymus gland has long been a favorite subject for study and for speculation as to its function and possible effect upon growth. Much work has been done in extirpation of the gland in postnatal animals in order to note the effect upon metabolism. Different results have been obtained as different species of animals were examined, depending largely upon the time of involution of the gland in that particular animal. H. Matti (1) found that extirpation of the thymus in pups (eighteen days to eight weeks in age) caused slowness of movement, muscular weakness, softness of bones, bone changes resembling those in rickets, and subsequent death. Almost similar results were reported by Basch (2). Such findings would seem to indicate a direct effect upon bone formation, and accordingly upon the size of the animal. That the size of thymus is correlated with size of animal (*i. e.*, in individuals below age of involution stage) is evidently accepted as probable by Badertscher (3), who states in a description of a sketch that "[above is an] outline drawing of the exposed left thymus of a 'runty' pig, one day old and only 240 mm. in length; the thymus in this specimen was a few millimeters shorter than that in the full-term embryo; this is perhaps due to the fact that the specimen was a 'runt.'" On the contrary, Hatai (4), in a study of postnatal rat thymi, states that "the weight of the thymus is correlated with the *age* of the rat rather than the body weight," thus showing a counter finding.

This problem, then, was deemed worthy of investigation, and for study the fœtal pig was chosen, largely because it shows the typical mammalian characteristics and because little work of any sort has been attempted with the fœtal pig; then, too, the material was fairly easily obtained and was found to be highly satisfactory. Since the pig had been selected, a further phase of the subject arose, and its importance became evident: as yet (as we believed after a search through literature) no one had studied the thymus in any great number of fœtal pigs and had tabulated measurements and thus secured normal averages and percentages. Such tables of averages, etc., we recognized to be of great value as a basis for further work in this direction or in any phase of thymus work in pigs. Extensive work of this sort has been done by Hatai (5) and by Jackson (6) in albino rats, and by others.

Therefore, it is with this twofold purpose that this paper is presented: (1) to give our findings as to the relation of the size of the thymus gland to the size of the fœtal pig, and (2) to furnish, as a possible basis for further research, tables of measurements and weights of many individual pig fœti of various sizes, with the measurements and weights of their thymi and individual and group averages. We hope to further continue the study to include postnatal pigs; in this study a further object of interest will be the determination of the time of the involution stage, since such time would be expected to lie in the postnatal period.

METHODS OF OBTAINING SPECIMENS AND LABORATORY TECHNIQUE USED.

Specimens were obtained from the plant of the Armour Packing Company in Kansas City, Kan. The collectors went on the killing floor of the plant, secured suitable uteri, removed the fœti, tied the umbilical cords, and put the pigs into a preservative solution (formaldehyde) ready for shipping. Litters were kept separate by means of cheesecloth bags for individual litters. Care was taken to get fœti of as wide a range of lengths as possible, varying from 9.5 to 28.5 centimeters.

In the laboratory each pig was weighed, its length recorded (head to rump measurement taken), and its sex determined; then each pig was given a litter letter and a serial number, and tagged so that future identification was possible. The remaining procedure in the actual bulk of the work was simple, and the dissection progressed rather rapidly once the technique was mastered, and an exact idea of the extent of the thymus was secured. The neck and upper thoracic region of the body were stripped of skin, and the thymus beneath (easily seen) dissected away from the surrounding tissue. The gland was then washed, dried superficially on filter paper, and weighed. This process was carried out on almost 150 pigs, and tables and curves were made and studied to determine tendencies.

RELIABILITY OF RESULTS.

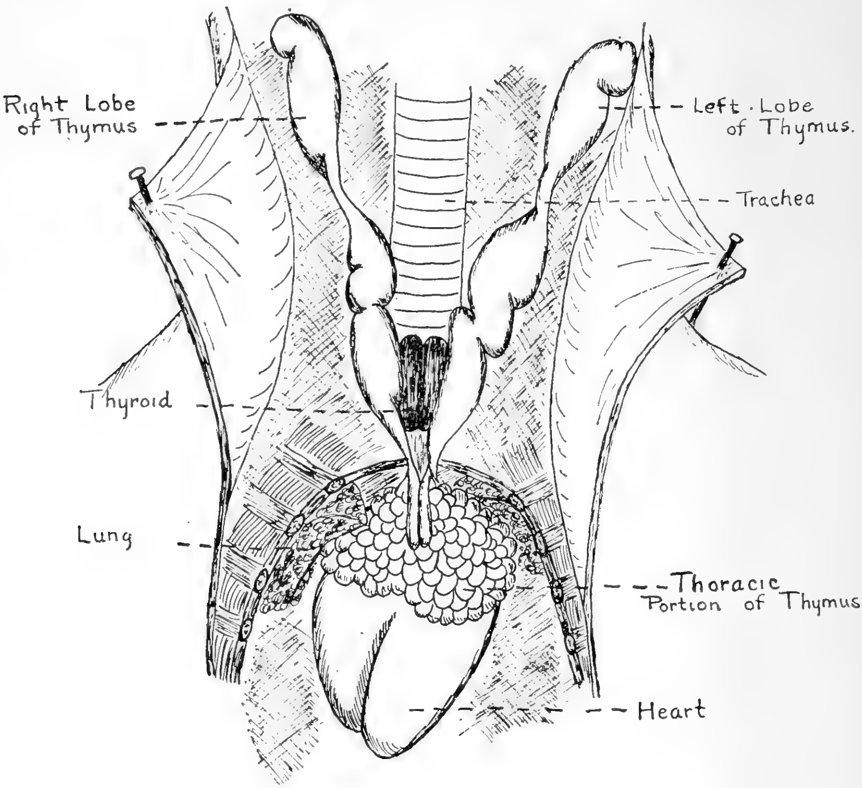
Before going into the body of the report it may be well to consider just how reliable were the results obtained, and wherein lay sources of error. (1) In the weighing of the pigs, some of them may have absorbed more of the formaldehyde preservative than others; some may have lost more of their body fluids than others. This error seems to us, however, as negligible. (2) The chemical balances used were not of the best, and, too, the thymi may not have received exactly the same treatment after removal from the pig, although every effort was put forth to secure uniformity. To this end, all weighings (practically) were made by one operator. (3) Lengths of the pigs may not be entirely accurate, although here, too, the greatest care possible was taken to secure exactness. (4) Lastly, incomplete removal of the thymus, or removal of other tissue as thymus, may have occurred in some cases. The greatness of this error depends, of course, upon the skill of the workers, and it is their hope that this has been a negligible factor of error. Taking all in all, then, it is extremely probable that the material and data to be set forth are accurate to this degree, that they may be taken as the basis for conclusions of a definite nature. Such conclusions are, in our minds, accurate and reliable enough to merit consideration.

THE THYMUS: ITS GENERAL SHAPE AND EXTENT.

It was not our purpose to study the structure of the thymus in any detail, and this part of the report is merely made in passing, without any attempt at thoroughness. Our findings seem to be similar in many respects to those of Badertscher (3) as to the anatomy of the gland.[1] In the fœtal pig it is comparatively very long, extending usually from a point over the upper half or third of the heart, underneath the sternum (as viewed from the ventral side), and up to the base of the mandible. The portion covering the heart is strongly attached to the pericardium; it is roughly triangular in shape, with the apex pointing posteriorly, and lies mainly to the left of the median line. The anterior end of this, the thoracic

1. In a further paper (7) Badertscher discusses the development of the thymus in the pig from the standpoint of histogenesis.

portion of the gland, narrows down, and the thymus appears beneath the sternum as two slender, parallel ribbons of glandular tissue. Once into the neck region, however, these two ribbons become very much larger and diverge, passing anteriorly to the base of the mandible, one on each side. In the thyroid region they parallel each other closely, lying on opposite sides of the thyroid, and thus fairly close to the median line. Then each passes from here into deeper tissue and obliquely away from the median line, ending behind the mandible. The thymus seems to be made up of many small lobules, combined into larger lobes. The accompanying sketch will give, perhaps, a clearer idea of the form of the gland.



SKETCH of the THYMUS in SITU

TABLE NO. 1.

Table No. 1 shows the original data as taken in the laboratory concerning each pig, together with individual averages, sex averages, and litter averages. From the table all the derivations and calculations of the report will be taken. Its value lies largely in reference, and will not be used much to point out conclusions. However, it is well to note from it the number of pigs dissected, namely, 147 from 18 different litters.

Relation of Sex to Thymus.

An examination of the averages listed beneath each litter in table No. 1 will readily show, in regard to sex, that males and females have practically the same percentage of thymus in the same stage of development. Consider particularly the percentage thymus by weight as balanced against the length of the pig, and this statement becomes evident. It is true that in several of the litters the females have the greater percentage of gland, but this tendency is practically balanced by the fact that many of the litters show approximately equal averages for males and females, and others show the balance in favor of the males. If our results be taken to show any positive tendency at all, it is that the females have the larger thymi (proportionally), but the writers believe that this is due to the small number of pigs dissected, and that such a positive tendency is too weak to merit much consideration. As such, special curves and tables have not been made for this part of the report. Notwithstanding, Hatai (4) in relevant material states that "so far as our present data are concerned, the thymus gland of the female of the albino rat appears to be slightly heavier than that of the male; nevertheless, the difference found is too slight to justify treating the sexes separately."

TABLE No. 1.

