The Effect of Arsenic, as Used in Poisoning Grasshoppers, Upon Birds

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I. INTRODUCTION

Grasshoppers have always been one of the most destructive insect pests known to civilized man. As far back as records exist, they are reported as injuring man's products. In Biblical times, swarms of locusts destroyed every green thing in certain areas. Within the memory of many now living, the early settlers of that area lying between the Mississippi River and the Rocky Mountains saw great swarms of locusts settle and completely destroy all crops above the ground. During the past few summers there were areas where grasshoppers destroyed immense amounts of crops.

Although records of early attempts to combat grasshoppers are very incomplete, it is probable that from the beginning of history man has waged battle with these insects; and, until the coming of modern methods and conditions, he has for the most part fought a losing fight.

Of the modern methods of combating these pests after they have become numerous in the fields there is one that stands out above all others. This consists of poisoning them by placing an arsenical in some medium upon which the grasshoppers feed and scattering it in the fields where they are feeding.

The method was first reported on by the Coquilett[9] in California in 1885. The formula consisted of bran, arsenic, sugar, and water. The mixture was placed in small piles throughout the fields where the experiment was carried on, and usually in the shade. Coquillett used this bait over some 300 acres of land and reported it very successful as it almost entirely cleaned up the infestation. He also states, "Several other parties used this poisonous mash, and so far as I was able to learn, it gave entire satisfaction in every instance."

In spite of the fact that such satisfactory results were obtained at this time, and in spite of several serious outbreaks in the meantime, the method was used comparatively little for the next several years. No doubt one of the factors contributing to the reluctance with which this control measure was taken up was the fear of poisoning domestic animals and birds as well as grasshoppers in scattering poison so promiscuously.

The poison bait method received its next impetus with the announcement of Norman Criddle about 1900 that grasshoppers could be killed by a bait similar to the one suggested by Coquillett; but in this case horse manure was substituted for the bran. Such a substitute, of course, cheapened the bait very materially; and in some localities, under certain conditions at least, it was very effective. This method also failed to become

popular over the country as a whole. The same objection still held with regard to scattering poison; and, in addition, the nature of the ingredients made this bait disagreeable to mix and scatter.

The poison bait method really became popular following its marvelous success in Kansas in 1913, as reported by Dean[12] and Hunter[28] in 1914. During this campaign, 874 tons of poison bran mash were distributed over a number of counties in western Kansas; and this resulted in so diminishing the grasshopper population of these counties that very little damage occurred after the poison was put out, whereas before that time grasshoppers were so numerous that they were destroying thousands of dollars worth of crop daily.

The formula during this campaign was as follows: bran, 20 pounds; Paris green, 1 pound; oranges or lemons, 3 fruits; syrup, 2 quarts; and water, 3½ gallons. Thus it is seen that this formula differs from the one used by Coquillett in 1885 in that another form of arsenical was used, the proportions were different, and a substance for attracting the grasshoppers was added. Still, in its essential respects, it was the same as the first formula used.

This formula became known as the "Kansas bait." It almost immediately became very widely used, and its success when used under the proper conditions was almost unquestioned. Since that time there have been slight changes made in the formula and time of day that it is to be scattered; but it, or its variations, have become standard over the entire country where grasshopper outbreaks occur, and it is generally considered among entomologists to be the best control of grasshoppers known after they have become numerous in the fields.

In looking back over the brief outline of the history of poison bran mash as a control for grasshoppers, it is seen that there was a period of approximately 30 years from the time its effectiveness first became known until it became widely and generally used. In the interim, thousands of dollars worth of crops were destroyed that might have been saved had the information that was then available been used, and every year there are numerous cases in which poison bran mash is not used although its use would pay large dividends.

It is the writer's opinion that the fear of poisoning domestic fowls and wild birds is not a major reason for so many failures to use grasshopper bait in cases when it should be used; but there are instances where this fear does play an important part. It has been his experience that, in many communities where it is desired to put out poison, individuals are to be found who firmly believe that such a procedure is likely to result in

the death of a large percentage of the birds of the area. In practically every community where poison bran mash has been used are found individuals who cite instances where birds or other animals have been killed through its use. Usually they tell of instances of which they have heard rather than those they have seen themselves, but plenty are found who claim first hand information concerning such cases. In addition to those that are told within the community, similar stories also appear in various papers, giving additional weight to those that are circulated oraly.

The following are two examples of such stories that appeared in papers receiving a large circulation in this particular community. One published in the Stillwater Daily Press, Sept. 8, 1931, was a United Press dispatch under the dateline of Winner, South Dakota, and read: "Farmers in the Rosebud country have lost thousands of dollars worth of hogs and poultry because of the widespread use of poison to curtail the grasshopper plague. Hundreds of pheasants have also died after eating grasshoppers which had been killed by the poison mash." The other, printed in the Oklahoma Farmer-Stockman of Aug. 15, 1931, page 5, was the following letter sent in by a subscriber: " * * * * there is one thing it (referring to the Oklahoma Farmer-Stockman), as well as other papers, the Experiment Station and County Agents, advocates that is doing vastly more harm than good. I refer to the use of insect poison, especially grasshopper dope. The wholesale scattering of this dope in some parts of this state has almost annihilated the birds, the farmer's best friends. Mother birds are killed and the young ones left in the nest to starve. It has been a veritable slaughter of the innocent. You can drive for miles along some of our highways without seeing a bird, where there used to be hundreds. And what is accomplished by all this poisoning? The more poison you put out the more birds you kill and the more insects you have * * * *. If this cruel practice of scattering poison over our farms is not stopped, it won't be long until birds will be a thing of the past in Oklahoma, and the whole state will be the loser and no one be the gainer except the few engaged in the manufacture of this devilish poison. Stop it."

The writer of the above was obviously radical in his views, but such statements have a dampening effect on grasshopper poisoning campaigns and thus far there is very little experimental evidence to indicate that such stands are not well taken. It is true that numerous observations have been made that domestic animals and fowls were not killed when poison

bran has been put out; but, on the other hand, it is also true that dead fowls and animals have been found in vicinities where the poison has been spread. This, to one group, is just as positive proof that it does kill as the lack of dead animals is to the other that it does not.

A search of the literature on the subject reveals that though the matter has been given careful consideration and close observation since poison bran mash was first used, there has been an exceedingly small amount of experimental work carried on in an attempt to determine the amount of danger arising from the spreading of the poison.

The foregoing statements indicate that more information on the subject is needed, in order that the economic entomologist may have more definite knowledge concerning this possibility. If birds are endangered he certainly should know it and govern his actions accordingly. On the other hand, if they are not endangered he should have available the information to prove it to those who might believe otherwise. It was the writer's purpose, in undertaking this problem, to determine as definitely as possible, first, to what extent the lives of birds are endangered through the use of poison bran mash as used in the control of grasshoppers, and, second, to determine if the birds, especially chickens, would obtain a sufficient amount of arsenic to affect humans or other animals that might eat them after they had fed on the poison bran or on poisoned grasshoppers.

II. REVIEW OF LITERATURE

Coquillett[9], who introduced grasshopper bait, discussed in considerable detail his observation concerning the danger of poisoning other animals and birds through its use. It appears to be his belief that the mixture can be used safely provided the following conditions are met: It should be mixed indoors; poultry and domestic animals of all kinds should not have access to the fields when the mixture is used; the mixture should be saturated to prevent the poison being blown about by the wind, and should be placed in piles for the same reason; if used in alfalfa or similar fields, those fields should not be pastured, even after the poison has been removed.

A large number of writers including Hunter and Claassen[23], Dean[12], Dean, Kelly and Ford[18], Webster[58], Felt[14], Milliken[38 39], Merrill[37], Cooley, Parker and Seamans[7], Cooley, Parker and Strand[8], Corkins[11], and Granovsky[22], have recorded numerous observations wherein the absence of poisoning of birds was noted even though extremely large quantities of poisoned

bran mash were used. Several of them saw cases of poisoning but stated that each case was due to carelessness. A few of them state definitely that it is impossible for fowls to obtain a sufficient amount of the bait to poison them if the bait is properly scattered, while others are more cautious, making such statements as "It seems that there is little if any danger" or "Ordinarily there is no danger" when the bait is properly used.

Judging from their recommendations, it appears that other writers consider the danger to be more definite. Jones[29] states that "The mixture should be used with care where domestic fowls are apt to feed as there is danger of poisoning them." Urbahns[53] and Fluke[15] each state that chickens should not have immediate access to fields where the mash has been scattered; and the former recommends that, in case it is not practical to keep them out, they should be well fed in the morning before leaving for the fields so that they will not pick up too many of the poisoned hoppers. Bruner[4] had been called in 1893 to Grand Junction, Colorado, to investigate a grasshopper outbreak where poisoned bran mash had been used. After looking over the situation, he states "Some bran and arsenic had been used, but so carelessly in many instances that not only were the domestic fowls and an occasional larger animal, but also nearly all of the native birds of the region, destroyed." Lugger[35], Pettit[43] and Shoesmith[49] state that poisoning should not be conducted in fields to which poultry have access and that it should not be used where partridges or quail are likely to feed. Hunter[27] states that livestock, especially chickens, are likely to be poisoned if they have access to the poison, but that his observation indicated little, if any, danger of poisoning beneficial wild birds. Washburn[55] [56] believed that there was little, if any, danger to adult fowls but states that it probably would be dangerous if used in proximity to small chickens. Kaupp[32], a veterinarian, believes that poultry is endangered through eating the grasshoppers that have been poisoned by this bait. He says: "We have had cases brought to our attention in which birds become poisoned by eating poisoned grasshoppers. In these cases the grasshoppers were given arsenic in bran. The birds devouring large numbers of grasshoppers became ill and many died." This statement is followed by a description of the symptoms and notes of autopsy, which closely correspond with those of arsenical poisoning. Heelsbergen[25] states that in America poultry suffered arsenical poisoning after feeding on grasshoppers which had been destroyed by arsenical baits. It seems probable that Heelsbergen was referring to Kaupp's statement.

Judging from the foregoing citations it appears that opinions are about equally divided concerning the danger or lack of danger to birds through the use of poisoned bran mash. However, there appears to have been in recent years a decided swing of opinions, among entomologists at least, to the view that poisoned bran mash properly used does not endanger birds.

The writer recently sent letters of inquiry to the Entomologists of each of the State Experiment stations, and to the Federal Entomologists known to have had experience in grasshopper control, asking their opinions concerning the danger of poisoning birds by the spreading of poisoned bran mash. Of the 62 letters received in reply, not one of them definitely expressed the opinion that poisoned bran mash properly used would endanger birds. A large number of them, particularly among those who had had much experience in poisoning grasshoppers, were very definite in their statements that there was no danger. It is also true, however, that a number were quite cautious in their replies, making such statements as, "Thinly spread bait is fairly safe."

One of the surprising facts that a review of the literature brings out is that, although the question of poisoning birds constantly arises, the amount of experimental work carried on is exceedingly small as compared with the number of opinions that have been expressed. With very few exceptions, the statements made concerning the poisoning of fowls appear to have been based on chance observations rather than on recorded experimental work.

Washburn[55] apparently is the only American writer who has carried on any experimental work to determine the effect of arsenic, as used in the control of grasshoppers, upon poultry. He reports " * * * * This department of the station has recently made a most severe test, using a full grown turkey and full grown and two-thirds grown chickens, with most satisfactory results. The conditions were much more severe in this test—which was with confined fowls, lasting over two weeks and using meal into which some grain was introduced instead of horse manure—than could possibly exist in the use of Criddle mixture, the fowls being obliged to pick their food from this poisoned mass or go without."

In a later publication Washburn[56] also reported testing a formula consisting of sodium arsenite 1 pound, horse manure 120-150 pounds, and molasses one pint, as follows: "It was

tested on poultry to see whether these animals in picking grain from such material would be injured. Two roosters were fed upon it for some time with no bad results."

These reports indicate that the experiments were not sufficiently thorough to justify the drawing of definite conclusions.

Van Zyl[54] in 1929 in South Africa carried out some much more thorough experiments which indicated that the danger to poultry from arsenic, as used there in the control of grasshoppers, is extremely slight. His experiments, however, are of little use in the United States for two reasons: (1) In South Africa the common practice in controlling grasshoppers is to spray them with a solution of sodium arsenite, (2) Van Zyl investigated the danger attached to grinding the poisoned hoppers and feeding them to poultry, a practice used in South Africa; while here the danger to poultry lies in their feeding upon the poisoned bran, or upon the poisoned hoppers in the field where they die.

Another phase of interest to anyone investigating this problem is the amount of arsenic constituting a lethal or toxic dose to birds.

Gallagher[18], after conducting a short series of experiments in which 3-pound and 4-pound hens were administered As_2O_3 in gelatin capsules arrived at the following conclusions: 1 to 3 gms. of As_2O_3 has no noticeable effect upon hens; 5 gms. constitutes a lethal dose.

Reinhardt[46] administered 0.2 gm. without injury to birds but killed them with 0.4 gm.

Skiba[50] states that 0.06 to 0.15 gm. per kg. of body weight is poisonous.

Heelsbergen[25] states that the lethal dose of arsenic for poultry is on the average 100 to 150 mgs. per bird.

Van Zyl[54], as reported previously in this paper, carried on a series of experiments in which 7.5 gms. As_2O_3 per 100 kgs. body weight or 75 mgs. per bird of 1 kg. was fatally toxic, while 7.1 gms. per 100 kgs. or 160 mgs per bird of 2.25 kgs. weight was only slightly toxic.

Transporting all of these into units of milligrams, it is seen that the minimum fatal dose of As_2O_3 for chickens is placed by the different workers on the subject as follows: Gallagher, 324; Reinhardt, somewhere between 200 and 400; Skiba, 60-160 for a 2.2-pound chicken; Heelsbergen, 100-150; Van Zyl, 75 for a 2.2-pound chicken. Thus it appears that there is quite a wide variation in the results that these different workers obtained. There are several things that may have been responsible for this variation, a few of them being as follows: (1) Variation in the size of birds used (several of the workers

failed to state the weight); (2) variation in crop content at time of administration of poison; (3) variation in arsenic used, such as age, purity, fineness to which it had been ground, presence of lumps in it, presence of moisture, etc.; (4) variation in methods of administering the poison; and (5) variation in susceptibility of the birds used.

III. EXPERIMENTAL

It is apparent that there are two sources from which birds may obtain arsenic: First, from the poison bran; second, from grasshoppers that have eaten poison bran. The poison bran may be obtained at the place the bait is prepared, or where it is stored, or from containers from which the bait has been scattered if they are not well cleaned thereafter, or from the fields in which the bait has been scattered. In the latter case, the bait may have been scattered in piles and large lumps or it may have been scattered as it should have been—evenly and thoroughly. In the case of the first three sources, the possibilities of poisoning are self evident and no further discussion is required here. When the bait is scattered in lumps or piles, there is also no question that birds may secure a lethal dose. However, such cases are avoidable, and are due to improper precautions or carelessness of the persons using the bait. Therefore, in this work consideration is given only to the possibility of poisoning from grasshopper bait that has been properly scattered, and from grasshoppers that have eaten poisoned bran.

Amount of Poisoned Bran Constituting a Toxic or Lethal Dose to Chickens

In an investigation of the possibility of birds securing an injurious amount of arsenic through picking up the poision bran that has been scattered in the fields, it is desirable to know just how much is required to constitute a toxic or lethal amount.

The previous statements given concerning the toxicity of arsenic to fowls show a wide variation in the amount of arsenic the different workers on the subject have found to constitute a lethal dose for chickens. The writer did not attempt to solve the matter of variation in the results obtained, but did consider it necessary to gather some data on the susceptibility to arsenical poisoning of the birds in the flock with which he was working.

The birds used in carrying on this experiment were from the flock of the Poultry Department of the Oklahoma A. and M. College. The poison, powdered white arsenic (As_2O_3), was administered in the form of poison bran mash prepared simi-

larily to the common formula used in the preparation of grasshopper bait, except that the attrahents were left out. The formula used was bran 96 pounds, arsenic 4 pounds, and water to moisten. Ninety-six pounds of bran were used rather than 100 in order to facilitate figuring the percentage of arsenic. The bran was sifted by means of ordinary window screen, having 14 meshes per inch, in order to remove any shorts contained in it. The white arsenic was finely powdered, dry, and chemically pure. The bran and arsenic were thoroughly mixed and then dampened with finely sprayed water. This mixture was then permitted to dry. All weights of bait, unless otherwise stated, refer to the weight of this mixture after it was thoroughly dried.

A careful examination of the bottom of the receptacle in which the material was stored after being dried indicated that the arsenic was adhering well to the bran as none could be found, where it no doubt would have settled had it become loosened.

The following technique was used in administering the poison bran to the chickens. The bran was weighed and placed in a clean bowl. It was then moistened with water to the approximate consistency at which grasshopper bait is scattered. It was then placed in a one-fourth inch glass tube, one end of which had been well rounded by heating in a gas flame to remove any sharp corners. The moistened bran was then tamped lightly into place in the tube by means of a metal plunger which just fitted the inside diameter of the tube. Approximately two inches of the lightly tamped material was administered at one time, followed immediately by a like amount until all had been given. The tube was inserted into the mouth of the bird to a point posterior to the base of the tongue and bran forced into the chicken's throat by means of the plunger. By this method the exact amount of poison bran desired could be fed with no waste.

Table I (page 12) gives the results of these feeding tests.

The results of the experiments on chickens Nos. 1 and 2 indicated that 3.36 mgs. As_2O_3 per ounce of bird weight constitutes a toxic dose and that an amount between the above and 4.78 mgs. per ounce of bird weight constitutes a lethal dose. For the purposes of the problem it was considered desirable to determine the toxic non-lethal dose, and therefore birds Nos. 4 to 17 were fed approximately 3.36 mgs. As_2O_3 per ounce bird weight in order to determine if this amount was consistently toxic and non-lethal under varying conditions. The results of these feeding tests indicate that this amount is consistently

non-lethal and may or may not be noticeably toxic. Nos. 4, 6, and 7 were fed the poisoned bran on an empty crop, the others on a filled or partially filled crop. This rather definitely indicates that when the crops of chickens are partially filled, there is less danger attending their feeding upon poisoned bran.

TABLE I.—Amount of Grasshopper Bait Constituting a Toxic or Lethal Dose to Chickens

Chicken No.	Variety of chicken	Weight in oz.	Dose in gms.	Mgs. of As_2O_3 per oz. of bird wt.	Results
1	White Leghorn	22	1.85	3.36	Slight illness
2	White Leghorn	23	2.77	4.78	Died second day
3	White Leghorn	26	3.7	5.69	Died third day
4	Barred Rock	73.5	6.2	3.37	Slight illness
5	Barred Rock	75	6.3	3.36	No indications of poisoning
6	White Rock	67	5.6	3.34	Slight illness
7	White Rock	70	5.9	3.37	Moderately ill
8	Barred Rock	118.5	9.9	3.34	No indications of poisoning
9	Barred Rock	121	10.1	3.34	No indications of poisoning
10	White Leghorn	53	4.4	3.32	No indications of poisoning
11	White Leghorn	56	4.7	3.36	No indications of poisoning
12	White Rock	88	7.4	3.36	No indications of poisoning
13	White Rock	87	7.3	3.36	No indications of poisoning
14	Barred Rock	88	7.4	3.36	No indications of poisoning
15	Barred Rock	82	6.9	3.37	No indications of poisoning
16	Brown Leghorn	70.5	5.9	3.34	No indications of poisoning
17	Brown Leghorn	67	5.6	3.34	No indications of poisoning

While the number of birds used in the above experiment was not sufficiently large to justify the drawing of definite conclusions as to the amounts of poisoned bran or arsenic required to constitute a toxic or lethal dose to chickens, a sufficient number was used to indicate that an amount of arsenic under 3.36 mgs. per ounce of bird weight should not be considered dangerous to the lives of the birds.

Possibility of Birds Securing a Toxic or Lethal Dose of Arsenic from Scattered Poisoned Bran

A pen 10 by 66 feet was set up in a pasture. The ground in this pen was quite similar in regard to its covering to the

usual type of ground over which grasshopper bait is scattered. In one end the vegetation consisted of very short thin grass, in the middle were large weeds with very little vegetation under them, while in the opposite end was a heavy stand of grass. The birds were placed in this pen and left for two or three days to become accustomed to the conditions. During this time they were fed grain lightly and made to clean up all before they were fed any more. Plenty of water was kept before them at all times. Poison bran was then scattered in this pen with the chickens, as indicated in the following discussion.

On August 13, 6 White Leghorn cocks, weighing from 1½ to 2 pounds were placed in this pen and fed grain lightly Aug. 14 at 8 a. m. and 4 p. m. Again at 8 a. m., Aug. 15, they were fed lightly and at 4 p. m. they were fed the amount they would clean up. At 10 a. m. the next morning (Aug. 16), 16 hours later, 12.12 ounces of poison bran mash was distributed evenly over the floor of the cage. The mash used in this experiment had the usual amount of arsenic in it. As in the previous experiment, this mash was prepared, allowed to dry, weighed for the experiment, and moistened again before using.

The cage in which this bait was scattered contained 660 square feet, or 1/66 of an acre. Thus the bran was distributed at the rate of 50 pounds per acre rather than the usual 5 to 10 pounds.

No other food material was placed in the cage. During the next 24 hours there was no visible evidence of any poisoning. Judging from previous experience, if any poisoning had occurred it would have become evident by this time. Absence of appetite was in previous experiments one of the first indications of poisoning, so it was assumed that if any poisoning had occurred it would show up in this manner when the chickens were again fed. Therefore, at the end of 24 hours, Aug. 17, 10 a. m., mixed grain was thrown before them and all ate greedily. They were fed again that afternoon and again the following morning and each time all fed normally.

Aug. 18 at 10 a. m. the chickens were fed as much grain as they would clean up readily. All food was then withheld until 10 a. m. Aug. 19, when 24.24 ounces of the poison mash were scattered in the pen. Thus, the chickens had been without food for 24 hours and the mash was scattered at the rate of 100 pounds per acre. The chickens again picked lightly over the floor of the cage but no evidence of poisoning could be detected during the next 24 hours. At the end of this time, they were fed and all ate greedily and continued to feed normally.

Using the same method, except that the mash was scattered only at the rate of 100 pounds per acre, the following birds were tested: 2 Rhode Island Red chickens, weighing approximately 4 pounds each; 4 White Cochin chickens, weighing approximately 3½ pounds each; 4 Buff Orpington chickens, weighing approximately 3 pounds each; 4 turkeys about 2 months old, and weighing 2 pounds each; and 4 adult quail, weighing approximately 6 ounces each. In no case was there any indication of poisoning.

Two White Leghorns, weighing 1½ pounds each, and 2 Rhode Island Red chickens, weighing 4 pounds each, and 4 adult quail, weighing approximately 6 ounces each, were also tested, using bran mash poisoned with sodium arsenite at the rate of 1 quart (2 pounds As_2O_3) per 100 pounds of bran; and again no indications of poisoning occurred.

In these tests the conditions were much more severe than would occur under field conditions, because of the following facts: (1) In the field it is neither necessary nor advisable to scatter the bran at the rate of more than 20 pounds per acre, and under most circumstances 5 to 10 pounds per acre is sufficient. Thus, in the pens the bran was scattered from five to twenty times as thickly as is necessary in the field. (2) Since these birds had been without food for 24 hours, it seems that they would probably have eaten more bran than chickens would under field conditions. This seems probable because chickens having access to fields would always be able to find considerable food at the time grasshopper outbreaks occur and therefore would not be as hungry as those used in these experiments. (3) All the bran eaten by these experimental birds was received on an empty crop, which probably would not be the case in the field, and arsenic is thought to be more toxic when received on an empty crop.