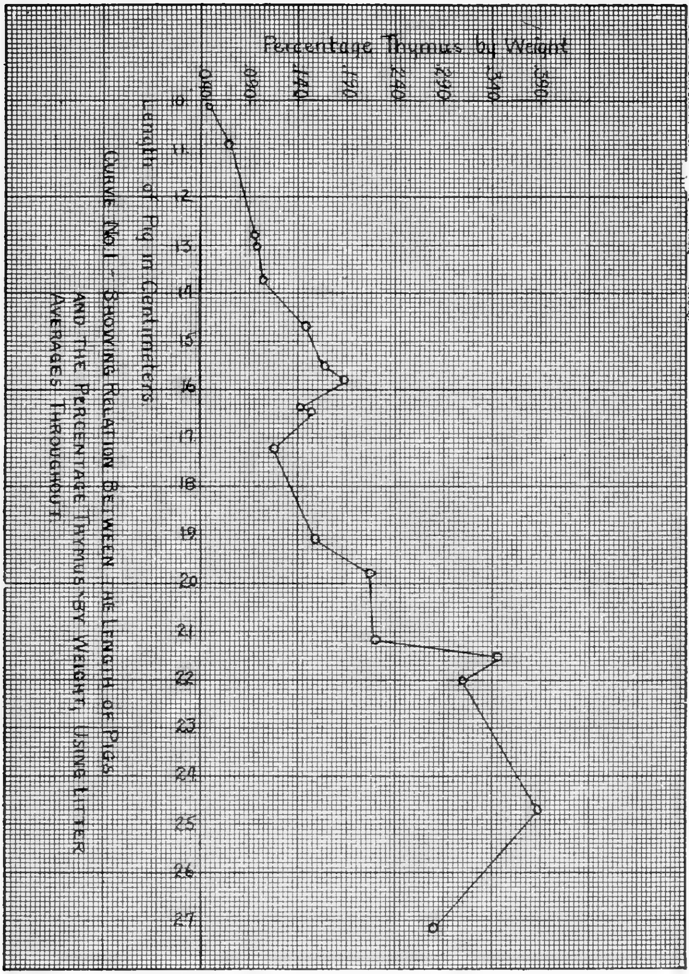
Pig.	Sex.	Pig length in cms.	Thymus length in cms.	Per cent by length.	Pig weight in grams.	Thymus weight in grams.	Per cent by weight.
1 A1	Male	15.5	4.0	25.8	235	.310	.132
2 A2	Male	15.0	3.75	25.0	192	.454	.236
3 A3	Male	15.5	3.8	24.5	233	.255	.109
4 A4	Male	15.5	3.8	24.5	202	.260	.129
5 A5	Male	16.0	4.0	25.0	212	.295	.134
6 A6	Female	17.5	4.5	25.7	265	.503	.189
7 A7	Female	16.0	3.5	21.9	237	.636	.268
8 A8	Male	16.0	3.7	23.1	228	.325	.143
9 A9	Male	16.5	3.7	22.4	243	.402	.165
10 A10	Male	15.5	3.8	24.5	228	.295	.129
11 A11	Male	14.0	3.5	25.0	174	.205	.118
12 A12	Male	16.0	3.8	23.8	234	.350	.150
13 A13	Male	11.5	2.3	20.0	102	.140	.137
14 A14	Male	17.0	4.5	26.5	265	.661	.287
Averages	Male, 86 per cent	15.3	3.72	24.2	212	.329	.156
	Female, 14 per cent	16.8	4.0	23.8	251	.569	.229
	Litter	15.5	3.8	24.1	218	.364	.166
15 B1	Male	11.0	2.5	22.7	100	.070	.070
16 B2	Female	11.0	2.75	25.0	102	.095	.093
17 B3	Female	10.0	2.5	25.0	76	.031	.041
18 B4	Male	10.5	....	....	89	....	....
19 B5	Female	11.0	2.75	25.0	90	.070	.078
Averages	Male, 40 per cent	11.0	2.5	22.7	100	.070	.070
	Female, 60 per cent	10.7	2.7	25.0	89	.065	.071
	Litter	10.9	2.6	24.4	92	.067	.071
20 C1	Female	11.5	2.5	21.7	107	.120	.112
21 C2	Male	13.0	2.5	19.2	145	.121	.083
22 C3	Female	13.5	2.7	20.0	136	.130	.096
23 C4	Female	13.0	2.5	19.2	123	.150	.122
24 C5	Male	13.0	2.5	19.2	122	.130	.107
25 C6	Male	14.0	3.5	25.0	164	.150	.091
26 C7	Female	14.0	4.0	28.6	143	.134	.094
27 C8	Male	11.5	2.5	21.7	102	.110	.108
28 C9	Male	13.5	3.25	24.1	164	.158	.096
Averages	Male, 56 per cent	13.0	2.85	21.8	139	.134	.097
	Female, 44 per cent	13.0	2.9	22.3	127	.134	.106
	Litter	13.0	2.9	22.1	134	.134	.101
29 D1	Male	25.0	6.5	26.0	752	2.986	.397
30 D2	Male	25.0	7.0	28.0	771	2.580	.334
31 D3	Male	25.0	7.5	30.0	815	2.860	.351
32 D4	Female	25.0	7.0	28.0	843	3.550	.421
33 D5	Male	23.5	7.0	29.8	669	2.788	.417
Averages	Male, 80 per cent	24.6	7.0	28.5	752	2.804	.375
	Female, 20 per cent	25.0	7.0	28.0	843	3.550	.421
	Litter	24.7	7.0	28.4	770	2.953	.384
34 E1	Female	14.5	3.4	23.5	184	.276	.150
35 E2	Female	15.0	3.5	23.3	196	.268	.137
36 E3	Male	15.0	3.5	23.3	211	.238	.113
37 E4	Male	15.0	3.5	23.3	208	.410	.197
38 E5	Male	16.0	3.5	21.9	195	.250	.128
39 E6	Male	12.5	3.0	24.0	126	.180	.143
Averages	Male, 67 per cent	14.6	3.4	23.1	185	.269	.145
	Female, 33 per cent	14.8	3.4	23.4	190	.272	.144
	Litter	14.7	3.4	23.2	187	.270	.145
40 F1	Female	13.5	3.0	22.2	122	.125	.102
41 F2	Female	13.5	3.0	22.2	130	.214	.165
42 F3	Male	13.0	3.0	23.1	115	.184	.160
43 F4	Male	13.0	3.2	24.6	115	.085	.074
44 F5	Female	13.0	3.2	24.6	120	.115	.096
45 F6	Male	13.0	2.5	19.2	102	.080	.078
46 F7	Male	12.0	2.75	22.9	95	.068	.072
47 F8	....	13.5	....	....	....	....	....
48 F9	Male	13.5	3.0	22.2	140	.082	.059
49 F10	Female	12.5	3.2	25.6	120	.108	.090
50 F11	Female	11.0	2.5	22.7	83	.072	.087
51 F12	Male	13.0	3.3	25.4	126	.117	.093
52 F13	Female	12.0	2.6	21.7	96	.085	.089
Averages	Male, 50 per cent	12.9	2.96	22.9	116	.103	.089
	Females, 50 per cent	12.6	2.9	23.2	112	.120	.105
	Litter	12.8	3.0	23.0	114	.111	.097

TABLE No. 1—CONTINUED.

Pig.	Sex.	Pig length in cms.	Thymus length in cms.	Per cent by length.	Pig weight in grams.	Thymus weight in grams.	Per cent by weight.
53 G1		22.0	6.0	27.3	635	3.241	.510
54 G2		22.0	5.5	25.0	549	1.280	.233
55 G3		22.0	6.2	28.2	665	1.900	.286
56 G4	Males, 5	22.0	6.0	27.3	658	2.914	.443
57 G5	Females, 3	21.5	5.8	27.0	640	1.999	.312
58 G6		21.5	5.5	25.6	581	2.379	.409
59 G7		22.0	6.0	27.3	635	2.205	.347
60 G8		19.0	5.2	27.4	346	.755	.218
Averages	Male, 63 per cent Female, 37 per cent	21.5	5.8	26.9	589	2.084	.345
61 H1	Male	17.0	4.5	26.5	251	.305	.122
62 H2	Male	16.0	4.3	26.9	257	.420	.163
63 H3	Female	16.5	4.0	24.2	271	.751	.277
64 H4	Male	12.5	3.3	26.4	118	.133	.112
65 H5	Male	13.5	4.0	29.6	154	.323	.209
66 H6	Female	16.0	4.0	25.0	235	.519	.221
67 H7	Male	17.5	4.5	25.7	318	.705	.222
68 H8	Male	14.0	3.2	22.9	159	.205	.129
69 H9	Male	18.0	4.5	25.0	316	.847	.268
70 H10	Male	16.5	3.8	23.0	245	.410	.168
	Male, 80 per cent	15.6	4.0	25.8	227	.419	.174
Averages	Female, 20 per cent	16.25	4.0	24.6	253	.635	.249
	Litter	15.8	4.0	25.5	232	.462	.189
71 I1	Male	14.0	3.7	26.4	137	.137	.100
72 I2	Female	13.5	2.9	21.5	135	.170	.126
73 I3	Female	14.0	3.5	25.0	125	.114	.091
74 I4	Male	14.0	3.5	25.0	150	.160	.107
75 I5	Male	13.5	3.2	23.7	145	.120	.083
76 I6	Female	13.5	3.1	23.0	137	.155	.113
77 I7	Female	13.5	3.2	23.7	145	.160	.110
78 I8	Male	13.5	3.3	24.4	143	.142	.099
	Male, 50 per cent	13.8	3.4	24.9	144	.140	.097
Averages	Female, 50 per cent	13.6	3.2	23.3	136	.150	.110
	Litter	13.7	3.3	24.1	140	.145	.104
79 J1	Male	17.0	4.3	25.3	267	.332	.124
80 J2	Male	18.5	4.3	23.2	295	.385	.131
81 J3	Male	17.0	4.5	26.5	285	.320	.112
82 J4	Male	17.5	4.0	22.9	255	.340	.113
83 J5	Female	17.5	4.0	22.9	245	.228	.094
84 J6	Female	17.0	4.0	23.5	250	.232	.093
85 J7	Male	17.0	4.0	23.5	228	.260	.114
86 J8	Male	16.0	4.0	25.0	205	.280	.137
	Male, 75 per cent	17.17	4.2	24.4	256	.319	.122
Averages	Female, 25 per cent	17.25	4.0	23.2	248	.230	.093
	Litter	17.2	4.1	24.1	254	.297	.115
87 K1	Male	19.5	5.5	28.2	440	.750	.170
88 K2	Male	20.0	4.5	22.5	460	.813	.177
89 K3	Female	20.0	5.0	25.0	430	1.055	.245
90 K4	Female	20.0	4.5	22.5	420	.820	.195
91 K5	Male	19.5	4.3	22.5	405	1.115	.275
	Male, 60 per cent	19.7	4.7	24.4	435	.893	.207
Averages	Female, 40 per cent	20.0	4.8	23.8	425	.938	.220
	Litter	19.8	4.76	24.1	431	.911	.212
92 L1	Male	16.5	4.4	26.7	270	.432	.160
93 L2	Male	16.5	4.4	26.7	245	.392	.160
94 L3	Female	17.0	4.2	24.7	270	.335	.124
95 L4	Male	16.5	3.5	21.2	250	.407	.163
96 L5	Male	16.5	4.3	26.0	250	.370	.148
97 L6	Female	16.5	4.2	25.5	240	.365	.152
98 L7	Male	16.5	4.5	27.3	250	.365	.146
99 L8	Male	15.5	3.6	23.2	125	.200	.160
	Male, 75 per cent	16.3	4.1	25.2	232	.361	.156
Averages	Female, 25 per cent	16.8	4.2	25.1	255	.350	.138
	Litter	16.4	4.1	25.1	238	.358	.152
100 M1	Male	21.5	6.0	27.9	515	1.220	.237
101 M2	Female	21.0	5.3	25.2	515	.920	.179
102 M3	Female	20.5	5.4	26.3	445	1.032	.232
103 M4	Female	21.0	5.3	25.2	475	1,183	.250
104 M5	Male	21.0	5.5	26.2	445	.887	.200
105 M6	Male	19.0	5.3	27.9	342	.685	.200
106 M7	Male	22.5	5.5	24.9	550	1.315	.239
107 M8	Male	22.0	5.5	25.0	500	1.255	.251
108 M9	Male	22.0	5.5	25.0	420	.772	.184
	Male, 67 per cent	21.3	5.55	26.2	462	1.014	.218
Averages	Female, 33 per cent	20.8	5.3	25.6	478	1.045	.220
	Litter	21.2	5.48	26.0	467	1.030	.219

TABLE No. 1—CONCLUDED.