Since it is necessary for a 22-ounce chicken to obtain 1.65 gms. of poison bran (4 percent arsenic) in order to obtain a toxic dose, it will be seen that when bran is scattered at the rate of 10 pounds per acre, it would be necessary for a chicken of this size to pick up and swallow an amount of bran equivalent to every flake of bran on 18 square feet of ground. While such a thing may be in the range of possibility, it seems very improbable that it would occur when the bran is well scattered. The fact that they did not obtain this amount under as severe conditions as were imposed upon them in the pens lends much weight to this argument.

To the writer, the foregoing facts seems to justify the conclusion that chickens will not pick up a sufficient amount of

poisoned bran to constitute a toxic dose when it is well scattered, even at the rate of 100 pounds per acre, and therefore certainly will not when it is scattered at the recommended rates.

Possibility of Birds Receiving a Toxic or Lethal Dose of Arsenic Through Eating Poisoned Grasshoppers

The next part of this experiment was to determine the possibility of birds receiving a toxic or fatal dose of arsenic by feeding upon grasshoppers that had eaten the poisoned bait. Birds in general are very fond of insects, eating large numbers of them; and as a result, the question has arisen numerous times, "Would not birds in eating large numbers of poisoned grasshoppers receive sufficient arsenic to poison them?" Entomologists have often observed the absence of poisoning where chickens had access to large numbers of poisoned grasshoppers, and as a result, have stated chickens will not be poisoned by this means.

However, a search of the literature reveals that very few and meager experiments have been conducted to determine definitely this point, most of the assertions apparently having been made on chance observations. To the writer it appears that in order to state definitely that poultry would not be poisoned from eating poisoned grasshoppers, it would necessarily have to be assumed that, first, the conditions were most favorable for the poisoning of poultry at the time the observations were made, and second, that no case of poisoning could possibly have escaped notice. Under field conditions, which seems to have been the conditions under which these observations were made, it seems that neither of the above assumptions would be entirely justifiable. Numerous factors might vary that would tend to influence the first assumption. Among these are: first, amount of other food available; second, age of poultry; third, number of chickens ranging over a given area; fourth, the number of poisoned grasshoppers in this area; fifth, variations in the amount and kinds of poison used in the bait; and sixth, crop content of chickens at the time grasshoppers were eaten.

The second assumption under many circumstances would scarcely be justifiable, because there exists on most farms many places where poisoned poultry could die and not be found until several days later, or perhaps never. As before stated, Kaupp[32] records cases of poisoning and death of fowls from this source. Therefore, it was felt that more definite data concerning this point were desirable.

In working on this phase of the problem, it was considered desirable to answer the following questions:

1. What would be the average amount of arsenic consumed by each species of grasshopper used in the experiment, when fed upon the commonly used arsenical bait?
2. How many poisoned grasshoppers would the chickens consume? The answer to these two questions would answer the third:
3. How much arsenic would the chickens thus obtain? Other questions then needing solution would be:
4. Would this amount constitute a lethal or toxic dose?
5. Even though the amount of arsenic eaten were proved neither lethal nor toxic if fed over a long period of time would it have a cumulative effect?
6. Would it affect their growth? If so, how?

The species of grasshoppers used in these experiments were *Melanoplus bivittatus* (Say), *Melanoplus femur-rubrum* (De Geer) and *Melanoplus bispinosus* (Scudder), as determined by Mr. A. N. Caudell of the U. S. Bureau of Entomology. They were selected because they were most available. The first two named are very frequently the species causing the most damage during grasshopper outbreaks, which fact seemed to make them a logical choice for such an experiment.

After trying several plans, the following method of handling the grasshoppers was adopted as being most satisfactory. They were caught in a "hopper dozer," which was operated by means of an automobile. Figures 1, 2 and 3 illustrate the construction and operation of the "hopper dozer."

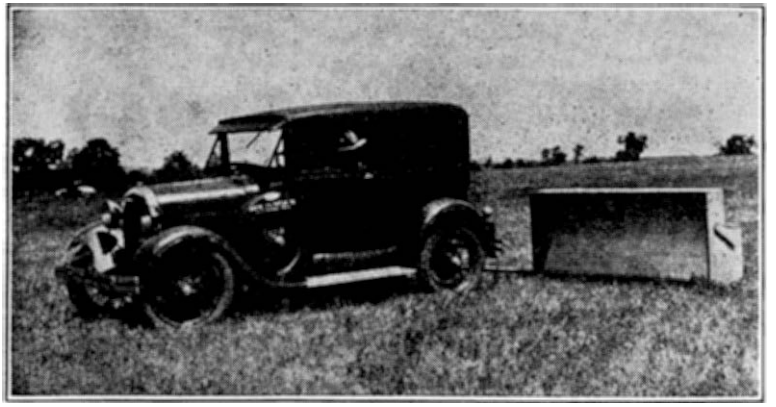

Fig. 1.—Hopper dozer attached to car.

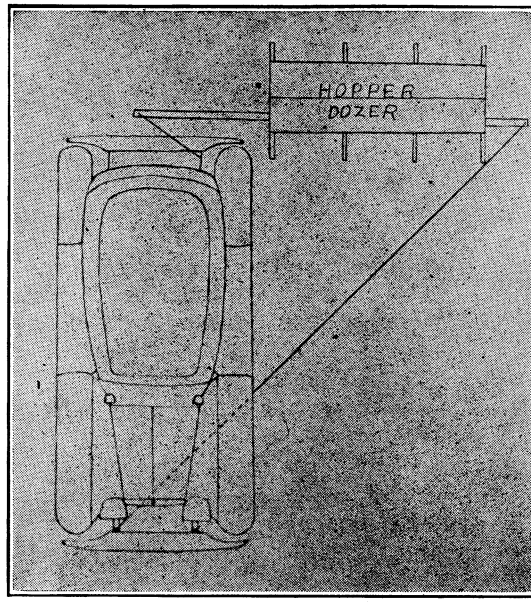

Fig .2.—Diagram illustrating attachment of hopper dozer to car.

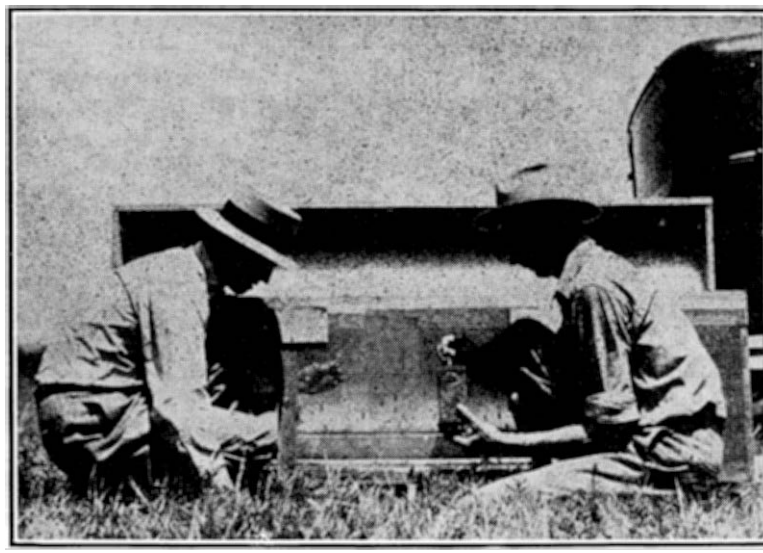

Fig. 3.—Removing grasshoppers from dozer.

After the grasshoppers were removed from the dozer, they were placed in screen wire cages and taken to the insectary.

Amount of Arsenic Consumed by Grasshoppers.—To determine the average amount of arsenic consumed by each species of grasshopper used, it was necessary to learn how much poisoned bran they would eat. It was first planned to feed a weighed amount of bran to the grasshoppers and then weigh the amount remaining after they had been killed. This, however, did not prove to be practical because: (1) The dry weight of the bran had to be used, otherwise there would be too great a variation in the water content. In view of the fact that under field conditions the bran is fed moist, it was felt that it should be fed moist during the experiment. (2) Small bits of bran were lost and feces and dirt became mixed with that remaining.

To avoid these difficulties the following plan was devised: A standard size of bran flake was selected. This was a large, easily handled flake; and only flakes very nearly this size were used. In counting them, when it was necessary or convenient to select one somewhat larger than this standard the next one selected would be slightly smaller than the standard, which resulted in keeping variations to a low point. In order to determine the average weight of flakes of this size, 100-flake samples were weighed. Results of these weighings are shown in Table II.

TABLE II.—Weight of 100-Flake Samples of Bran

Sample No.	Weight in gms.	Sample No.	Weight in gms.
1	0.232	6	0.231
2	0.225	7	0.238
3	0.241	8	0.239
4	0.228	9	0.238
5	0.233	10	0.232

This table shows the total weight of the 10 samples to be 2.337 gms., and the average weight of each sample was .2337 gm. Since these were 100-flake samples, .2337÷100=.002337 gm., which was the average weight of each flake of bran of the standard selected. These weighings show a variation of only .016 gm. between the heaviest and the lightest sample, and therefore indicate that the amount of bran used by this method may be kept quite constant.

The poisoned bran used in the experiment was the same as that described for the previous experiment and therefore contained 4 percent arsenic. Therefore, .04 of .002337 or 0.00009348 gm. was the average amount of arsenic on each bran flake.

By determining the number of flakes the average grasshopper would eat, the amount of arsenic consumed could be obtained by multiplying the number of flakes eaten by the amount of arsenic found on each flake.

The number of flakes eaten was obtained as follows: Single grasshoppers of each species used were placed in small screen cages, together with a certain number of bran flakes. The cages were observed twice daily and the number of flakes remaining at the grasshopper's death recorded. Then this number subtracted from the original number gave the number of flakes eaten by that particular individual. It was learned that approximately 15 flakes was the maximum number of flakes

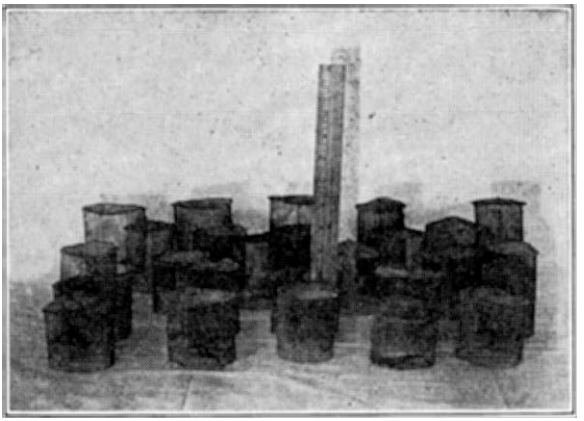

Fig. 4.—Individual cages used for determining amount of poison bran eaten by grasshoppers.

that the larger species, *M. bivittatus,* would eat, while 10 or less was the maximum for the smaller species. Therefore, 15 flakes were placed in the cages with the larger species and 10 with the others. The soil on which the cages were to be placed was dampened sufficiently to thoroughly moisten blotting paper placed upon it. Small squares of blotting paper were then placed upon the soil and the bran flakes distributed evenly over the surface. This resulted in the bran flakes being in a moist, attractive condition. The cage was then placed over the bran flakes and the grasshoppers introduced. Only adult grasshoppers were used. One hundred specimens of each of the three species of grasshoppers were used.

The number of flakes eaten by *M. bivittatus* was 805, by *M. femur-rubrum* 302, and *M. bispinosus* 320. Therefore the

average number of flakes of bran consumed by each *M. bivittatus* is 8.05, by each *M. femur-rubrum* 3.02 and by each *M. bispinosus* 3.20.