Pig.	Sex.	Pig length in cms.	Thymus length in cms.	Per cent by length.	Pig weight in grams.	Thymus weight in grams.	Per cent By weight.
109 N1	Female	19.0	4.5	23.7	400	.710	.178
110 N2	Male	19.5	4.6	23.6	360	.517	.144
111 N3	Male	19.0	4.8	25.3	420	.580	.138
112 N4	Male	19.5	5.0	25.6	430	.550	.128
113 N5	Male	18.5	4.5	24.3	360	.466	.130
114 N6	Male	18.5	4.5	24.3	380	.635	.167
115 N7	Female	19.0	4.3	22.6	395	.805	.204
116 N8	Male	19.5	5.0	25.6	407	.672	.165
Averages	Male, 75 per cent	19.1	4.7	24.8	393	.570	.145
	Female, 25 per cent	19.0	4.4	23.1	398	.757	.172
	Litter	19.1	4.65	24.4	394	.617	.157
117 O1	Male	14.0	3.5	25.0	170	.180	.106
118 O2	Female	17.0	4.7	27.6	275	.602	.219
119 O3	Female	16.5	4.2	25.5	280	.405	.145
120 O4	Male	16.0	4.6	28.7	230	.255	.111
121 O5	Female	16.0	4.2	26.3	263	.426	.162
122 O6	Female	17.0	4.1	24.1	262	.425	.162
123 O7	Male	18.0	4.5	25.0	313	.370	.118
124 O8	Female	16.5	4.1	24.8	290	.351	.121
Averages	Male, 38 per cent	16.0	4.2	26.2	238	.268	.112
	Female, 62 per cent	16.6	4.3	25.7	274	.442	.162
	Litter	16.4	4.2	25.9	260	.377	.143
125 P1	Male	24.5	6.4	26.1	735	2.285	.311
126 P2	Female	24.0	6.0	25.0	700	2.135	.305
127 P3	Female	23.5	6.0	25.5	590	1.610	.273
128 P4	Female	23.5	6.0	25.5	665	1.940	.292
129 P5	Female	24.5	6.0	24.5	675	1.975	.293
130 P6	Female	21.5	5.0	23.3	495	1.540	.311
131 P7	Female	20.5	5.5	26.8	435	1.375	.316
132 P8	Female	23.5	6.3	26.8	740	2.002	.271
133 P9	Male	22.0	6.1	27.7	620	1.930	.311
Averages	Male, 22 per cent	23.3	6.3	26.9	678	2.108	.311
	Female, 78 per cent	23.0	5.8	25.3	614	1.797	.294
	Litter	23.1	5.9	25.7	628	1.866	.298
134 Q1	Male	9.5	2.3	24.2	55	.019	.035
135 Q2	Male	10.5	2.5	23.8	68	.040	.059
136 Q3	Male	10.0	2.3	23.0	66	.032	.048
137 Q4	Female	10.0	2.2	22.0	63	.029	.046
138 Q5	Female	10.5	2.3	21.9	63	.022	.035
139 Q6	Male	10.0	2.4	24.0	63	.025	.040
140 Q7	Female	10.0	2.5	25.0	61	.035	.057
141 Q8	Female	10.5	2.5	23.8	61	.032	.052
Averages	Male, 50 per cent	10.0	2.4	23.8	63	.029	.046
	Female, 50 per cent	10.3	2.4	23.2	62	.030	.048
	Litter	10.1	2.4	23.5	63	.029	.047
142 R1	Male	27.0	9.0	33.3	1,098	2.480	.226
143 R2	Male	25.5	7.0	27.5	693	1.549	.224
144 R3	Male	27.5	8.0	29.1	932	3.365	.361
145 R4	Male	27.5	7.5	27.3	999	3.010	.301
146 R5	Female	26.5	8.6	32.5	925	2.500	.270
147 R6	Male	28.5	9.0	31.6	1,035	2,972	.287
Averages	Male, 83 per cent	27.2	8.1	29.8	951	2,675	.280
	Female, 17 per cent	26.5	8.6	32.5	925	2.500	.270
	Litter	27.1	8.2	30.2	947	2.646	.278


Percentage Thymus by Weight
.040
.090
.140
.190
.240
.290
.340
.390
Length of Pig in Centimeters
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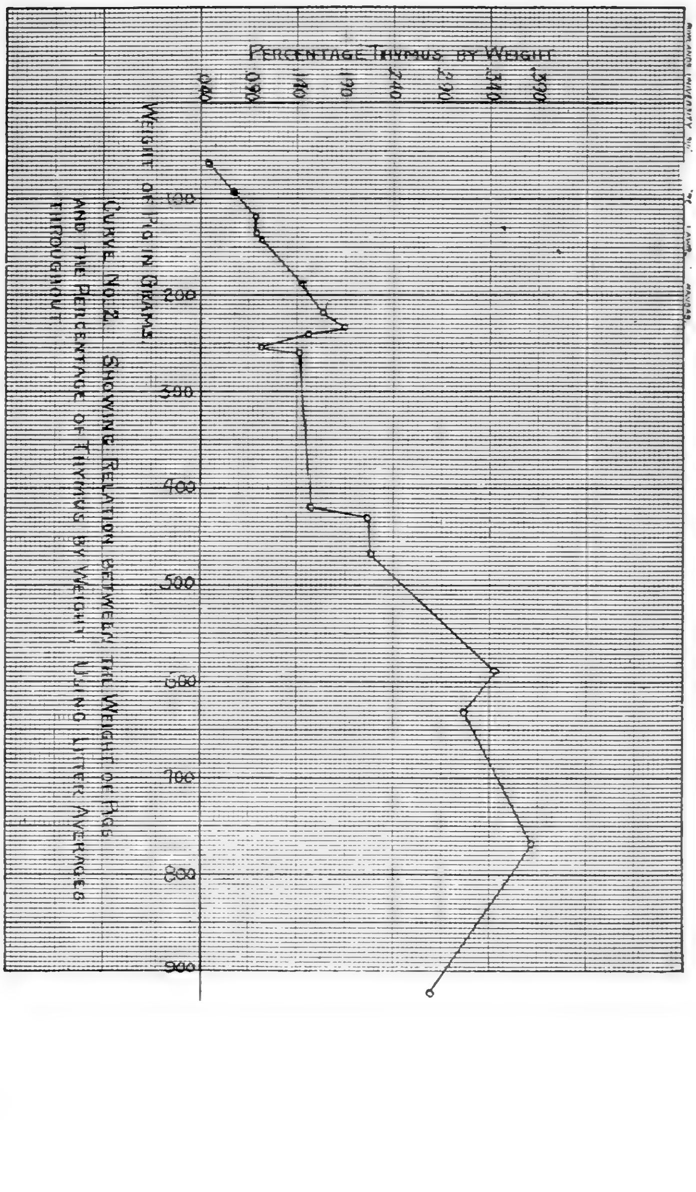
Curve No 1 - Showing Relation Between the Length of Pigs
and the Percentage Thymus by Weight, Using Litter
Averages Throughout

Relation Between the Length of Pigs and the Percentage Thymus by Weight, Using Litter Averages Throughout.

Table No. 2 and curve No. 1 are to be considered in this connection. Curve No. 1 shows that as litters made up of larger and larger fœti, as regards length, are examined, the percentage thymus by weight increases steadily. There is a marked drop near the center of the curve which cannot be explained, but it does not obscure the general tendency of an increase in percentage thymus by weight. It will be noted that the value for the litter of pigs of average length, 27.1 centimeters, has dropped quite appreciably. Whether or not this means that at 24 cm. or 25 cm. the gland reaches its greatest stage of development we do not know; not enough pigs longer than 25 cm. were examined. It would be an interesting problem to work out to see at just what stage the thymus development ceases, and when it commences to atrophy.

TABLE No. 2.

Litter.	Pig length in cms.	Thymus length in cms.	Per cent by length.	Pig weight in gms.	Thymus weight in gms.	Per cent by weight.
Q	10.1	2.4	23.5	63	.029	.047
B	10.9	2.6	24.4	92	.067	.071
F	12.8	3.0	23.0	114	.111	.097
C	13.0	2.9	22.1	134	.134	.101
I	13.7	3.3	24.1	140	.145	.104
E	14.7	3.4	23.2	187	.270	.145
A	15.5	3.8	24.1	218	.364	.166
H	15.8	4.0	25.5	232	.462	.189
L	16.4	4.1	25.1	238	.358	.152
O	16.4	4.2	25.9	260	.377	.143
J	17.2	4.1	24.1	254	.297	.115
N	19.1	4.7	24.4	419	.617	.157
K	19.8	4.8	24.1	431	.911	.212
M	21.2	5.5	26.0	467	1.030	.219
G	21.5	5.8	26.9	589	2.084	.345
P	22.0	6.1	27.7	628	1.930	.311
D	24.7	7.0	28.4	770	2.953	.384
R	27.1	8.2	30.2	947	2.646	.278



CURVE NO. 2. SHOWING RELATION BETWEEN THE WEIGHT OF PIGS AND THE PERCENTAGE OF THYMUS BY WEIGHT, USING LITTER AVERAGES THROUGHOUT.

Relation Between the Weight of Pigs and the Percentage Thymus by Weight, Using Litter Averages Throughout.

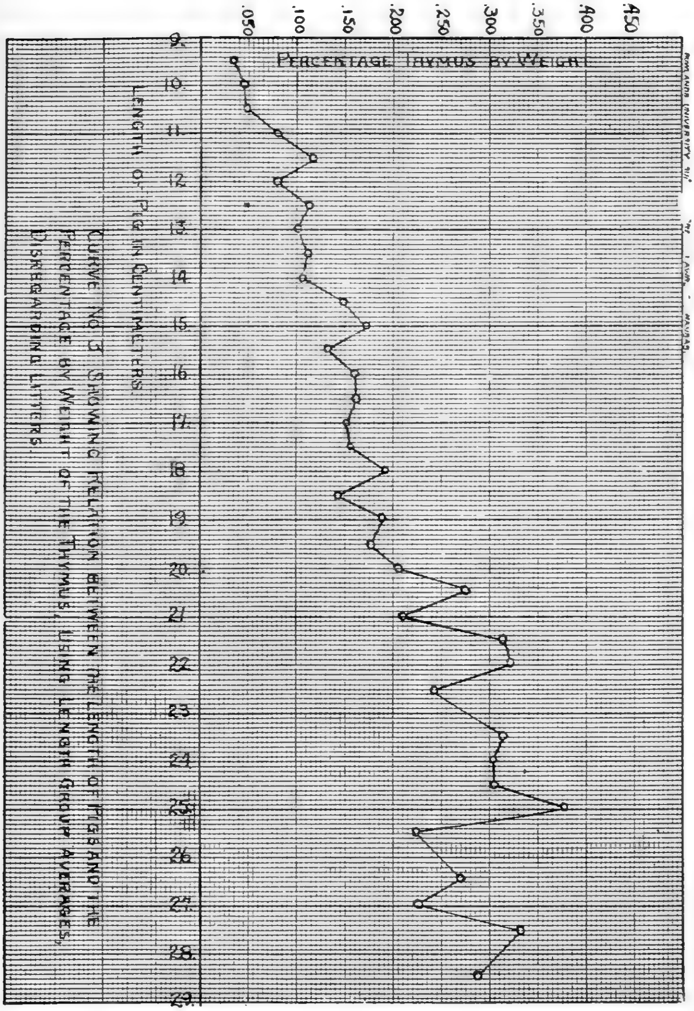
Table No. 3 and curve No. 2 show practically the same tendency as to table No. 2 and curve No. 1, *i. e.*, as heavier and heavier pigs are examined, the percentage of thymus by weight increases steadily. There is practically the same inexplicable deviation or drop near the center of the curve, and the possible maximum point centering about pigs of a weight of 770 grams.

TABLE No. 3.

Litter.	Pig weight in gms.	Thymus weight in gms.	Per cent by weight.	Pig length in cms.	Thymus length. in cms.	Per cent by length.
Q	63	.029	.047	10.1	2.4	23.5
B	92	.067	.071	10.9	2.6	24.4
F	114	.111	.097	12.8	3.0	23.0
C	134	.134	.101	13.0	2.9	22.1
I	140	.145	.104	13.7	3.3	24.1
E	187	.270	.145	14.7	3.4	23.2
A	218	.364	.166	15.5	3.8	24.1
H	232	.462	.189	15.8	4.0	25.5
L	238	.358	.152	16.4	4.1	25.1
J	254	.297	.115	17.2	4.1	24.1
O	260	.377	.143	16.4	4.2	25.9
N	419	.617	.157	19.1	4.7	24.4
K	431	.911	.212	19.8	4.8	24.1
M	467	1.030	.219	21.2	5.5	26.0
G	589	2.084	.345	21.5	5.8	26.9
P	628	1.930	.311	22.0	6.1	27.7
D	770	2.953	.384	24.7	7.0	28.4
R	947	2.646	.278	27.1	8.2	30.2

Relation Between the Length of Pigs and the Percentage by Weight of the Thymus, Using Length Group Averages Throughout, Disregarding Litters.