Since 0.00009348 gm. or .09348 mg. was the amount of arsenic on one flake of bran, 8.05 times .09348 or .7525 mg. was the average amount of arsenic consumed by each *M. bivittatus*. In a like manner, it was found that .2804 and .2991 mg. was the average amount consumed by each *M. femur-rubrum* and *M. bispinosus*, respectively.

A simpler and perhaps better method of approach to this problem would have been a chemical analysis of the poisoned hoppers, to determine the amount of arsenic they contained; but, at the time this information was desired, the equipment for making such determinations was not available. As a matter of fact, a chemical analysis of some poisoned hoppers was made later. In connection with an experiment to be described later in this paper, portions of the bodies of chickens that had fed upon poisoned grasshoppers were sent to the office of the U. S. Food and Drug Administration at Kansas City, Mo., for a chemical analysis of arsenical content. At the time this material was prepared for shipment (January, 1930), 72 poisoned grasshoppers *M. bivittatus*, all that were available at that time, were included. According to figures of the above experiment, the 72 hoppers would have consumed 72×.7525 mg. or 54.18 mgs. The chemical analysis showed them to contain exactly 54 mgs. The fact that each method obtained such similar results indicates that the method herein used was quite accurate.

The possibility that a large variation might occur according to the age of the grasshoppers used was given consideration; but Langford's[34] work in Colorado indicated that the age of grasshoppers does not influence the amount of food they take, and hence it was not considered necessary to investigate further this phase of the problem.

The above data indicate that the following figures at least very closely approximate the amount of arsenic the average grasshopper will consume when feeding on poison bran mash with no other food available:

Melanoplus bivittatus	.7525 mg.
M. bispinosus	.2991 mg.
M. femur-rubrum	.2804 mg.

Method of Handling Grasshoppers for Feeding Tests. The next experiment consisted of feeding poisoned grasshoppers to

the experimental birds in order to determine the number of grasshoppers they would eat, the amount of arsenic thus obtained, and its effect upon the birds.

As the grasshoppers were brought in from the field, they were placed in cages 12 by 12 by 12 inches in size, constructed of 1 by 3 inch boards and ordinary window screen. The wooden frames were covered on 5 sides with screen, the sixth being placed on the ground and serving as the floor. In the center of the side opposite the floor a hole was made, sufficiently large to admit the hand and arm. Adhesive tape was placed around the edge of this hole to prevent scratching of the skin while handling material within the cage. To close the cage, squares of screen were placed over the holes and weighted with flower pots.

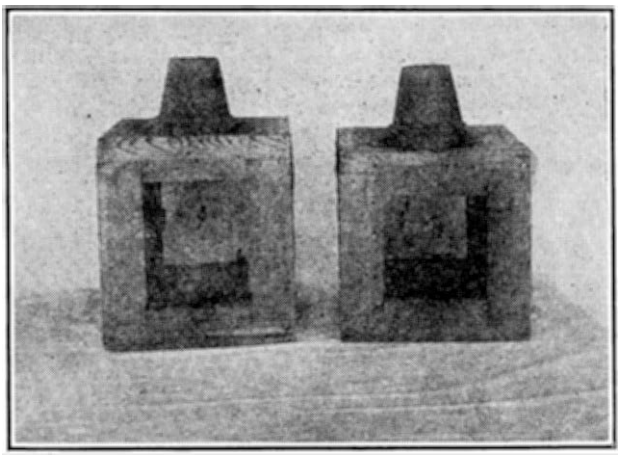

Fig. 5.—Cages used for poisoning grasshoppers.

Some of these cages were placed in the greenhouse, others out of doors. The cages were placed in pairs. In one cage of each pair was placed poison bran mash (from the same mix already described); in the other was placed bran which had been treated the same as the poisoned bran except that no poison was mixed with it. Usually 50 grasshoppers were placed in each cage.

At the beginning of the experiment, it was decided to use for feeding purposes only grasshoppers from those pairs of cages in which 90 percent of the grasshoppers in the poison cage died while 90 percent of those in the check cage were still alive. But early in the season there was considerable cloudy

weather; and under such conditions it was very difficult to secure a 90 percent kill in the poison cages before 10 percent of the checks died. As a result, the majority of all hoppers collected had to be discarded, making it extremely difficult to keep sufficient poisoned hoppers to keep the feeding experiments going. Therefore, it was decided to use in the feeding experiments grasshoppers where 75 percent of those in the poison cages were killed while 75 percent of the checks were still alive.

Two to six hours after the grasshoppers were placed in the cages, all dead ones were removed and discarded, it being assumed that such deaths were more likely to be due to mechanical injury suffered in catching and handling them than to poisoning.

It was assumed that the same number in the poison cage died from some cause other than poisoning that died in the check cage. Therefore, it was figured that the number of dead in the poison cage minus the number of dead in the check cage, had been killed from the poison. Thus, if 25 were dead in the poison cage and 5 in the unpoisoned cage, the 25 were fed to the chickens but recorded as though only 20 had been fed. The same results were obtained by recording the percent poisoned, and it was found more expedient to keep the records in this manner, so this plan was used. Under this plan, in the above circumstances, the 25 hoppers would be fed and recorded as 25 hoppers 80 percent poisoned, which of course would be the equivalent amount of poison found in 20 hoppers 100 percent poisoned. Then the amount of arsenic eaten by the fowl was considered to be 80 percent of 25 multiplied by the average amount of arsenic eaten by a single grasshopper of that particular species.

From one to three days were required to kill the grasshoppers. To prevent decomposition of those that died first, all dead hoppers in each cage were removed each morning and afternoon. Notes were made of the number removed and they were then placed in an electric ice box at a temperature of 35° F. until the last ones were removed and the percentage of poisoning figured. As a matter of fact, all were kept in the ice box from shortly after death until used. At the time the last of the grasshoppers in the poison cage were removed, those in the check were placed in a fruit jar, which was tightly closed and placed in the sun until all the hoppers were killed. They were then placed in the ice box until fed. By this method, all were kept in good condition so that it was not necessary to feed partially decomposed grasshoppers.

In using this plan, conditions were made as favorable as

possible for poisoning of birds, as it seems probable that grasshoppers with no other type of food available would consume more poison than those under field conditions where so much other food could be obtained.

Feeding Poisoned Grasshoppers to Domestic Fowls

In conducting this series of experiments the birds were confined in cages and fed for a few days before the experiments were started. This was necessary because of the fact that they frequently do not feed normally for a few days after they are first placed in pens. They were observed until they appeared to be feeding normally and the experiment was then started.

In feeding the grasshoppers the usual procedure was as follows: From 5 to 15 grasshoppers were thrown on the floor of each cage. If these were eaten they were replaced with others as soon as eaten. This was continued as long as the birds continued to eat them. A few were usually left on the floor of each cage to be eaten before the next feeding. If they had not been eaten at the time of the next feeding, they were removed and replaced with fresh grasshoppers. In the case of experimental chickens Nos. 29 to 41 inclusive, the checks were given approximately the same number of grasshoppers given the experimental birds. In each case the checks ate practically all that were given them while a large number of those left in the cage were never eaten by the birds receiving poisoned grasshoppers. In the other experiments with domestic fowls (birds Nos. 43 to 59) both experimental birds and checks were fed all the grasshoppers they would eat.

As previously explained, the amount of arsenic contained in the bodies of the grasshoppers had already been obtained. Therefore the total amount of arsenic eaten by one bird was easily determined by obtaining the sum of the amounts eaten by all the grasshoppers which the bird had eaten.

The grasshoppers were fed arsenic in two forms. In one case white arsenic was mixed with the bran as described previously. In the other case sodium arsenite (Na_2HAsO_3) was mixed with the bran to be fed the grasshoppers. This was considered desirable because in at least some communities this form of arsenical is being used quite extensively in grasshopper control work. It is cheaper, is water soluble and hence more toxic, and is more easily and uniformly mixed than white arsenic.

The sodium arsenite used in these experiments was prepared by the Agricultural Chemistry Department of the Oklahoma A. and M. College, as follows: 111 grams of sodium hydroxide were dissolved in 400 c. c. of water. While the solu-

tion was still hot, 1 lb. of chemically pure white arsenic (As_2O_3) was added with stirring; when cool, water was added to bring its volume to one pint.

The poisoned bran was prepared by using the above mixture at the rate of 1 quart to 98 lbs. bran, since this is the amount commonly recommended in preparing grasshopper bait. In preparing the poisoned bran the sodium arsenite was first diluted with approximately one-half the amount of water required, placed in a knapsack spray and sprayed as a fine misty spray over the bran as it was stirred. By this method each flake of bran was as evenly moistened as seemed possible.

It will be seen that in this case two pounds of white arsenic were used in the form of sodium arsenite, while in the other mixture 4 lbs. of As_2O_3 in the insoluble form was used. Van Zyl[54] found As_2O_3 in the soluble form of sodium arsenite to be just twice as toxic to chickens as white arsenic. His findings were accepted in this case and no experimental work was conducted to determine the toxicity of this mixture to chickens.

In a part of the experiments the fowls received a "growing ration" in addition to the poisoned grasshoppers. This ration contained corn meal, shorts, bran, alfalfa meal, meat scraps, cottonseed meal, dried butter milk, bone meal, salt and limestone. Thus the fowls had a balanced ration without eating any grasshoppers. In other experiments, grain only was fed in addition to grasshoppers. The grain consisted of cracked corn and kafir. This was done to determine if the fowls would eat more grasshoppers when receiving grain only. In still other experiments grasshoppers only were fed throughout the experiment.

Tests More Severe Than Field Conditions

In conducting the series of experiments, it was intended to make the conditions fully as severe, if not more so, than could ever occur under field conditions. It is believed that they were very much more severe than would ordinarily occur under field conditions for the following reasons:

1. In some of the experiments poisoned grasshoppers were the only food to which the experimental birds had access. It seems extremely improbable that this condition could exist under field conditions, due to the fact that so many other forms of food are to be found in fields at the time of year when grasshoppers are poisoned. The birds would have available not only unpoisoned grass-

hoppers, but many other forms of insects, as well as waste grain, weed seeds, and various refuse found in the fields or farm yards.

2. The fact that no other food was available forced the chickens at all times to consume the arsenic contained in the grasshoppers' bodies on an empty crop. Under field conditions where other foods may be found, it also seems extremely improbable that in all cases the arsenic would be received into an empty crop. The experiments previously reported in this paper, as well as numerous others, indicate that arsenic is more likely to have toxic or fatal results when received on an empty crop.
3. Most of the grasshoppers fed to the chickens in these experiments were poisoned in cages where no other form of food was available except the poisoned bran mash, while under field conditions their natural food also is available. Therefore it would seem probable that these grasshoppers might eat more of the mash than those in a field where poisoning was being conducted; and this in turn would of course result in the poultry receiving larger amounts of arsenic.
4. In some of the experiments the fowls fed upon poisoned grasshoppers over a longer period of time than they would under field conditions. One of the experiments extended through 66 days, and all of them extended through at least 10 days. Under field conditions large numbers of poisoned grasshoppers usually are available only a few days at a time.

Each of the above conditions would have a tendency to increase the amount of arsenic that the experimental birds would eat. Therefore, it is thought that toxic or fatal results would be much more likely to occur during the experiments than under field conditions where grasshopper poisoning was being conducted.

The results of the experiments in feeding poisoned grasshoppers to domestic fowls are given in Table III.

The most outstanding fact brought out by these experiments was that none of the domestic fowls died from feeding upon grasshoppers that had been killed by eating poisoned bran mash, even though they fed on poisoned hoppers as long as 66 days and in some cases no other food of any kind was available for a period of 10 days. This in itself is very strong evidence that the lives of domestic fowls are not endangered through having access to large numbers of poisoned grasshoppers.