Table No. 4 and curve No. 3 show that as larger and larger fœti (as regards length) are examined and classified regardless of litter, there is a steady increase in the percentage thymus by weight. The increase is not as uniform, however, as when the pigs are classified according to litter, as will be shown by a comparison of curve No. 1 with curve No. 3. The former is the smoother. Hence from these calculations on lengths, we may conclude that pigs tend to have the same size thymus, relatively, as that of other pigs of the same litter, regardless of individual pig lengths.



CURVE NO. 3 SHOWING RELATION BETWEEN THE LENGTH OF PIGS AND THE PERCENTAGE BY WEIGHT OF THE THYMUS, USING LENGTH GROUP AVERAGES, DISREGARDING LITTERS.

TABLE No. 4.

Class.	Pig.	Per cent thymus by weight.	Pig weight in gms.	Per cent thymus by length.
9.5 cm....	Q1	.035	55	24.2
	Avg.	.035	55	24.2
10.0 cm....	Q7	.057	61	25.0
	Q6	.040	63	24.0
	Q4	.046	63	22.0
	Q3	.048	66	23.0
	B3	.041	76	25.0
	Avg.	.046	66	24.0
10.5 cm....	Q8	.052	61	33.8
	Q5	.035	63	21.9
	Q2	.059	68	23.8
	Avg.	.049	64	26.5
11.0 cm....	F11	.087	83	22.7
	B5	.078	90	25.0
	B1	.070	100	22.7
	B2	.093	102	25.0
	Avg.	.082	94	23.9
11.5 cm....	C8	.108	102	21.7
	A13	.137	102	20.0
	C1	.112	107	21.7
	Avg.	.119	104	21.1
12.0 cm....	F7	.072	95	22.9
	F13	.089	96	21.7
	Avg.	.081	95.5	22.3
12.5 cm....	H4	.112	118	26.4
	F10	.090	120	25.6
	E6	.143	126	24.0
	Avg.	.115	121	25.3
13.0 cm....	F6	.078	102	19.2
	F4	.074	115	24.6
	F3	.160	115	23.1
	F5	.096	120	24.6
	C5	.107	122	19.2
	C4	.122	123	19.2
	F12	.093	126	25.4
	C2	.083	145	19.2
	Avg.	.102	121	21.8
13.5 cm....	F1	.102	122	22.2
	F2	.165	130	22.2
	I2	.126	135	21.5
	C3	.096	136	20.0
	I6	.113	137	23.0
	E9	.059	140	22.2
	I8	.099	143	24.4
	I5	.083	145	23.7
	I7	.110	145	23.7
	H5	.209	159	29.6
	C9	.096	164	24.1
	Avg.	.114	141	23.3
14.0 cm....	I3	.091	125	25.0
	I1	.100	137	26.4
	C7	.094	143	28.6
	J4	.107	150	25.0
	H8	.129	159	22.9
	C6	.091	164	25.0
	O1	.106	170	25.0
	A11	.118	174	25.0
	Avg.	.105	153	25.4
14.5 cm....	E1	.150	184	23.5
	Avg.	.150	184	23.5

Class.	Pig.	Per cent thymus by weight.	Pig weight in gms.	Per cent thymus by length.
15.0 cm....	A2	.236	192	25.0
	E1	.137	196	23.3
	E4	.197	208	23.3
	E3	.113	211	23.3
	Avg.	.171	202	23.7
15.5 cm....	L8	.160	175	23.2
	A4	.129	202	24.5
	A10	.129	228	24.5
	A3	.109	233	24.5
	A1	.132	235	25.8
	Avg.	.132	215	24.5
16.0 cm....	E5	.128	195	21.9
	J8	.137	205	25.0
	A5	.134	212	25.0
	A8	.143	228	23.1
	O4	.111	230	28.7
	A12	.150	234	23.8
	H6	.221	235	25.4
	A7	.268	237	21.9
	H2	.163	257	26.9
	O5	.162	263	26.3
	Avg.	.162	230	24.8
16.5 cm....	L6	.152	240	25.5
	A9	.165	243	22.4
	L2	.160	245	26.7
	H10	.168	245	23.0
	L7	.146	250	27.3
	L5	.148	250	26.0
	L4	.163	250	21.2
	L1	.160	270	26.7
	H3	.277	271	24.2
	O3	.145	280	25.5
	O8	.121	290	24.8
	Avg.	.164	258	24.8
17.0 cm....	J7	.114	228	23.5
	J6	.093	250	23.5
	H1	.123	251	26.5
	O6	.162	262	24.1
	A14	.287	265	26.5
	J1	.124	267	25.3
	L3	.124	270	24.7
	O2	.219	275	27.6
	J3	.112	285	26.5
	Avg.	.151	261	25.4
17.5 cm....	J5	.094	245	22.9
	J4	.113	255	22.9
	A6	.189	265	25.7
	H7	.222	318	25.0
	Avg.	.155	271	24.1
18.0 cm....	O7	.118	313	25.0
	H9	.269	316	25.0
	Avg.	.194	314.5	25.0
18.5 cm....	J2	.131	295	23.2
	N5	.130	360	24.3
	N6	.167	380	25.4
	Avg.	.143	345	24.3
19.0 cm....	M6	.200	342	27.9
	G8	.218	346	27.4
	N7	.204	395	22.6
	N1	.178	400	23.7
	N3	.138	420	25.3
	Avg.	.188	381	25.4

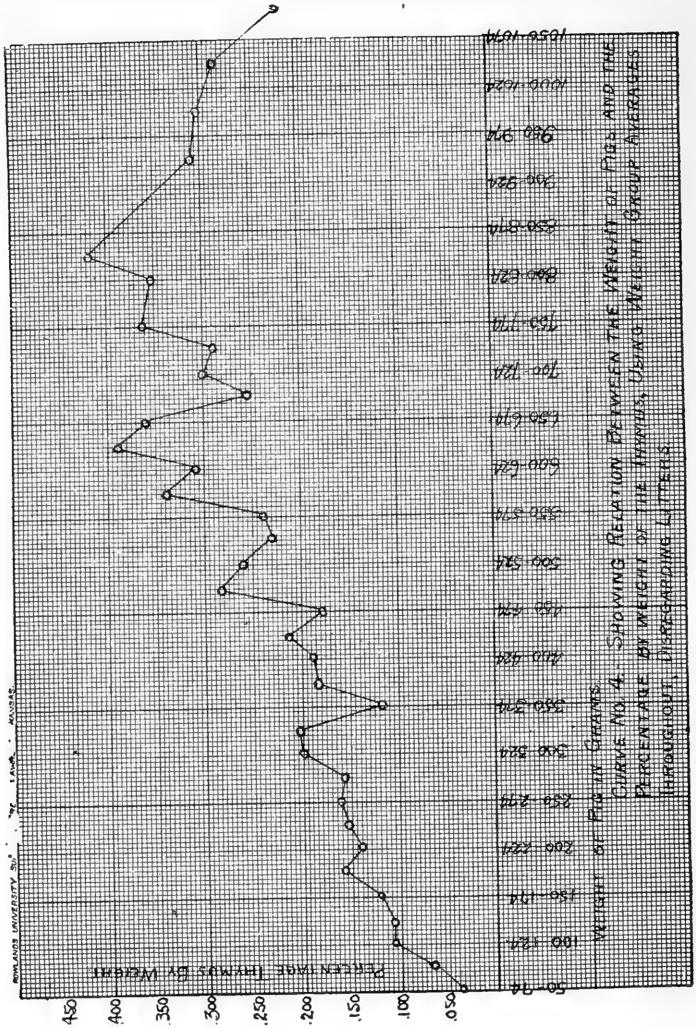
TABLE No. 4—CONCLUDED.

CLASS.	Pig.	Per cent thymus by weight.	Pig weight in gms.	Per cent thymus by length.
19.5 cm....	N2	.144	360	23.6
	K5	.275	405	22.5
	N8	.165	407	25.6
	N4	.128	430	25.6
	K1	.170	440	28.2
	Avg.	.176	408	25.1
20.0 cm....	K4	.195	420	22.5
	K3	.245	430	25.0
	K2	.177	460	22.5
	Avg.	.206	437	23.3
20.5 cm....	P7	.316	435	26.8
	M3	.232	445	26.3
	Avg.	.274	440	26.6
21.0 cm....	M5	.200	445	26.2
	M4	.250	475	25.2
	M2	.179	515	25.2
	Avg.	.210	478	25.5
21.5 cm....	P6	.311	495	23.3
	M1	.237	515	27.9
	G6	.409	581	25.6
	G5	.312	640	27.0
	Avg.	.317	558	26.0
22.0 cm....	M9	.184	420	25.0
	M8	.251	500	25.0
	G2	.233	549	25.0
	P9	.311	620	27.7
	G7	.347	635	27.3
	G1	.510	635	27.3
	G4	.443	658	27.3
	G3	.286	665	28.2
	Avg.	.321	585	26.6

CLASS.	Pig.	Per cent thymus by weight.	Pig weight in gms.	Per cent thymus by length.
22.5 cm....	M7	.239	550	24.9
	Avg.	.239	550	24.9
23.5 cm....	P3	.273	590	25.5
	P4	.292	665	25.5
	D5	.417	669	29.8
	P8	.271	740	26.8
	Avg.	.313	666	26.9
24.0 cm....	P2	.305	700	25.0
	Avg.	.305	700	25.0
24.5 cm....	P1	.311	735	26.1
	P5	.293	675	24.5
	Avg.	.302	705	25.8
25.0 cm....	D1	.397	752	26.0
	D2	.334	771	28.0
	D3	.351	815	30.0
	D4	.421	843	28.0
	Avg.	.376	795	28.0
25.5 cm....	P2	.224	693	27.5
	Avg.	.224	693	27.5
26.5 cm....	R5	.270	925	32.5
	Avg.	.270	925	32.5
27.0 cm....	R1	.226	1,098	33.3
	Avg.	.226	1,098	33.3
27.5 cm....	R3	.361	932	29.1
	R4	.301	999	27.3
	Avg.	.331	965.5	28.7
28.5 cm....	R6	.287	1,035	31.6
	Avg.	.287	1,035	31.6

RELATION BETWEEN THE WEIGHT OF PIGS AND THE PERCENTAGE BY WEIGHT OF THE THYMUS, USING WEIGHT GROUP AVERAGES THROUGHOUT, DISREGARDING LITTERS.

Table No. 5 and curve No. 4 show that as larger and larger fœti (as regards weight) are examined and classified regardless of litter, there is a steady increase in the percentage of thymus by weight. As has already been noted in curve No. 3, the increase is not uniform. When we compare this curve No. 4 with curve No. 2 (where the pigs are classified according to litters), it is evident that the latter is smoother by far. Hence from these calculations on weights in addition to the calculations already noted on lengths, we may conclude that pigs tend to have the same size thymus as that of other pigs in the same litter, regardless of individual sizes.



Curve No. 4. Showing Relation Between the Weight of Pigs and the Percentage by Weight of the Thymus, Using Weight Group Averages throughout, Disregarding Litters.