TABLE III.—Data in Feeding Poisoned Grasshoppers to Domestic Fowls.

Bird No.	Variety	Other food received	No. days fed	Weight beginning of exp. (oz.)	Hoppers poisoned with	No. hoppers eaten	Gain or loss in wt. during exp. (oz.)
29-30	Brahmas	Gr. ration	66	4.65	White arsenic	415	+60.35
31-32	Brahmas	Gr. ration	66	4.60	Not poisoned	481	+61.4
33-34	Wh. Leghorn	Grain	52	15.1	White arsenic	714	+16.6
35-36	Wh. Leghorn	Grain	52	16.4	Not poisoned	859	+18.9
37	Wh. Leghorn	Gr. ration	37	8.0	White arsenic	302	+14.2
38	Wh. Leghorn	Gr. ration	37	9.0	Not poisoned	310	+10.0
39	Wh. Leghorn	Grain	21	12.2	White arsenic	207	+ .6
40	Wh. Leghorn	Grain	21	12.6	Not poisoned	213	+ 8.2
41	Wh. Leghorn	None	10	23.0	White arsenic	424	− 0.5
42	Wh. Leghorn	None	10	25.0	Not poisoned	561	+ 1.0
43	R. I. Red	Ration gr.	10	70.0	Sodium arsenite	410	+18.0
44	R. I. Red	Ration gr.	10	68.0	Not poisoned	594	+ 9.0
45	R. I. Red	Ration gr.	10	88.0	Sodium arsenite	247	− 4.0
46	R. I. Red	Ration gr.	10	77.0	Not poisoned	748	0.0
47	B. Orpington	None	10	30.0	White arsenic	171	− 7.0
48	B. Orpington	None	10	31.0	Sodium arsenite	79	− 6.0
50	B. Orpington	None	10	26.0	Not poisoned	309	− 2.0
51	Wh. Leghorn	None	10	26.0	Sodium arsenite	314	− 3.0
52	Wh. Leghorn	None	10	25.0	Not poisoned	972	+ 4.0
53	B. Turkey	Gr. ration	10	31.5	Sodium arsenite	82	+ 5.5
55	B. Turkey	Gr. ration	10	26.0	White arsenic	57	+11.0
56	B. Turkey	Gr. ration	10	28.0	Not poisoned	915	+16.0
57	Muscovy Dks	Grain	11	76.0	White arsenic	1069	+ 8.0
58	Muscovy Dks	Grain	5	74.0	Sodium arsenite	1687	+ 4.0
60	Muscovy Dks	Grain	11	73.0	Not poisoned	1513	+10.0

Not only do these data show that, in spite of the severity of the tests, the fowls were not killed, but they also give very direct indications as to the reasons the birds were not killed. The basic reason ,entirely self evident, was that they did not consume a sufficient amount of arsenic. The fact that they lived is probably ample evidence for the statement, though the possibility exists that even though a sufficient amount was eaten it might have undergone such chemical changes in the alimentary tracts of the grasshoppers as to render it less toxic to the birds. However, since it was found that 3.36 mgs., As_2O_3 per ounce of bird weight is the approximate toxic dose for the birds, and since the amount consumed each day was known, it was possible to determine the percentage of a toxic or lethal dose consumed each day. The data were studied to determine the maximum percentage of a toxic dose each bird received. Table IV gives this information.

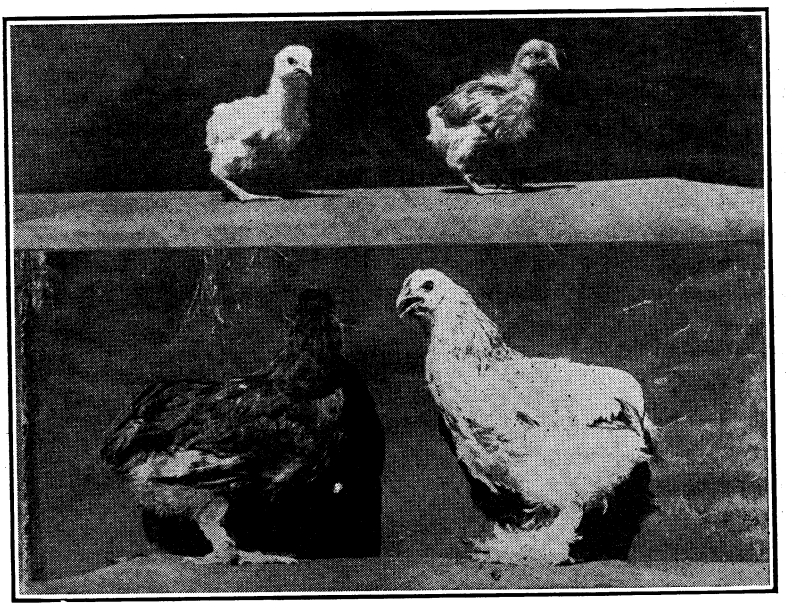

Fig. 6.—(top) Chickens Nos. 29 and 30 at beginning of experiment.
Fig. 7.—(bottom) Chickens Nos. 29 and 30 after feeding twice daily.

TABLE IV.—Maximum Percentage of a Toxic Dose of Arsenic Consumed in One Day by Fowls in Feeding upon Poisoned Grasshoppers.

Fowl No.	Greatest percent of a toxic dose eaten	Form in which arsenic was fed	Other food available
29 and 30	15.30	White arsenic	Growing ration
33 and 34	28.70	White arsenic	Grain
37	45.21	White arsenic	Growing ration
39	26.13	White arsenic	Grain
41	48.77	White arsenic	None
43	17.90	Sodium arsenite	Growing ration
44	17.88	Sodium arsenite	Growing ration
47	21.77	White arsenic	None
48	10.27	Sodium arsenite	None
51	37.58	Sodium arsenite	None
53	35.55	Sodium arsenite	Growing ration
55	18.54	White arsenic	Growing ration
57	39.98	White arsenic	Grain
58	46.55	Sodium arsenite	Grain

Table IV shows that the largest percentage of a toxic dose of arsenic consumed by any of the birds was less than 50 percent. No. 41, a White Leghorn chicken, consumed 48.77 percent of a toxic dose the 8th day of the experiment. At the time this amount was consumed the bird had had nothing at all to eat except poisoned grasshoppers for a period of 7 days and was exceedingly hungry. As a result of this diet, the bird had a light attack of diarrhea. At no time, however, were there any other indications of poisoning.

In 8 of the 14 experiments the maximum percentage of a toxic dose of arsenic was consumed during the first four days, and the average for all was 3.93 days. In the cases where the maximum was eaten later, the maximum was but a small percentage of a toxic dose. The fact that the maximum amount was eaten so early in the experiment would seem to indicate that the birds recognized soon after starting to feed upon poisoned grasshoppers that too many should not be eaten and therefore refused to eat sufficient grasshoppers to obtain an injurious amount of arsenic.

Chickens Eat Fewer Grasshoppers When They Are Poisoned

A number of the other experiments also indicated quite clearly that the fowls recognized the fact the grasshoppers fed them contained an injurious substance. The fowl that indicated this the most clearly of all was chicken No. 51, a White Leghorn pullet. She was fed for a period of 10 days on grasshoppers poisoned with sodium arsenite and bran. During this time she received no other food of any kind. The check bird, a White Leghorn cockerel, was fed similarly except that the grasshoppers he received were not poisoned. At the end of 10 days the feeding was reversed so that the one that had been receiving poisoned grasshoppers then received unpoisoned grasshoppers, and vice versa. They were fed twice daily. Table V gives the results of this experiment.

This table shows that each of the chickens ate similarly on the first day of the experiment, but that beginning with the second day there was a distinct difference in the number of grasshoppers eaten. In the absence of other food, each bird became more hungry during the following days; but they exhibited their hunger in distinctly different ways. Fowl No. 52 showed it by increasing the number of grasshoppers consumed, but No. 51 decreased the number of grasshoppers she ate even though her actions indicated that she was ravenously hungry. When the experiment was started, No. 51 was wild and would fly about the cage trying to escape when one approached the cage. But by the end of the 4th day she would rush to the door and

TABLE V.—Data on Feeding Chickens a Diet Consisting of Grasshoppers Only.

		BIRD NO. 51: FED HOPPERS POISONED WITH SODIUM ARSENITE AND BRAN WT. 1 LB., 10 OZ.			BIRD NO. 52: FED UNPOISONED HOPPERS WT. 1 LB., 9 OZ.
Date	Hour	No. eaten	Percent poisoned	Amount arsenic in mgs.	No. eaten
7-15	5 p. m.	29	90.4	9.6638	25
7-16	8 a. m.	15	90.4	5.1019	11
	5 p. m.	3	88.8	0.9796	30
7-17	8 a. m.	13	88.8	4.2456	30
	5 p. m.	21	88.8	6.8583	38
7-18	8 a. m.	26	97.2	9.5086	40
	5 p. m.	19	97.2	6.9486	40
7-19	8 p. m.	20	97.2	7.3143	48
	5 p. m.	21	91.2	7.2059	61
7-20	8 a. m.	16	91.2	5.4902	60
	5 p. m.	8	91.2	2.7451	45
7-21	8 a. m.	24	84.6	7.6394	54
	5 p. m.	13	84.6	4.1380	65
7-22	8 a. m.	21	84.6	6.6845	60
	5 p m.	21	84.6	6.6845	75
7-23	8 a. m.	8	100.0	3.0100	70
	5 p. m.	12	89.0	4.0183	60
7-24	8 a. m.	6	75.2	1.8976	50
	5 p. m.	11	75.2	3.1123	50
7-25	8 a. m.	7	75.2	1.9806	60
		314		105.2271	972
Beginning 7-26, No. 51 was fed unpoisoned hoppers and No. 52 poisoned hoppers.					
7-26	8 a. m.	14	75.2	15.8446	56
	5 p. m.	24	75.2	1.1318	4
7-27	8 a. m.	20	75.2	1.1318	4
	5 p. m.	60			0
7-28	8 a. m.	60			0
Total		178		18.1082	64

Weights 7-25, No. 51—1 lb. 7 oz.
No. 52—1 lb. 13 oz.

pick ravenously at the hands of any one feeding her, in attempts to get something more to eat. When grasshoppers were thrown before her she picked at them rapidly and vigorously, but ate only a very few. In picking at them, she detached the posterior legs of the grasshopper; and these were quickly swallowed. After following this procedure a few times she apparently learned that the legs of the hoppers would help appease her hunger without the unpleasant effects obtained when their bodies were eaten. Thereafter when grasshoppers were thrown

before her she would pick off and eat the legs at once but would eat only a few of their bodies. On the other hand, the chicken eating unpoisoned grasshoppers, as was usually the case with the chickens eating unpoisoned grasshoppers, picked them up and struck them against the floor of the cage two or three times, apparently to crush them before swallowing. As a result the posterior legs of the grasshoppers became detached and fell through the floor of the cage to the tray beneath.

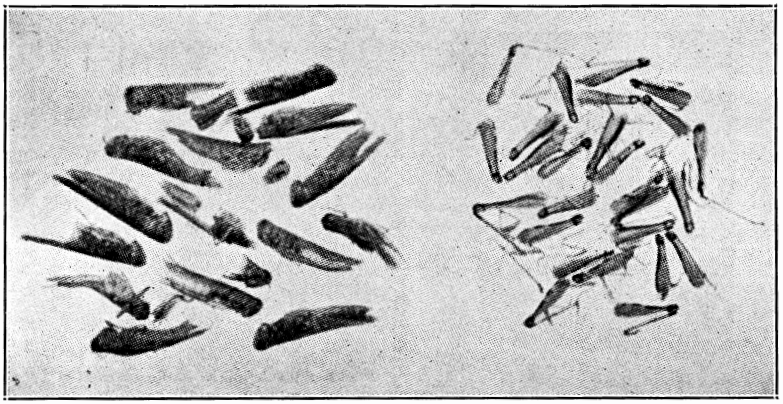

Fig. 8.—Remains of grasshoppers fed to birds Nos. 51 (left) and 52.