TABLE No. 5.

CLASS.	Pig.	Pig weight in gms.	Per cent weight.	Pig length in cms.	Per cent length.
50–74	Q1	55	.035	9.5	24.2
	Q8	61	.052	10.5	23.8
	Q7	61	.057	10.0	25.0
	Q5	63	.035	10.5	21.9
	Q6	63	.040	10.0	24.0
	Q4	63	.046	10.0	22.0
	Q3	66	.048	10.0	23.0
	Q2	68	.059	10.5	23.8
	Avg.	....	.0465	....	23.47
75–99	B3	76	.041	10.0	25.0
	F11	83	.087	11.0	22.7
	B5	90	.078	11.0	25.0
	F7	95	.072	12.0	23.9
	F13	96	.089	12.0	21.7
	Avg.	....	.0734	....	23.66
100–124	B1	100	.070	11.0	22.7
	F6	102	.078	13.0	19.2
	B2	102	.093	11.0	25.0
	C8	102	.108	11.5	21.7
	A13	102	.137	11.5	20.0
	C1	107	.112	11.5	21.7
	F4	115	.074	13.0	24.6
	F3	115	.160	13.0	23.1
	H4	118	.112	12.5	26.4
	F10	120	.090	12.5	25.6
	F5	120	.096	13.0	24.6
	F1	122	.102	13.0	22.2
	C5	122	.107	13.0	19.2
	C4	123	.122	13.0	19.2
	Avg.	....	.1115	....	22.51
125–149	I3	125	.091	14.0	25.0
	L8	125	.160	15.5	23.2
	F12	126	.093	13.0	25.4
	E6	126	.143	12.5	24.0
	F2	130	.165	13.0	22.2
	I2	135	.126	13.5	21.5
	C3	136	.096	13.0	20.0
	I1	137	.100	14.0	26.4
	I6	137	.113	13.5	23.0
	F9	140	.059	13.5	22.2
	C7	143	.094	14.0	28.6
	I8	143	.099	13.5	24.4
	C2	145	.085	13.0	19.0
	I5	145	.083	13.5	23.7
	I7	145	.110	13.5	23.7
	Avg.	....	.1078	....	23.49
150–174	I4	150	.107	14.0	25.0
	H5	154	.209	13.5	29.6
	H8	159	.129	14.0	22.9
	C6	164	.091	14.0	25.0
	C9	164	.096	13.5	24.1
	O1	170	.106	14.0	25.0
	A11	174	.118	14.0	25.0
	Avg.	....	.1223	....	25.23
175–199	E1	184	.150	14.5	23.5
	A2	192	.236	15.0	25.0
	E5	195	.128	16.0	21.9
	E2	196	.137	15.7	23.3
	Avg.	....	.1628	....	23.43
200–224	A4	202	.129	15.5	24.5
	J8	205	.137	16.0	25.0
	E4	208	.197	15.0	23.5
	E3	211	.113	15.0	23.3
	A5	212	.134	16.0	25.0
	Avg.	....	.1420	....	24.26
225–249	J7	228	.114	17.0	23.5
	A10	228	.129	15.5	24.5
	A8	228	.143	16.0	23.1
	O4	230	.111	16.0	28.7
	A3	233	.109	15.5	24.5
	A12	234	.150	16.0	23.8
	A1	235	.132	15.5	25.8
	H6	235	.221	16.0	25.4
	A7	237	.268	16.0	21.9
	L6	240	.152	16.5	25.5
	A9	243	.243	16.5	22.4
	J5	245	.094	17.5	22.9
	L2	245	.160	16.5	26.7
	H10	245	.168	16.5	23.0
	Avg.	....	.1567	....	24.41
250–274	J6	250	.093	17.0	23.5
	L7	250	.146	16.5	27.3
	L5	250	.148	16.5	26.0
	L4	250	.163	16.5	21.2
	H1	251	.122	17.0	26.5
	J4	255	.113	17.5	22.9
	H2	257	.163	16.0	26.9
	O6	262	.162	17.0	24.1
	O5	263	.162	16.0	26.3
	A6	265	.189	17.5	25.7
	A14	265	.287	17.0	26.5
	J1	267	.124	17.0	25.3
	L3	270	.124	17.0	24.7
	L1	270	.160	16.5	26.7
	H3	271	.277	16.5	24.2
	Avg.	....	.162	....	25.5
275–299	O2	275	.219	17.0	27.6
	O3	280	.145	16.5	25.5
	J3	285	.112	17.0	26.5
	C8	290	.121	16.5	24.8
	J2	295	.131	18.5	23.2
	Avg.	....	.146	....	25.5
300–324	O7	313	.118	18.0	25.0
	H9	316	.268	18.0	25.0
	H7	318	.222	17.5	25.0
	Avg.	....	.203	....	25.0
325–349	M6	342	.200	19.0	27.9
	G8	346	.218	19.0	27.4
	Avg.	....	.209	....	27.3
350–374	N5	360	.130	18.5	24.3
	N2	360	.144	19.5	23.6
	Avg.	....	.137	....	24.0
375–399	N6	380	.167	18.5	24.3
	N7	395	.204	19.0	22.6
	Avg.	....	.186	....	23.5
400–424	H1	400	.178	19.0	23.7
	K5	405	.275	19.5	22.5
	N8	407	.165	19.5	25.6
	N3	420	.138	19.0	25.3
	M9	420	.184	22.0	25.0
	K4	420	.195	20.0	22.5
	Avg.	....	.189	....	24.1
425–449	N4	430	.128	19.5	25.6
	K3	430	.245	20.0	25.0
	P7	435	.316	20.5	26.8
	K1	440	.170	19.5	28.2
	M5	445	.200	21.0	26.2
	M3	445	.232	20.5	26.3
	Avg.	....	.215	....	26.4

TABLE No. 5—Concluded.

Class.	Pig.	Pig weight in gms.	Per cent weight.	Pig length. in cms.	Per cent length.	Class.	Pig.	Pig weight in gms.	Per cent weight.	Pig length in cms.	Per cent length.
450–474	K2	460	.177	20.0	22.5	675–699	P5	675	.293	24.5	24.5
	Avg.	....	.177	....	22.5		R2	693	.224	25.5	27.5
							Avg.	....	.259	....	26.0
475–499	M4	475	.250	21.0	25.2						
	P6	495	.311	21.5	23.3	700–724	P2	700	.305	24.0	25.0
	Avg.	....	.281	....	24.3		Avg.	....	.305	....	25.0
500–524	M8	500	.251	22.0	25.0	725–749	P1	735	.311	24.5	26.1
	M2	515	.179	21.0	25.2		P8	740	.271	23.5	26.8
	M1	515	.237	21.5	27.9		Avg.	....	.291	....	26.5
	Avg.	....	.222	....	26.0						
						750–774	D1	752	.397	25.0	26.0
525–544	G2	549	.233	22.0	25.0		D2	771	.334	25.0	28.0
	Avg.	....	.233	....	25.0		Avg.	....	.366	....	27.0
550–574	M7	550	.239	22.5	24.9	800–824	D3	815	.351	25.0	30.0
	Avg.	....	.239	....	24.9		Avg.	....	.351	....	30.0
575–599	G6	581	.409	21.5	25.6	825–849	D4	843	.421	25.0	28.0
	P3	590	.273	23.5	25.5		Avg.	....	.421	....	28.0
	Avg.	....	.341	....	25.6						
						925–949	R5	925	.270	26.5	32.5
600–624	P9	620	.311	22.0	27.7		R3	932	.361	27.5	29.1
	Avg.	....	.311	....	27.7		Avg.	....	.316	....	31.3
625–649	G7	635	.347	22.0	27.3	974–999	R4	999	.301	27.5	27.3
	G1	635	.510	22.0	27.3		Avg.	....	.301	....	27.3
	G5	640	.312	21.5	27.0						
	Avg.	....	.390	....	27.3	1025-1049	R6	1,035	.287	28.5	31.6
							Avg.	....	.287	....	31.6
650–674	G4	658	.443	22.0	27.3						
	G3	665	.286	22.0	28.2	1075-1099	R1	1,098	.226	27.0	33.3
	P4	665	.292	23.5	25.5		Avg.	....	.226	....	33.3
	D5	669	.417	23.5	29.8						
	Avg.	....	.360	....	27.7						

Comparisons Made to Correlate the Size of Underdeveloped and Overdeveloped Pigs with the Size of the Thymus, Taking Percentage Thymus by Weight as a Standard, and Grading Pigs in the Litters by Length.

As the title above indicates, table No. 6 is the result of an attempt made to correlate the size of underdeveloped and overdeveloped pigs with the size of the thymus, taking percentage thymus by weight as a standard, and grading pigs in the litters by length. In each litter the two smallest fœti (by length) and the two largest were studied as to percentage thymus by weight as seen in column F in the table. The percentages of the two smallest and the two largest were individually averaged (column G), and the two averages compared; the correlation noted was recorded in column H. Positive or + correlation is taken to mean that the overdeveloped pigs in the litter had a greater percentage of thymus than the underdeveloped pigs. As seen from the table, there were nine positives and nine negatives, hence we must conclude, from the data at hand now, that no parallelism exists between the large and small size, respectively, of underdeveloped and overdeveloped fœti, and the percentage of thymus by weight.

TABLE No. 6.

Column A. Serial No.	Column B. Litter No.	Column C. Pig length in centimeters.	Column D. Per cent thymus by length.	Column E. Pig weight in grams.	Column F. Per cent thymus by weight.	Column G. Averages of column F.	Column H. Correlation.
13	A13........	11.5	20.0	102	.137	.128	+
11	A11........	14.0	25.0	174	.118		
6	A6.........	17.5	25.7	265	.189	.238	
14	A14........	17.0	26.5	265	.287		
17	B3.........	10.0	25.0	76	.041	.065	+
19	B5.........	11.0	25.0	90	.078		
16	B2.........	11.0	25.0	102	.093	.082	
15	B1.........	11.0	22.7	100	.070		
27	C8.........	11.5	21.7	102	.108	.110	−
20	C1.........	11.5	21.7	107	.112		
26	C7.........	14.0	28.6	143	.094	.093	
25	C6.........	14.0	25.0	164	.091		
33	D5.........	23.5	29.8	669	.417	.407	−
29	D1.........	25.0	26.0	752	.397		
32	D4.........	25.0	28.0	843	.421	.386	
31	D3.........	25.0	30.0	815	.351		
39	E6.........	12.5	24.0	126	.143	.147	−
34	E1.........	14.5	23.5	184	.150		
38	E5.........	16.0	21.9	195	.128	.121	
36	E3.........	15.0	23.3	211	.113		
50	F11........	11.0	22.7	83	.087	.079	+
46	F7.........	12.0	22.9	95	.072		
48	F9.........	13.5	22.2	140	.059	.112	
41	F2.........	13.5	22.2	130	.165		
60	G8.........	19.0	27.4	346	.218	.314	+
58	G6.........	21.5	25.6	581	.409		
53	G1.........	22.0	27.3	635	.510	.429	
59	G7.........	22.0	27.3	635	.347		
64	H4.........	12.5	26.4	118	.112	.162	+
65	H5.........	13.5	29.6	154	.209		
69	H9.........	18.0	25.0	316	.268	.245	
67	H7.........	17.5	25.7	318	.222		
72	I2.........	13.5	21.5	135	.126	.120	−
76	I6.........	13.5	23.0	137	.113		
74	I4.........	14.0	25.0	150	.107	.104	
71	I1.........	14.0	26.4	137	.100		
86	J8.........	16.0	25.0	205	.137	.126	−
85	J7.........	17.0	23.5	228	.114		
80	J2.........	18.5	23.2	295	.131	.122	
82	J4.........	17.5	22.9	255	.113		
91	K5.........	19.5	22.5	405	.275	.223	−
87	K1.........	19.5	28.2	440	.170		
88	K7.........	20.0	22.5	460	.177	.211	
89	K3.........	20.0	25.0	430	.245		
99	L8.........	15.5	23.2	125	.160	.156	−
97	L6.........	16.5	25.5	240	.152		
94	L3.........	17.0	24.7	270	.124	.142	
92	L1.........	16.5	26.7	270	.160		

TABLE No. 6—CONCLUDED.