A few minutes after the chickens had finished eating on July 23, the remains of the grasshoppers fed were collected and photographed. The accompanying reproduction of this photograph (Fig. 8) shows that the chickens feeding on poisoned grasshoppers had eaten all the posterior and the most of the other legs from the grasshoppers. Even though her actions indicated she was frantically hungry she had left approximately 14 of the bodies of the 22 hoppers fed. On the other hand the chicken eating unpoisoned grasshoppers had wasted a large percentage of the legs, but had consumed every one of the bodies of the 70 hoppers given him. Similar results were obtained throughout the remainder of the 10-day period.

When the procedure was reversed so that the chicken accustomed to eating unpoisoned grasshoppers was fed poisoned grasshoppers, and vice versa, the results were distinctly different at each feeding. No. 52, now receiving poisoned grasshoppers, ate 56 at the first feeding, four at each of the next two feedings and none at all thereafter. To the writer the above indicated that No. 52 learned quickly that the poisoned hoppers were injurious and thereafter refused to eat them even though

no other food of any kind was available. On the other hand, No. 51, which had already learned that the hoppers she had been eating were injurious, learned after three feedings that those she was now receiving were not injurious and thereafter ate much greater numbers of them.

While the experiment discussed above furnished the most outstandindg indication that fowls recognize and refuse to eat too many poisoned grasshoppers, practically all of the experiments gave indications of the same thing to a greater or less extent. For instance, the check turkey, No. 56, which ate an average of 91.5 unpoisoned grasshoppers per day for a 10-day period when no other food was present, was placed on a diet of poisoned grasshoppers for 6 days. At the first feeding, 36 poisoned grasshoppers were eaten, and during the balance of the 6 days only 16 grasshoppers were eaten though no other food of any kind was available.

In a part of the experiments (birds Nos. 29 to 42) the check fowls were fed approximately the same number of grasshoppers that the experimental birds ate. In the others (birds Nos. 43-60) both experimental birds and checks were fed all the grasshoppers they would eat. In those experiments in which the check fowls were fed all they would eat, they consumed a total of 7,631 grasshoppers, while the experimental birds during the same period and under the same conditions ate 2,569 poisoned grasshoppers or only 33.67 percent of the number eaten by the other group. To the writer the above facts appear to justify the conclusion that the fowls have the ability to recognize the presence of an injurious substance in poisoned grasshoppers, and as a result refuse to eat a sufficient number of them to endanger their lives.

Effect on Growth and Weight

Although the experiments indicated quite definitely that the eating of poisoned grasshoppers does not endanger the lives of fowls, there still remains the possibility that even though they may live they may be injured to such an extent that their growth and general health may be adversely affected.

Three lines of study were carried on in an endeavor to obtain information concerning this possibility. They were as follows: First, at the close of the experiments both the experimental and check birds were autopsied, to determine what effects the arsenic contained in the grasshoppers' bodies may have had; second, portions of the liver, kidneys, heart, intestines, gizzard and flesh of a number of both experimental and check fowls were sectioned, placed on slides and stained, in order to study what histological changes may have taken place in

the organs; third, accurate weight records of all were kept to determine how their growth may have been affected. These three studies will be discussed in the order mentioned. The autopsies were conducted by Dr. H. W. Orr and Dr. L. H. Moe of the Veterinary Department of the Oklahoma A. and M. College. The following is the summary of the findings in the case of the 14 fowls that were autopsied:

Five of the experimental and three of the check fowls had enteritis of the intestines. Two experimental and one check fowl had ulceration of the gizzard. Three experimental and one check fowl had inflamed kidneys. The above indicates that such conditions are more common in fowls eating poisoned grasshoppers than in those eating unpoisoned grasshoppers. It is seen, however, that each of the conditions found was present in the check fowls as well as the experimental ones. More definite results probably would have been obtained concerning this phase of the problem had a larger number of autopsies been conducted; but on account of shortage of funds the fowls used in the later experiments were traded for others with which to conduct further experiments, rather than killed and autopsied.

The histological study of the organs of the fowls failed to reveal any additional information. Aside from the effects noted in the autopsies no evidence of any kind was found in the slides to indicate that there were any histological differences between the fowls eating unpoisoned and those eating poisoned grasshoppers.

The effect of the different diets on the amount of weight gained or lost during the experiments is not clear until the several factors involved are studied. The data in Table III show the net gain of the check fowls in all the experiments to have been 136.5 ozs., while the net gain of the birds receiving poisoned hoppers was only 117.75 ozs. Thus it is seen that those eating unpoisoned hoppers gained 18.75 ozs. more than the experimental birds. However, in those experiments in which grasshoppers only were fed, the fowls eating poisoned hoppers so definitely reduced the numbers of hoppers they ate that they invariably lost weight. The conditions were so extremely unnatural that the results give little information as to the effect under field conditions of such a diet on weight. Therefore, it appears that a more accurate idea as to what might be expected to occur under field conditions would be gained should those ex-experiments in which grasshoppers only were fed be eliminated in calculating the total weight gain. When such experiments are eliminated the net gain of all experimental fowls is 134.25

ozs. while that of the check fowls is 133.5 ozs. These figures, however, are somewhat misleading due to the fact that in three of the experiments only one check fowl was used as a check for two experimental fowls. Therefore, the average amount of weight gained per bird would be a more accurate estimate of the influence the poisoned grasshoppers may have had upon the weight of the birds. The average amount of weight gained per fowl for those feeding upon unpoisoned hoppers was 16.9 ozs., and for those feeding on poisoned hoppers it was 13.42 ozs. Thus it is seen that the check fowls gained an average of 3.48 ozs. more than the experimental fowls. Another factor that should be considered before drawing conclusions is the probability that this additional weight gained was due to the additional grasshoppers they ate.

The check birds ate an average of 666 grasshoppers during the experiment while the experimental birds ate an average of only 419 grasshoppers. Thus it is seen that an additional 247 grasshoppers per fowl was eaten by the birds that gained the extra 3.48 ozs. The average weight of the species of grasshoppers fed (*Melanoplus bivitattus*) was found to be 1.626 gms. Therefore the 247 extra grasshoppers eaten by the check birds would weigh 247×1.626 or 402.622 gms. or 14.202 ozs. Therefore, it seems probable that the smaller amount of food eaten by the experimental birds, due to the fact they recognized its injurious nature, at least partially accounted for the extra weight gained by the check fowls.

The above data give the following indications: 1. Chickens, turkeys and ducks will neither be killed nor noticeably injured through feeding upon poisoned grasshoppers, even under conditions much more severe than would ordinarily occur under field conditions. 2. The reason they are not injured is that they recognize the fact that poisoned grasshoppers contain an injurious substance and refuse to eat a sufficiently large number to obtain an injurious amount of arsenic. 3. As a result, even under the most severe conditions it was found possible to impose upon the fowls, less than 50 percent of a toxic dose of arsenic was consumed by any of them. 4. The fowls may feed upon poisoned grasshoppers for a period exceeding two months without its having any noticeable toxic effect.

Feeding Poisoned Grasshoppers to Quail, *Colinus virginianus* Linn.

Since in many cases where grasshopper bait is used it is scattered directly over the feeding grounds of quail, many persons have thought that it is likely to result in the death of the quail. Quail feed exclusively upon the ground, and feed upon both grain and insects. Since they feed upon grain, they prob-

ably feed upon bran also. Therefore, in feeding over areas where poison bran has been spread and grasshoppers killed, it seems reasonable that they would feed upon both the poison bran and poisoned grasshoppers. It is easy to imagine that either of these, or the combination of the two, might result in death.

Pettit[43] and Shoesmith[49] each states that poison bran should not be scattered where partridge and quail are likely to feed. If we accept this view, it is the equivalent of saying that most communities should never use poison bran. Therefore, the importance of this point is such that more definite information concerning it is needed.

The quail for this experiment were furnished by the State Game Warden of Oklahoma. Some of them were shipped to Stillwater from Laredo, Texas, having been secured across the border in Mexico, and others were secured from a game farm in Oklahoma.

As previously stated, quail after being starved for 24 hours and then having poison bran scattered at the rate of 100 pounds per acre among them, suffered no noticeable ill effects. From this it was concluded that quail were not endangered through the scattering of poison bran.

In the first experiment in feeding the poisoned grasshoppers to quail, two birds were placed in each of the two cages. In one cage poisoned grasshoppers were fed; in the other unpoisoned grasshoppers were fed. The grasshoppers were thrown before the quail on the floor of the cage twice daily. The number of grasshoppers placed in the cage at each feeding was recorded. At the next feeding all uneaten grasshoppers were removed and fresh ones added. Thus a constant supply of fresh grasshoppers was before the quail at all times. Table VI gives the results of this experiment.

These birds remained very shy throughout the experiment, always hiding whenever anyone came near. As a result, very little was seen of them. However, at no time during the experiment could any symptoms of poisoning be detected.

The number of grasshoppers eaten and likewise the amount or arsenic consumed was so small that it scarcely seemed possible that any poisoning could occur. Judging from the information published concerning the food habits of these birds, it was expected that they would consume a great many more grasshoppers than they did.

Numbers of Grasshoppers Eaten by Quail. Much data has been taken concerning the food habits of quail, but it has not

TABLE VI.—Data on Feeding Grasshoppers and Grain to Quail.
(Each cage contained 1 male and 1 female adult quail, weighing approximately 6 oz. each)

	BIRDS NOS. 69 AND 70				BIRDS NOS. 71 AND 72
	QUAIL EATING GRASSHOPPERS POISONED WITH WHITE ARSENIC AND BRAN				QUAIL FED UNPOISONED GRASSHOPPERS
Date	Species of hopper	No. eaten	Percent poisoned	Amount of arsenic in mgs.	No. eaten
6-10	M. bis.	14	95	3.9780	18
6-11	M. bis.	6	90	1.6151	2
6-12	M. bis.	10	100	2.9910	10
6-13	M. fem.	10	100	2.8040	10
6-14	M. fem.	10	90	2.5236	10
6-15	M. fem.	10	95	2.6638	10
6-16	M. bis.	10	100	2.9910	10
6-17	M. bis.	5	90	1.3459	3
6-18	M. fem.	6	84	1.4132	7
6-19	M. fem.	10	88.8	2.4899	10
6-20	M. fem.	8	84.7	2.1243	10
6-21	M. biv.	6	100	4.5150	4
6-22	M. biv.	2	100	1.5050	5
6-23	M. biv.	4	100	3.0100	2
6-24	M. biv.	5	95	3.5743	4
6-25	M. biv.	2	100	1.5050	3
6-26	M. biv.	2	100	1.5050	1
6-27	M. fem.	5	86.6	1.2141	0
6-28	M. biv.	4	94.7	2.8504	1
6-29	M. biv.	1	83.4	0.8276	4
6-30	M. biv.	2	90	1.3545	1
7- 1	M. bis.	4	88.8	1.0624	5
7- 2	M. bis.	5	90	1.3460	2
7- 3	M. bis.	5	90	1.3460	4
7- 4	M. bis.	6	90	1.6151	5
7- 5	M. bis.	4	100	1.1964	5
7- 6	M. bis.	6	94.7	1.6995	6
7- 7	M. bis.	6	82.3	1.4770	6
7- 8	M. bis.	6	100	1.7946	6
7- 9	M. bis.	6	82.3	1.4770	6
7-10	M. bis.	3	82.3	1.4955	6
7-11	M. bis.	5	100	1.4955	5
7-12	M. biv.	1	90	0.6773	0
7-13	M. bis.	5	100	1.4955	6
7-14	M. bis.	5	100	1.4955	5
7-15	M. bis.	7	100	2.0937	6
7-16	M. bis.	6	100	1.7946	6
7-17	M. bis.	6	100	1.7946	7
7-18	M. bis.	6	90	1.6151	6
7-19	M. bis.	6	80	1.4357	6
7-20	M. bis.	5	88.2	1.3120	7
7-21	M. bis.	5	100	1.4955	6
Total		242		79.8262	236

been published in such form that it gives information as to the maximum numbers of grasshoppers that quail may eat at any particular feeding. In most of the published articles along this line, lists of insects eaten by quail are given and the percentage of the total amount of food that these insects constitute is given, but the maximum numbers of grasshoppers eaten at any one time were found in only two publications. One of these was by Judd[31] in which he gives the data taken by Aughey in 1874-1875 in Nebraska during the outbreaks of the Rocky Mountain locusts *Melanoplus spretus,* Uhler. "Stomach examinations of 21 quail showed 17 of the 21 birds had eaten grasshoppers, the average number being 25 and the greatest number 39," Judd reports. While it was not so stated, it is assumed that these were the Rocky Mountain locusts.