Column A. Serial No.	Column B. Litter No.	Column C. Pig length in centimeters.	Column D. Per cent thymus by length.	Column E. Pig weight in grams.	Column F. Per cent thymus by weight.	Column G. Averages of column F.	Column H. Correlation.
105 102	M6........ M3........	19.0 20.5	27.9 26.3	342 445	.200 .232	.216	+
106 107	M7........ M8........	22.5 22.0	24.9 25.0	550 500	.239 .251	.245	
113 114	N5........ N6........	18.5 18.5	24.3 24.3	360 380	.130 .167	.149	—
112 116	N4........ N8........	19.5 19.5	25.6 25.6	430 407	.128 .165	.147	
117 120	O1......... O4.........	14.0 16.0	25.0 28.7	170 230	.106 .111	.109	+
123 118	O7......... O2.........	18.0 17.0	25.0 27.6	313 275	.118 .219	.169	
131 130	P7......... P6.........	20.5 21.5	26.8 23.3	435 495	.316 .311	.314	—
125 129	P1......... P5.........	24.5 24.5	26.1 24.5	735 675	.311 .293	.302	
134 140	Q1......... Q7.........	9.5 10.0	24.2 25.0	55 61	.035 .057	.046	+
135 138	Q2......... Q5.........	10.5 10.5	23.8 21.9	68 63	.059 .035	.047	
143 146	R2........ R5........	25.5 26.5	27.5 32.5	693 925	.224 .270	.247	+
147 145	R6........ R4........	28.5 27.5	31.6 27.3	1,035 999	.287 .301	.294	

Total result, 9+, 9 —.

Comparisons Made to Correlate the Size of Underdeveloped and Overdeveloped Pigs with the Size of the Thymus, Taking Percentage of Thymus by Weight as a Standard, and Grading Pigs in the Litters by Weight.

As the title above indicates, table No. 7 is the result of an attempt made to correlate the size of underdeveloped and overdeveloped fœti with the size of the thymus, taking percentage thymus by weight as a standard, and grading pigs in the litters by weight. In each litter the two smallest fœti (by weight) and the two largest were studied as to percentage thymus by weight as seen in column F in the table. The percentages of the two smallest and the two largest were individually averaged (column G), and the two averages compared; the correlation noted was recorded in column H. Positive or + correlation is taken to mean that the overdeveloped pigs in the litter had a greater percentage of thymus than the underdeveloped pigs. As seen from the table, there were ten positives and eight negatives. This is indeed a very weak positive correlation; so slight, in fact, that we feel that it must be disregarded until more positive data can be secured. Hence, once more we must decide, on the basis of the data at hand now, that no parallelism exists between the large and small size, respectively, of underdeveloped and overdeveloped fœti and the percentage of thymus by weight.

TABLE No. 7.

Column A. Serial No.	Column B. Litter No.	Column C. Pig weight in grams.	Column D. Pig length in centimeters.	Column E. Per cent thymus by length.	Column F. Per cent thymus by weight.	Column G. Averages of column F.	Column H. Correlation.
13	A13........	102	11.5	20.0	.137	.128	+
11	A11........	174	14.0	25.0	.118		
14	A14........	265	17.0	26.5	.287	.238	
6	A6.........	265	17.5	25.7	.189		
17	B3.........	76	10.0	25.0	.041	.060	+
19	B5.........	90	11.0	25.0	.078		
15	B1.........	100	11.0	22.7	.070	.082	
16	B7.........	102	11.0	25.0	.073		
27	C8.........	102	11.5	21.7	.108	.108	—
24	C5.........	122	13.0	19.2	.107		
25	C6.........	164	14.0	25.0	.091	.094	
28	C9.........	164	13.5	24.1	.096		
33	D5........	669	23.5	29.8	.417	.407	—
29	D1........	752	25.0	26.0	.397		
32	D4........	843	25.0	28.0	.421	.386	
31	D3........	815	25.0	30.0	.351		
39	E6.........	126	12.5	24.0	.143	.147	+
34	E1.........	184	14.5	23.5	.150		
37	E4.........	208	15.0	23.3	.197	.155	
36	E3.........	211	15.0	23.3	.113		
50	F11........	83	11.0	22.7	.087	.080	+
46	F7.........	95	12.0	22.9	.072		
41	F2.........	130	13.5	22.2	.165	.112	
48	F9.........	140	13.5	22.2	.059		
60	G8........	346	19.0	27.4	.218	.226	+
54	G2........	549	22.0	25.0	.233		
55	G3........	665	22.0	28.2	.286	.365	
56	G4........	658	22.0	27.3	.443		
64	H4........	118	12.5	26.4	.112	.162	+
65	H5........	154	13.5	29.6	.209		
67	H7........	318	17.5	25.7	.222	.245	
69	H9........	316	18.0	25.0	.268		
73	I3.........	125	14.0	25.0	.091	.109	—
72	I2.........	135	13.5	21.5	.126		
67	I4.........	150	14.0	25.0	.107	.095	
69	I5.........	145	13.5	23.7	.083		
86	J8.........	205	16.0	25.0	.137	.126	—
85	J7.........	228	17.0	23.5	.114		
80	J2.........	295	18.5	23.2	.131	.122	
81	J3.........	285	17.0	26.5	.112		
91	K5........	405	19.5	22.5	.275	.235	—
90	K4........	420	20.0	22.5	.195		
88	K2........	460	20.0	22.5	.177	.174	
87	K1........	440	19.5	28.2	.170		
99	L8.........	125	15.5	23.2	.160	.156	—
97	L6.........	240	16.5	25.5	.152		
94	L3.........	270	17.0	24.7	.124	.142	
92	L1.........	270	16.5	26.7	.160		

TABLE No. 7—CONCLUDED.

Column A. Serial No.	Column B. Litter No.	Column C. Pig weight in grams.	Column D. Pig length in centimeters.	Column E. Per cent thymus by length.	Column F. Per cent thymus by weight.	Column G. Averages of column F.	Column H. Correlation.
105 108	M6 M9	342 420	19.0 22.0	27.9 25.0	.200 .184	.192	+
106 100	M7 M1	550 515	22.5 21.5	24.9 27.9	.239 .237	.238	
110 113	N2 N5	360 360	19.5 18.5	23.6 24.3	.144 .130	.137	—
111 112	N3 N4	420 430	19.0 19.5	25.3 25.6	.138 .128	.133	
117 120	O1 O4	170 230	14.0 16.0	25.0 28.7	.106 .111	.108	+
124 123	O8 O7	290 313	16.5 18.0	24.8 25.0	.121 .118	.120	
131 130	P7 P6	435 495	20.5 21.5	26.8 23.3	.316 .311	.314	—
132 125	P8 P1	740 735	23.5 24.5	26.8 26.1	.271 .311	.291	
134 140	Q1 Q7	55 61	9.5 10.0	24.2 25.0	.035 .057	.046	+
135 136	Q2 Q3	68 66	10.5 10.0	23.8 23.0	.059 .048	.054	
143 146	R2 R5	693 925	25.5 26.5	27.5 32.5	.224 .270	.251	+
142 147	R1 R6	1,098 1,035	27.0 28.5	33.3 31.6	.226 .287	.257	

Total result, 10 +, 8 —.

NOTE NO. 1.—It will have been noticed that in the foregoing report nothing has been said concerning the percentage of thymi by length. An examination of the tables will show that there is indeed an increase in this percentage as larger and larger pigs are examined, but that this increase is neither marked nor uniform, and we must consider that part of the increase in weight must come by this increase in length. We feel that the method by which we secured the thymus lengths was not accurate and uniform enough to allow much value to be attached to the figures recorded. They may be taken as rather approximate. In general, the length of the thymus will average about 25 per cent of the total length of the pig. Suffice it to say, however, that we believe that as the fœti grow older and older there is an increase in the percentage of thymus by length; just how regular and consistent this increase is, we cannot say.

NOTE NO. 2.—It is interesting to note that the pigs used for dissection showed a preponderance of males. This was probably purely accidental, however, and if larger numbers of animals had been used a more balanced ratio would have been secured.

CONCLUSIONS.

1. The thymus gland in the fœtal pig is comparatively very large, extending from a point above the upper half or third of the heart to the base of the mandible. In the thorax it consists of a single triangular body, but in the neck region is made up of paired branches which approximately parallel each other.

2. Sex appears to have no connection with the percentage of thymus found, except that possibly the values for the females may average a trifle higher than those for the males.

3. As larger and larger fœti, as regards both weight and length, are examined, the percentage of thymus by weight increases fairly steadily and rather uniformly.

4. Fœti tend to have the same size thymus as the average of pigs in their litter, regardless of individual size. No parallelism apparently exists between the small and large size, respectively, of underdeveloped and overdeveloped pigs, and the percentage of thymus by weight. Perhaps further work on this one question might bring a reversal of opinion, but the data obtained so far point to the statement made above.

5. Figures of percentage of thymus by length, while not very reliable, show that this percentage increases as larger and larger fœti are examined. Such increase, however, does not seem to be as uniform as that of the percentage by weight.

It is a pleasure to express here our appreciation of the help kindly given by Prof. W. J. Baumgartner in the preparation of this bit of work. It was at his suggestion that it was undertaken and by his guidance that it was carried out. Whatever of merit it has is due in large measure to him.

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VOL. XIII.] JULY, 1920. [No. 15.

A Comparison of the Antigenic and Cultural Characteristics of a Number of Strains of *Bacillus Typhosus*.*

BY CORA M. DOWNS.

Department of Bacteriology.

ALTHOUGH it has seemed to be the general concensus of opinion that *Bacillus typhosus* is a very homogeneous organism, yet in view of the fact that some observers have reported cultural and serological variations, it was thought advisable to investigate the cultural and serological reactions of the strains of *typhosus* used in this laboratory.

The work done may be divided into three phases, namely: cultural reactions, agglutination and absorption tests, and the Widal reaction. The source, place of isolation, name and date of the organisms used are tabulated in table I.

CULTURAL REACTIONS.

TECHNIQUE: The carbohydrate medium used was semisolid, to which was added 1 per cent of the carbohydrate desired, and Andrade indicator to make a pale, flesh color when cold. As a check a second set of determinations was run, using meat infusion broth adjusted to Ph, 7.0, to which 1 per cent of the carbohydrate was added, litmus being used as an indicator. For the lead acetate agar 1 per cent lead acetate solution was added to semisolid medium. Two per cent peptone gelatine, made according to a formula devised by Treece (1), was used for liquefaction and to test for gas production in noncarbohydrate media.

* Received for publication October 18, 1921. Abstract published in Abstracts of Bacteriology, Feb. 1920, vol. IV, No. 1, p. 19.

TABLE I.—Organisms used for cultural and antigenic reactions.