Nice[41], in feeding quail in pens, gives several records of much greater numbers of grasshoppers eaten than this. In one series of tests, one quail ate an average of 28 grasshoppers daily (size or species not stated). The one quail that had the greatest record of all is recorded as having eaten a total of 1,532 insects in one day, 1,000 of which were grasshoppers. These grasshoppers, however, must have been either first or second instar hoppers, for the weight of the entire 1,532 insects is given as 24.6 gms. Thus, if the entire 24.6 gms. had been made up of the 1,000 grasshoppers, the average weight per grasshopper would have been but 0.0246 gm.

In the absence of the more detailed published information, it was thought perhaps the Bureau of Biological Survey could furnish it. However, in reply to a letter of inquiry, Mr. Aughey's work as above referred to was quoted; and Mr. W. L. McAtee, Chief of the Bureau, expressed his opinion that this was at least very near the maximum number of grasshoppers quail would eat at any one feeding, and a great many more than normal.

It was therefore decided to conduct experiments under the assumption that 39 Rocky Mountain locusts was the maximum number of grasshoppers that quail would be likely to eat at any one feeding and 24.6 gms. the maximum weight of grasshoppers in any one day.

The Rocky Mountain locust, according to Comstock[6], is approximately the same size as *M. femur-rubrum.* The species of grasshopper used in this work, because it was most available at this time, was *M. bispinosus.* Since this species is slightly larger than *M. spretus* it was assumed that *M. bispinosus* would consume at least as much poison as *M. spretus.* Since the earlier experiments reported in this paper gave the amount of

arsenic consumed by *M. bispinosus* as .2991 mg. it appears that 39 times this amount or 11.6644 mgs. would be the maximum amount of arsenic a quail could obtain at any one feeding through eating grasshoppers.

The average weight of *M. bispinosus* was found to be .526 gm. Therefore, 24.6 gms. (the weight of all the insects eaten in a day, as recorded by Nice)÷.526 gm., or 46.77 equals the number of grasshoppers of this species that would weigh the maximum amount eaten by a quail in one day. Therefore, 46.77× .2991 mg. (amount of arsenic consumed per grasshopper), or 13.9889 mgs., equals the maximum amount of arsenic a quail would obtain in any one day, even though it should eat the maximum amount of grasshoppers, each of which had fed upon grasshopper bait.

Therefore, it was felt that if the quail were fed 11.6649 mgs. arsenic in grasshoppers at one feeding and 13.9889 mgs. in one day without injurious effects, this would constitute strong evidence that quail would not be endangered through having access to poisoned grasshoppers.

In the first experiment, 7 of the smaller grasshoppers per bird per day was the greatest number a quail would eat by merely throwing the grasshoppers before it. It was learned, however, that by catching the quail and placing a grasshopper well down in its throat it could be forced to eat at one feeding from 6 to 8 hoppers of the largest species used, *M. bivittatus.*

Under these circumstances the problem of feeding the quail the desired amount of arsenic in the desired form consisted of getting 6 to 8 grasshoppers to eat 11.6649 and 13.9889 mgs. of arsenic, respectively, and to force feed them to the quail. It was found that, when the bran flakes contained a greater amount of arsenic than is contained in the standard mixture, many of the grasshoppers still ate almost as many flakes as when they contained only 4 percent arsenic. Therefore, a batch of bran was mixed containing 12 percent arsenic instead of 4 percent. In mixing this, the arsenic was re-ground with a mortar and pestle and every precaution possible taken to see that it was thoroughly and evenly mixed.

Since this mash contained three times as much arsenic, each flake should contain three times as much arsenic as the 4 percent arsenic mixture. As previously stated, the size of flake selected as a standard contained .09348 mg. of arsenic. Therefore, in this mixture a flake of the same size would contain 3×.09348 or .28044 mg. of arsenic. Since the maximum amount of arsenic obtainable by quail through feeding on poisoned grasshoppers at one feeding is 11.6644 mgs., this number di-

vided by .28044, or 41.59, would equal the number of flakes of bran that would contain the desired amount of arsenic. By a similar method it may be determined that the amount of arsenic obtainable by quail in any one day through feeding on grasshoppers (13.9889 mgs.) would be found on 49.88 flakes of bran. Therefore, if the number of grasshoppers that could be force fed to the quail at one time (6 to 8) could be induced to eat 41.59 and 49.88 flakes of this bran respectively, they would have consumed the desired amount for a maximum single feeding and maximum daily feeding.

Grasshoppers (*M. bivittatus*) were placed in individual cages as before, with 15 carefully selected flakes of the standard size from the 12 percent arsenic mixture. At death they were removed and the number of flakes they had eaten determined.

In feeding these larger grasshoppers to the quail the legs and wings were clipped off close to the body and then the bodies were force fed to the quail, as already described.

Table VII shows the data on the tests in which quail were force fed daily at least the amount of arsenic they would obtain through a maximum daily feeding on grasshoppers 100 percent poisoned.

TABLE VII.—Data on Force Feeding Grasshoppers to Quail.

	BIRD NO. 73		BIRD NO. 74		BIRD NO. 75 (Check)
Date	No. eaten	Amount arsenic* in mgs.	No. eaten	Amount arsenic in mgs.	No. eaten
(1931)					
8- 2	5	11.7784	5	12.0589	5
8- 3	5	11.7784	6	12.6918	6
8- 4	6	12.0589	5	11.7784	6
8- 5	5	12.0589	6	12.9002	6
8- 6	5	11.7784	5	11.7784	5
8- 7			4	11.7784	4
8- 8			5	11.7784	5
8- 9			5	11.7784	5
8-10			5	11.7784	5
Total	26	54.4530	51	120.0997	52

* At the first feeding of quail No. 73, one grasshopper had eaten 7 flakes of bran containing 12 percent arsenic, two had eaten 9 flakes each, another 10 flakes, and the other 6. Thus, a total of 42 flakes containing 11.7784 mgs. of As_2O_3 had been eaten by the 5 hoppers fed. The amount of arsenic consumed at each feeding was figured by the same method, as was also done in Table VIII.

No symptoms of poisoning were detected at any time throughout the experiment.

The birds, except No. 78 (check), remained normal throughout the experiment. No 78 appeared sickly beginning Aug. 20, and died Aug. 23.

TABLE VIII.—Data on Force Feeding Grasshoppers to Quail.

Date	BIRD NO. 76		BIRD NO. 77		BIRD NO. 78 (Check)
	No. eaten	Amount arsenic in mgs.	No. eaten	Amount arsenic in mgs.	No. eaten
(1931)					
8-12					
8:30 a. m.	3		3		3
4:30 p. m.	2	13.9887	2	14.3024	
8-13					
8:30 a. m.	3		3		2
4:30 p. m.	3	14.0220	3	14.3024	3
8-14					
8:30 a. m.	3		3		3
4:30 p. m.	3	14.0220	3	14.3024	3
8-15					
8:30 a. m.	3		3		3
4:30 p. m	3	14.3024	3	14.3024	3
8-16					
8:30 a. m.	3		3		3
4:30 p. m	2	14.3024	2	14.3024	2
8-17					
8:30 a. m.	3				3
4:30 p. m.	3	14.3024			3
8-18					
8:30 a. m.	4				4
4:30 p. m.	3	14.0220			3
8-19					
8:30 a. m.	3				3
4:30 p. m.	3	14.3024			3
8-20					
8:30 a. m.	3				3
4:30 p. m.	2	14.0220			2
8-21					
8:30 a. m.	3				3
4:30 p. m.	3	13.9887			
Total	58	141.2750	28	71.5120	58

Each of the above experiments very directly indicates that the lives of quail are not endangered through feeding upon poisoned grasshoppers. When the quail ate only the number of grasshoppers they voluntarily fed upon, the amount of arsenic consumed was so small that poisoning appears impossible. Even when force fed with a much larger amount of arsenic in poisoned grasshoppers, these data could lead only to the conclusion that the poisoning of grasshoppers does not endanger quail.

During the summer, 12 scaled quail (*Callipepla squamata vigors*) were shot in fields when an outbreak of grasshoppers was in progress. Only one grasshopper was found in the crop and stomach of the entire 12 birds, even though most of them had well filled crops that had been filled from fields abound-

ing with grasshoppers. This would indicate that the scaled quail are in even less danger of being poisoned through grasshopper poisoning activities than are the bobwhites.

Feeding Poisoned Grasshoppers to Song Birds

In attempting to determine the effect arsenic may have upon birds of various species that may be present in the vicinity where grasshoppers are being poisoned, a number of difficulties arise. In the first place, the birds are not available for experimental purposes except by trapping. Furthermore, if trapped and caged, wild birds do not behave normally, do not feed normally, and are difficult to keep alive. So many factors are involved in attempting to trap and feed them that it is extremely difficult to determine whether death is due to arsenic or some other factor. Therefore, it was felt that better data would be obtained by some other method.

One method tried was that of taking the young birds before leaving the nests and rearing them by hand for feeding tests. Some preliminary experiments were conducted with robins and blue jays. The young were taken at about the time they normally leave the nest, placed in cages, and fed upon various diets, including grasshoppers. In all cases, both experimental and check birds died in a very few days. Under such conditions it was of course impractical to obtain any data of value, through feeding poisoned grasshoppers to young birds in cages.

Since the feeding of birds entirely by hand was unsuccessful, it was decided to supplement the feeding of nestling birds by their parents.

In carrying out this plan, bird nests were found; and, when the young birds were from two to five days old, regular trips were made to the nest and grasshoppers fed to the young until they became old enough to leave the nest. Each bird was weighed the day the feeding was started. It was planned to weigh each bird at the close of the experiment also but this soon proved to be impractical because of the fact that so many of the birds left the nest unexpectedly. Daily weighings were not considered practical on account of the fact that the birds were necessarily handled more than they should be during the process of feeding.

It was first thought that in order to feed the birds, all that would be necessary would be to drop the grasshoppers into the open mouths of the young birds. It was soon discovered, however, that in a large percentage of the cases it was necessary to feed the young birds by force.

The procedure in feeding was usually as follows: The bird was removed from the nest and held in the left hand. With the index finger of the right hand its mouth was pried open and held in this position by means of the thumb and index finger of the left hand. The right hand was then free to insert a grasshopper well down into the throat of the bird. If the grasshopper was swallowed immediately another was at once inserted. If the bird did not swallow, it was put down while the other birds were fed and the process then repeated if it had swallowed any in the meantime. This was repeated as often as it was possible to get the birds to swallow. The birds were not fed during rains, in order to permit the parent birds to protect them from the rain.

Marking various parts of the body with paint or India ink was first tried as means of identification, but this did not prove satisfactory so the method finally used was tying colored strings around their legs. The constant handling of the birds that marking and feeding necessitated no doubt was detrimental to them and in all probability was a contributing factor to the death of many of those that died.