No.	Source.	Name.	Date.
1	Blood culture—Lawrence, Kan.	57	1913
21	Blood culture—Kansas City, Mo.		1919
223	Blood culture—University of California		1914
25	Blood culture—Johns Hopkins Hospital		
33	Blood culture—Youngstown Hospital	McCreary	1921
4	Feces—Lawrence, Kan.	Smith	1919
6	Feces—Lawrence, Kan.		1918
8	Feces—Lawrence, Kan.		1919
16	Feces—Carrier, Beau Desert, France	Schopinsky	1918
20	Feces—Topeka, Kan.		1919
24	Feces—Fatal case, John Hopkins		1919
27	Feces—Kansas City, Mo.		1920
28	Feces—Carrier	Light	1920
29	Feces—Carrier	Blythe	1920
30	Feces—Carrier	Dardrich	1920
31	Feces—Carrier	Cattler	1920
32	Feces—Carrier	Doud	1920
34	Feces—Carrier	Stitt	1920
35	Feces—Case	Levi	1920
7	Spinal fluid—Halstead, Kan.		1919
12	Spleen—Autopsy	Rawlings	
	Spleen—Autopsy	Rawlings	
15	Gall bladder—Autopsy, France	Wable	1918
2	No history—New York board of health		
3	No history—New York city board of health	Bender	
10		Mt. Sinai	
11	No history—New York city board of health	Pfeiffer	
13	No history—American Museum	Hopkins	
14	No history—American Museu n	Miller	
17	No history—Institute of Berlin	Ebert	1888
19	No history—University of Chicago	Jordan	1889
26	No history—Johns Hopkins Hospital		

TABLE II.—Cultural characteristics.

Number.	Motility	Gram	Gelatine	Indol	Lead acetate	Dextrose	Mannite	Maltose	Lactose	Saccharose	Dextrin	Rhamomitinose	Salacin	Dulcite	Arabinose	Xylose	Litmus milk.
1, 2, 3, 4, 6, 7, 8	—	—	—	—	+	+	+	+	—	—	+	—	—	—	—	+	1 Neutral after 1 week.
9	—	—	—	—	+	+	+	+	—	—	+	—	+	—	—	+	
10, 11, 13, 14, 15, 16, 17, 20	—	—	—	—	+	+	+	+	—	—	+	—	—	—	—	+	15, 17, 19, neutral after 3 weeks.
12	—	—	—	—	+	+	+	+	—	—	+	—	—	—	—	—	
21	—	—	—	—	+	+	+	+	—	—	+	—	—	—	—	+	10 days.
23-25	—	—	—	—	+	+	+	+	—	—	+	—	+	—	—	+	23, 24, 26, neutral after 3 weeks.
24, 28, 29, 30, 31, 32, 33, 34, 35	—	—	—	—	+	+	+	+	—	—	+	—	—	—	—	+	
26, 27	—	—	—	—	+	+	+	+	—	—	—	—	+	—	—	+	

The litmus milk was kept for six weeks before being discarded. The cultural reactions are tabulated in table II. It will be observed from the table that none of the strains exhibited any variation in the media commonly used in routine laboratory procedure. All strains gave acid in dextrose, mannite, maltose, negative in lactose and saccharose, no liquefaction of gelatine, no indol, and an initial acidity in litmus milk. Three strains gave slight acidity in salacin, one strain gave no acid in xylose, Rawlings' strain, and one gave acid only after ten days. Two strains were negative in dextrin. All strains except No. 7 gave a distinct greenish-black cloud around the stab in 2 per cent peptone gelatine, but no gas. In litmus milk all but six organisms remained a permanent lilac color, six turned back to neutral in three weeks and one became a deep blue after one week.

In addition to the above strains an organism isolated from the feces of a clinical case of mild typhoid was studied. This organism is designated as No. 5. The patient at no time gave a positive Widal. The organisms were abundant in the feces and culturally differed from *Bacillus typhosus* only in giving very slow blackening of lead acetate agar, negative in xylose, negative in dextrin, positive in rhamnose, and distinct alkaline reaction in litmus milk after 72 hours, but with no saponification.

DISCUSSION.

Weiss (2) has reported the cultural characteristics of thirty-one strains of *typhosus* and groups them according to xylose fermentation. Three of his strains produced acid slowly and four remained negative. One of the negative strains was the Rawlings' strain which we also found to be negative.

Teague (3) objects to such a classification on the basis of xylose fermentation on the ground that the so-called negative strains are not really incapable of fermenting xylose, but ferment it slowly. Four of his strains failed to give acid on the thirty-second day, but these strains could be trained to give acid by plating on xylose agar. No attempt was made by the author to discover mutants from negative strains on any of the carbohydrates used.

Our strains were uniformly negative on dulcite and arabinose. Teague (3) reports eleven out of forty-one strains fermenting these sugars slowly. Krumwiede (4) also reports the fermentation in dextrin as varying with the sample used. The two cultures giving negative in dextrin might, therefore, have shown typical acid production with another sample.

The salacin fermentation seemed variable and did not correlate with any other characteristics.

The danger of confusing nongas-producing paratyphoid strains with *typhosus* has been recently emphasized. Ten Broek (5) reports a nongas-producing hog-cholera bacillus which resembles in some respects *B. typhosus*. Krumwiede (4) also reports a similarity both culturally and serologically between *B. pullorum* and *B. sanguinorum* and *B. typhosus*. Myers (6) reports the isolation of a rhamnose positive *typhosus* from a clinical case of typhoid which was also atypical in its serological reaction. It was difficult to decide, therefore, whether No. 5 was a true but irregular typhoid or a nongas-producing paratyphoid. Krumwiede (7), using the fermentation of rhamnose as the deciding factor between typhoid and paratyphoid, would place it in the para group.

AGGLUTINATION AND ABSORPTION TESTS.

Antigenic irregularities had been observed in this laboratory in the course of routine agglutination tests on organisms isolated from clinical cases of typhoid and a number of Widals. Parke-Davis antityphoid serum, serum from the city laboratory of Wichita, Kan., and serum sent us from the University of Chicago were used in checking up the antigenic properties of the following organisms: Nos. 1, 2, 4, 5, 20, 50, 51 and 52.

Culturally they were all typhoid. Nos. 50, 51 and 52 were strains isolated from feces in cases resembling influenza. They are not included in the other tables because of accidental loss.

TABLE III.—Quantitative variations in agglutinations with commercial sera.

No.	Sera used.					
	Parke-Davis.		Wichita.		University of Chicago.	
	Titre.	Reaction.	Titre.	Reaction.	Titre.	Reaction.
1	1–50	—	1–50	....	1–8000	4+
2	1–10000	3+	1–50	1+	1–10000	4+
4	1–1000	4+	1–400	4+	1–2000	4+
6	1–2000	4+	1–400	....	1–4000	4+
50	1–50	—	1–50	....	1–50	....
51	1–50	—	1–50	....	1–50	....
52	1–50	....	1–50	....	1–50	....
20	1–4000	4+	....	....	1–8000	4+

Numerous observers have remarked on the antigenic differences in typhoid. Durham (8) observed such differences, but did not attempt to group his strains. Weiss (1) and Hooker (9), however, offered a tentative grouping on the basis of their agglutination and absorption tests.

The agglutination tests in this series were all done with suspensions in sterile saline made from twenty-four-hour cultures. The serum used came principally from rabbits immunized in this laboratory.

A high-titred bivalent horse serum from the New York city board of health* prepared from the Mt. Sinai strain, and a freshly isolated strain as well as a high-titred serum for which the Rawlings strain had been used for immunization from the Lederle laboratories, were also used. Table IV gives a summary of the results. In addition to the results given here, eight other immune sera were used for agglutination against all the organisms with similar results.

The following technique was used for the absorption tests: The serum to be tested was diluted to one-tenth of the titre. This dilution was then saturated with organisms, washed from a twenty-four-hour agar slant to make a heavy emulsion. This was incubated at 37° C. for four hours and for four days at ice-box temperature, more organisms being added as the supernatant fluid became clear. The control of diluted serum in every case gave a good agglutination in spite of the prolonged incubation. If the control gave agglutination after absorption with the homologous organism the test was repeated.

Since considerable prominence has been given to the mirror reaction in the recent literature, it might be well to establish some standard method for absorption tests in order to get comparable results. We found the following points must be carefully considered in any test:

1. Weight of suspension.
2. Dilution of serum.
3. Time of absorption.
4. Repeated saturation.
5. Temperature.
6. Controls.

Krumwiede (4) recommends a proportion of 1-4 or 3, or at most 1-2 of packed cells to supernatant fluid. Our proportion after the final centrifugation was about 1-3. It was found that a dilution of one-tenth the titre of the serum was perfectly satisfactory. Although higher dilutions could be used, a lower dilution did not give complete absorption. Three or four hours was not long enough

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* I am indebted to the kindness of Dr. Charles Krumwiede for the use of this serum.

to give complete absorption and frequently absorption was not complete in twenty-four or forty-eight hours. After a standard of four days was chosen no more trouble was experienced. It was always necessary to add more organisms as the supernatant fluid became clear; the greater the tendency to agglutinate, the larger the number of organisms necessary for complete absorption. It was necessary to keep the serum at ice-box temperature because of the well-known tendency of diluted serum to deteriorate at room or incubator temperatures. A control of diluted serum which had been incubated under the same conditions as the test sera was necessary to show that no drop in titre had occurred, and a control of the serum to be tested saturated with the homologous organisms indicated the completeness of the absorption. Table V gives a summary of the absorption tests.

From table IV it will be seen that the strains of typhoid differ perceptibly in their agglutinating properties. On this basis we have placed the organisms tentatively into three groups. Group I is made up of eleven organisms; group II of twelve organisms; group III of two organisms. Group I serum agglutinates all other organisms in this group in dilutions practically as high as that given for the homologous organisms. Group I serum also agglutinates group II organisms, but in lower dilutions; conversely, the group I organisms are agglutinated by group II serum, but in lower dilutions than are the group II organisms. These two groups are closely related and interagglutinate to the degree indicated in the table. Groups I and II serum give slight or no agglutination with group III organisms. Group III, consisting of two strains, Nos. 2 and 3, interagglutinate perfectly at 1–15000, but this high-titred serum agglutinates members of groups I and II in low dilutions or not at all.

The results of agglutination tests using horse serum indicated that the same antigenic differences were present, but that they appeared in higher dilutions because of the higher titre of the serum.

To illustrate: No. 12, the Rawlings strain, was completely agglutinated at 1–80000, and No. 1 at 1–5000.

Many of these agglutination tests were checked by using the microscopic method, care being used to rule out the personal equation. Where partial agglutination occurred, the macroscopic method seemed to give more definite results.

It will be seen that the absorption tests show an even closer relationship between groups I and II than do the agglutination tests, No. 1 being somewhat more irregular than the others. The ab-

TABLE IV.—Agglutination reactions with immune sera.

Strain.	Serum. 1		4		7		20		12—Lederle.		2		3	
	Titre.	Reaction.	Titre.	Reaction.	Titre.	Reaction.	Titre.	Reaction.	Titre.	Reaction.	Titre.	Reaction.	Titre.	Reaction.
1	1-2000	......	1-1000	......	1-500	3+	1-2000	4+	1-2000	3+	1-100	4+	1-100	+
4	1-2000	......	1-1000	......	1-500	4+	1-4000	3+	1-2000	4+	1-100	+	1-100	±
6	1-2000	......	1-500	......	1-500	5+	1-2000	3+	1-5000	3+	1-100	±	1-100	±
7	1-1000	......	1-1000	......	1-3000	4+	1-3000	3+	1-8000	3+	1-100	2+	1-100	3+
8	1-200	......	1-500	......	1-3000	4+	1-2000	3+	1-2000	3+				
20	1-1000	......	1-1000	......	1-500	3+	1-3000	4+	1-2000	3+	......	......	......	......
21	1-1000	......	1-500	......	1-2000	3+	1-2000	3+	1-2000	3+	......	......	......	......
23	1 200	......	1-500	......	1-1000	3+	1-1000	3+	1-8000	3+	......	......	1-200	3+
24	1 1000	......	1-500	......	1-3000	3+	1-3000	4+	1-8000	4+	......	......	1-100	2+
25	1-50	......	1-1000	......	1-1000	3+	1-3000	4+	1-5000	3+	......	......	1-200	3+
26	1-500	......	1-2000	......	1-3000	4+	1-3000	4+	......	......	......	......	......	......
27	......	......	......	......	1-1000	4+	......	......	1-1000	4+	......	......	......	......
28	......	......	......	......	1-1000	4+	1-1000	4+	1-5000	4+	......	......	1-50	3+
29	......	......	......	......	1-500	4+	1-1000	4+	1-5000	......	......	......	1-50	2+
11	1-200	......	1-500	......	1-1000	3+	1-500	3+	1-8000	4+	1-200	4+	1-100	4+
9	1-2000	......	1-2000	......	1-2000	3+	1-3000	3+	1-5000	3+	1-1000	3+	1-1000	3+
12	1-1000	......	1-2000	......	1-2000	4+	1-2000	4+	1-8000	3+	......	......	......	......
10	1-1000	......	1-2000	......	1-500	3+	1-2000	3+	1-5000	3+	1-200	3+	1-1000	3+
13	1-1000	......	1-1000	......	1-200	3+	1-2000	3+	1-5000	4+	1-200	4+	1-200	3+
14	1-1000	......	1-2000	......	1-1000	3+	1-1000	3+	1-2000	3+	1-200	3+	1-1000	3+
15	1-1000	......	1-500	......	1-2000	3+	1-2000	3+	1-500	3+	1-100	3+	......	......
16	1-1000	......	1-5000	......	1-5000	3+	1-3000	3+	1-5000	4+	1-100	2+	1-100	4+
17	1-1000	......	1-5000	......	1-1000	3+	1-300	3+	1-5000	3+	1-100	2+	......	......
19	1-1000	......	1-1000	......	1-1000	3+	1-1000	3+	1-5000	4+	1-100	2+	1-100	±
30	......	......	......	......	1-1000	4+	1-1000	4+	1-8000	4+	1-50	3+	1-50	3+
31	......	......	......	......	1-100	4+	1-1000	4+	1-8000	4+	1-50	±	1-50	2+
32	......	......	......	......	......	......	1-100	4+	1-5000	3+	......	......	1-50	3+
2	1-200	......	1-500	......	±	......	±	......	1-50	3+	1-15000	4+	1-12000	3+
3	1-200	......	......	......	±	......	±	......	1-50	3+	1-15000	3+	1-12000	4+

TABLE V.—Absorption tests with Immune sera.

Absorbing antigen.	Sera used.									
	1	12	9	2	3	27	7	13	20	8
1	+	±	±	±	—	±	±	+	±	±
4	+	+	+	—	—	+	+	+	+	+
6	±	+	±	—	—	—	+	+		+
7	±	+	+	—	±	+	+	+	+	+
8	±	+	+	—	—	—	+	+	+	+
20	±	±	+		—	+	+	+	+	+
21	+	+	±	—	—	+	+	+	+	+
23	+	±	+	±	±	+	+	+	+	+
24	+	+	+	—	—	+	+	+	+	+
25	+	±	+	—	—	+	+	+	+	+
26	+	+	±	—	—	+	+	+	+	+
27	+	—	+	—	—	+		+	+	+
9	+	+	+	—	—	+	+	+	+	
10	+	+	+	—	—	+	—	±	—	±
11	±	+	+	—	—	+	—	+	—	—
12	±	+	+	±	—	±	—	+	+	+
13	+	+	+	—	—	±	±	+	±	+
14	+	+	±	+	+	±		+	+	+
15	±	—	+	—		±	+	+	+	+
16	+	+	+	—		+	+	+	+	+
17	+	±	+	±	—	+	+	+	—	+
19	+	+	+	—		+	+	+	—	+
2	—	±	—	+	+	—	—	—	—	—
3	—	±	—	+	+	—	—	—	—	—

+ Absorption complete.
± Absorption incomplete but reduction of titre.
— No absorption.

sorption tests show a more striking difference between the two organisms in group III and the other groups. The antigenic differences shown by these organisms could not be correlated with their age as with Hooker's (9) organisms, nor with cultural differences as with Weiss' (2).

No. 5 was found to be entirely inagglutinable by any of the sera used. Serum prepared from this organism agglutinated only the homologous organism. It did not absorb any of the agglutinins from the sera prepared from other organisms, nor were its agglutinins absorbed by other organisms. These facts, in connection with the somewhat irregular carbohydrate reactions and the atypical growth on agar slants, made it seem advisable to consider this organism one of those unclassified, irregular organisms which are not infrequently isolated from stools, although in many respects this does not differ any more radically than irregular strains reported by other observers.

In running Widals in this laboratory it was customary to set up each serum with *B. typhosus,* para A and para B. A member of the department suggested that it might be advisable to use several strains of *B. typhosus* in setting up routine Widals. Accordingly, a Widal giving negative with the strain used, No. 2, was again set up, using three other strains of typhoid. It again gave a negative with No. 2, but was strongly positive with the other two strains. It was recognized that apparent antigenic differences of this sort might constitute an important source of error in making routine laboratory tests.

The sera for the Widals were obtained from various sources. Sera A, C, D, F, G, J and I were from clinical cases of typhoid from which the organism was subsequently isolated. The others came as positive Widals from reputable laboratories, the majority of which use the Rawlings strain. Most of the specimens were drops of blood dried on a metal slide or on filter paper. A dilution of 1–25 and 1–50 was made and an equal amount of a living suspension of the organism was added, making an ultimate dilution of 1–50 and 1–100. All Widals were set up using Nos. 1, 2, 3, 10 and 12. No. 12 was selected because it is the Rawlings strain and is used for the army vaccine. Numbers 2 and 3 were used because of the irregularities exhibited in the absorption tests and No. 10 because it was an organism giving a clear adherent agglutination with most sera used. The results of these tests may be seen in table VI.

It was noticed that fresh serum drawn from the clot and used within twenty-four or forty-eight hours gave positive agglutination with a larger number of organisms than those made from dried blood. In those Widals run with dried blood precipitation was usually marked in the tubes giving a positive Widal. This might be due to the presence of hemoglobin, foreign substances on the metal slides or paper, some change in reaction, or some biochemical change. This phenomenon is being investigated. No precipitation was noted in the Widals using clear serum, nor in the agglutination tests with rabbit serum. Stober (14) mentions the occurrence of both precipitation and agglutination with his immune sera.

TABLE VI.—Widal reactions.

Organisms.	Sera.																				Percentages.		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	+	±	—
1.	—	—	—	—	+	—	—	......	+	+	±	—	—	+	+	+	+	+	—	±	42	10	47
2.	—	±	+	—	—	±	±	—	+	—	—	±	—	+	—	+	±	—	—	—	20	25	55
3.	—	......	+	±	±	±	+	—	+	......	—	—	+	+	±	+	±	—	—	—	33	27	38
10.	+	......	+	+	+	+	+	......	+	......	±	±	±	±	—	±	+	+	+	+	70	23	.6
12.	+	+	+	+	+	+	—	+	+	+	+	—	±	+	+	±	±	+	+	+	75	15	10

+ = Clear-cut complete agglutination.
± = Partial agglutination.
— = Negative agglutination.

From table VI it is readily seen that different organisms with the same sera set up at the time showed marked differences in agglutinability. This may be due to the different agglutinabilities inherent in the organisms themselves and such marked differences probably would not be noted had absorption tests been possible. It is recognized that these twenty positive Widals are too few to provide a basis for accurate conclusions. It seems highly probable that the dried-blood method exaggerates the antigenic differences between the organisms, changing what is probably a quantitative into an apparently qualitative difference between the organisms. The low percentage of positives given with Nos. 2 and 3 might be expected from the results given in the absorption tests using immune sera. No. 10, on the other hand, gave a very low percentage of negatives. Those read as partial agglutination in clinical work would be called positive. The tubes read as positive gave complete clearing of the supernatant fluid; those read as partial agglutination showed unmistakable agglutination, but with some cloudiness of the supernatant fluid. No. 10, therefore, gave 93 per cent positive. No. 12, while giving the highest percentage of complete agglutinations, gave only 90 per cent positive when partial agglutinations are included. It seems probable in view of the results obtained that it might be worth while to use more than one strain of typhoid in running Widals and to select easily agglutinable strains, such as No. 10 Mt. Sinai strain, and No. 12 the Rawlings strain.

The serological reactions here recorded might have an important bearing on the following points:

1. The occurrence of typhoid fever in vaccinated persons.
2. The advisability of using a polyvalent vaccine.
3. The occurrence of negative Widals in clinical cases of typhoid fever.
4. Sources of error due to the dried-blood method.

A number of cases of typhoid fever occurring in vaccinated individuals may be found in the literature. Vaughn (10) says that "It is possible that in so far as vaccination has failed it is due to the disease being caused by other members of the typhoid group, . . . which in all probability is much larger than we now appreciate." Mock (11) reports the occurrence of forty-five cases of typhoid and paratyphoid in individuals who had been vaccinated about one year previous to the attack. Some of the strains isolated were atypical in regard to their cultural and serological reactions, but were identified positively as typhoid or paratyphoid organisms.

Trowbridge (12) reports the occurrence of a typhoid epidemic among vaccinated persons in an institution. Here the original source of infection came from the milk supply, which was infected by a vaccinated worker with a mild case of typhoid. It is realized that in such an epidemic the dosage may have been sufficient to overcome the immunity acquired from vaccination. Wade and McDaniel (13) report the occurrence of an epidemic in an institution among vaccinated individuals. Here there seemed to be an interesting correlation between the negative Widals given after vaccination and the susceptibility of these persons to typhoid. Myers and Nielson (6) report the isolation of an atypical strain of typhoid from the blood stream and stool, respectively, of two vaccinated persons.

Hooker (9) and Weiss (2) conclude from their experiments that a vaccine made from several strains of typhoid would be more efficient than one made from a single strain. The results of these observers and the others reported, together with our findings, would suggest that at least it might be well to consider the use of a vaccine made from several strains.

Stober (14) reports three negative Widals and seven positive Widals, using an organism isolated from urine. Mock (11) also reports negative agglutination with typical typhoid organisms isolated from clinical cases. Robinson (15), on the other hand, reports no variability in 100 Widals using the Worcester and Rawlings strains.

In summing up the work done the following conclusions may be drawn:

1. Culturally, the typhoid organisms studied differ very slightly from each other, the reaction being most variable in dextrine, xylose, salacin and litmus milk. These variations cannot be correlated with the age of the culture nor source.

2. Cross-agglutination and absorption tests establish the existence of at least quantitative antigenic differences between the strains used. It occurs to the author that the conflict as to whether there are antigenic differences in the typhoid group may be due to the fact that qualitative rather than quantitative differences have been emphasized.

3. There is a marked difference in the agglutination of organisms with the sera used in Widals, and it would be advisable to set up each Widal with more than one strain, selecting strains which were known to give a high percentage of positives.

4. The use of fresh serum drawn from the clot is much more satisfactory than the use of dried blood, changing what is probably a quantitative difference into an apparently qualitative difference.

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