The birds were fed from two to five times daily. It is fully realized that the parent birds feed a great many more times than this, but the preliminary work indicated that when the birds were disturbed and handled more often the fatality rate ran so high among checks, as well as among experimental birds, that most of the data were useless. In addition, after feeding as heavily as possible at these intervals, a longer period was required before the birds would again feed. As a result, they could be fed nearly as many grasshoppers by feeding only three times as by feeding them five times a day.

The grasshoppers fed in the following experiments were *Melanoplus bispinosus* and had been poisoned with the white arsenic and bran mixture previously described. Before feeding, the hind legs of the grasshoppers were removed in order to prevent injury to the birds from the spurs of the tibia.

In the great majority of cases, the birds when nearly mature would leave the nest when it was approached, although they otherwise would have remained in the nest a day or two longer. This, of course, was not a normal leaving of the nest, but appeared to be normal insofar as any effect their food might have on this action was concerned. When the birds were approximately ready to leave the nest, their leaving was noted as normal even though they left slightly early due to disturbance.

It became apparent early in the feeding of nestling birds that the previously used assumption concerning the amount of arsenic constituting a lethal or toxic dose for domestic fowls and quail would not stand the test of experiment with nestling birds. From the data available, it was figured that 4.783 mgs. of As_2O_3 (in the form of white arsenic) per ounce of bird weight would constitute a lethal dose. Since there are 28.35 gms. per ounce, 4.783÷28.35 or .1687 mg. per gram of bird weight should constitute a lethal dose. This being the case, 1.687 mgs. would constitute a lethal dose for a 10-gm. bird. It was noted, however, that many of the birds receiving poisoned grasshoppers consumed more than this proportionate amount of arsenic each day throughout the experiment. Number 79 on June 16, weighing 17 gms., consumed 3.3738 mgs. or 117.64 percent of a lethal dose, as calculated in feeding 1½ pound chickens. Therefore, no reference is made to the percentage of a toxic or lethal dose in the following tables or discussion. Table IX gives the results of these feeding tests.

A number of the experiments showed quite definitely that it is possible for nestling birds to consume large numbers of poisoned grasshoppers and still mature normally. However, that is about the only conclusion which may be definitely drawn from the data obtaind in these experiments. The majority of the feeding tests failed to indicate that any injury resulted from the feeding of poisoned grasshoppers, but in a few cases the birds receiving poisoned hoppers died while those receiving unpoisoned hoppers matured.

Table X summarizes the results of the feeding tests in which the nestling birds were fed grasshoppers. In formulating this table, it was assummed that the birds found dead in the nest were killed by the grasshoppers fed, regardless of whether the grasshoppers were poisoned or unpoisoned. It is realized that other factors, especially handling, were at least partially responsible for their death; but since there was no method of measuring the effect of the other factors it was decided to work under the assumption above mentioned.

A perusal of these data shows that they are so greatly varied that one finds indications that the eating of poisoned grasshoppers may be injurious to birds as well as indications that it is not injurious.

Effect of Poisoned Grasshoppers on Nestling Birds. Table X shows that, of the 49 birds that were fed poisoned grasshoppers, only 23 or approximately 49 percent matured normally. while of the 41 fed unpoisoned hoppers 25 or approximately 60

percent matured normally. This table also shows that, of the 49 birds that were fed poisoned grasshoppers, 13 or approximately 27 percent died, while of the 41 fed unpoisoned grasshoppers, only 5 or approximately 12 percent died.

TABLE IX.—Data on Feeding Grasshoppers to Nestling Birds.

Species of Bird	Nest No.	Bird No.	Weight at beginning of experiment (gms.)	No. days fed	No. times fed	No. hoppers eaten	Amount As_2O_3 eaten in mgs.	Results
Mocking Birds	1	79	17	5	18	95	27.1581	Matured
Mimus polyglottos	1	80	19	5	18	90	25.7525	Matured
leucopterous vigors	1	81	19	5	18	92	Check	Matured
" "	2	82	9	2	5	12	3.4097	Died
" "	2	83	11	2	5	12	3.4097	Died
" "	2	84	14.5	8	22	84	25.1244	Matured
" "	2	85	12.5	8	22	97	Check	Matured
" "	3	86	7.5	3	10	21	5.9869	Destroyed by predator
" "	3	87	7	3	10	21	5.9869	Destroyed by predator
" "	3	88	6	3	10	21	Check	Destroyed by predator
"	3	89	4.5	3	10	21	Check	Destroyed by predator
" "	4	90	34	2	4	23	6.4665	Matured
" "	4	91	36.5	2	3	15	11.2173	Matured
" "	4	92	26.5	2	5	28	Check	Matured
" "	4	93	32.5	2	5	15	Check	Matured
" "	5	94	29.5	2	5	25	7.0289	Died from exp.
" "	5	95	28	2	5	25	7.0289	Died from exp.
" "	5	96	28	2	5	25	Check	Died from exp.
" "	5	97	31	2	5	25	Check	Died from exp.
" "	6	98	15	7	18	46	20.0346	Matured
" "	6	99	16	3	7	15	4.2441	Disappeared
" "	6	100	20	7	18	46	Check	Matured
" "	6	101	10	7	18	47	Check	Matured
Robins	7	102	4.3	7	18	134	39.9860	Matured
Planesticus	7	103	4	7	15	127	37.9210	Matured
migratorius Linn.	7	104	4.6	7	18	122	Check	Matured
" "	7	105	3.8	7	18	107	Check	Killed by fall
Meadow Lark	8	106	33.5	4	10	57	15.9839	Died
Sturnella magnus	8	107	23.0	2	4	14	3.8704	Died
Linn.	8	108	29.5	4	10	62	Check	Matured
" "	9	109	28.0	3	11	39	11.1084	Died
" "	9	110	23.0	6	18	60	17.1918	Matured
" "	9	111	13.0	6	18	59	Check	Matured
" "	9	112	24.0	6	18	63	Check	Matured
" "	10	113	39.0	3	6	38	10.9147	Matured
" "	10	114	43.0	3	6	14	Check	Died
Redwing Black Birds	11	119	15.0	6	11	38	11.2222	Matured
Agelaius	11	120	13.5	6	11	38	11.2222	Matured
phoneiceus Linn.	11	121	9.0	6	11	40	Check	Matured
" "	11	122	15.0	6	11	42	Check	Matured
" "	12	123	21.0	3	6	32	9.4635	Died
" "	12	124	23.0	5	9	47	13.8154	Matured
" "	12	125	22.5	3	6	20	Check	Died
" "	13	126	11.0	2	3	7	2.0937	Died
" "	13	127	14.0	4	7	21	6.1555	Blown from nest
" "	13	128	15.5	4	6	18	Check	Blown from nest

TABLE IX—(Continued)

Species of Bird	Nest No.	Bird No.	Weight at beginning of experiment (gms.)	No. days fed	No. times fed	No. hoppers eaten	Amount As_2O_3 eaten in mgs.	Results
Brown Thrashers	14	129	9	1	3	11	3.1914	Nest torn down
Toxostoma	14	130	12	1	3	10	2.9013	Nest torn down
rufum Linn.	14	131	8	1	3	10	Check	Nest torn down
" "	14	132	14	1	3	11	Check	Nest torn down
" "	15	133	31	1	3	20	5.6828	Died
" "	15	134	27	1	3	12	3.4097	Died
" "	15	135	29.5	1	3	21	Check	Died
" "	16	136	7	2	4	5	1.4205	Died
" "	16	137	8.5	2	4	4	1.3640	Died
" "	16	138	9.5	2	4	3	Check	Died
" "	17	139	23	2	3	15	4.2171	Died
" "	17	140	25	2	1	4	1.7246	Died
" "	17	141	28.5	3	5	28	Check	Matured
" "	18	142	36	1	2	9	2.5438	Disappeared
" "	18	143	37.5	7	15	91	Check	Matured
Dickcissel	19	144	15.5	4	13	35	9.9925	Matured
Spiga americana	19	145	9	4	2	4	1.1246	Killed by fall
Gemel.	19	146	12.5	4	13	33	7.9884	Matured
"	19	147	13	4	13	33	Check	Matured
"	20	148	23	3	9	30	8.4345	Matured
"	20	149	15	1	4	9	2.5304	Disappeared
"	20	150	16	3	9	28	Check	Matured
"	20	151	21	1	4	11	Check	Disappeared
Orchard Oriole	21	152	16	5	12	37	10.9022	Matured
Icterus spurius Linn.	21	153	11	5	12	36	Check	Matured
Lark Sparrow	22	154	13.5	2	6	11	3.0956	Disappeared
Chondestes	22	155	16.0	1	3	3	.8478	Killed by fall
grammacus	22	156	15	2	4	5	Check	Killed by fall
strigatus Swains	22	157	13	2	6	10	Check	Disappeared
Scissor Tails	23	158	17	8	20	32	11.8894	Matured
Muscivora forficata	23	159	19	8	20	32	12.1723	Matured
Gemel.	23	160	20.5	8	20	27	Check	Matured
"	23	161	19.5	8	20	33	Check	Matured
"	23	162	12	8	20	29	Check	Matured
English Sparrow	24	163	16	4	10	23	6.3966	Matured
Passer domesticus	24	164	16	4	10	23	6.3966	Matured
Linn.	24	165	24.5	4	9	21	Check	Died
" "	24	166	22	4	10	23	Check	Matured
" "	24	167	11.5	4	10	19	Check	Matured
" "	25	168	20	6	16	36	10.0136	Matured
" "	25	169	21	6	16	36	10.0136	Matured
" "	25	170	20	6	16	36	Check	Matured
" "	25	171	19	6	10	36	Check	Matured
" "	25	172	15	6	16	36	Check	Matured

The two foregoing facts appear to indicate rather definitely that the poisoned hoppers were injurious. However, there were factors in the case of each of the birds that appeared to have been killed from feeding upon poisoned hoppers that make it doubtful whether the poisoned hoppers were responsible for their deaths. Mocking birds Nos. 82 and 83 died after consuming grasshoppers containing only 3.4097 mgs. of arsenic, but no. 84 consumed 25.1244 mgs. of arsenic in the grasshoppers and matured normally. In the case of meadow larks nos. 106,

107 and 109, which are listed as having died from eating poisoned grasshoppers, nos. 106 and 109 were both larger birds and consumed less arsenic than no. 110 which matured normally, and no. 107 was the same size as no. 110 but consumed less than one-fifth the amount of arsenic. Likewise blackbirds nos. 123 and 126 ate fewer poisoned grasshoppers than did other blackbirds which matured.

TABLE X.—Summary of Experiments in Feeding Nestling Birds.

Species	NO. MATURED		NO. APPARENTLY KILLED FROM EATING GRASSHOPPERS		NO. DISAPPEARED, OR DIED FROM OTHER CAUSES	
	Birds fed poisoned hoppers	Birds fed unpoisoned hoppers	Birds fed poisoned hoppers	Birds fed unpoisoned hoppers	Birds fed poisoned hoppers	Birds fed unpoisoned hoppers
Mocking birds	6	6	2	0	5	4
Robins	2	1	0	0	0	1
Meadowlarks	2	3	3	1	0	0
Blackbirds	3	2	2	1	1	1
Brown Thrasher	0	2	6	2	3	2
Dickcissel	3	2	0	0	2	1
Orchard Orioles	1	1	0	0	0	0
Lark Sparrows	0	0	0	0	2	2
Scissortails	2	3	0	0	0	0
English Sparrows	4	5	0	1	0	0
Totals - -	23	25	13	5	13	11

In the case of the brown thrashers, the rate of fatality was so high in both the checks and experimental birds that it seems that some factor other than poisoned grasshoppers must have been responsible for the deaths. Only 2 of the 15 birds fed matured. Had these birds not been included in the data, due to the high mortality rates of the checks as well as experimental birds, the percentage of experimental birds dying from eating poisoned grasshoppers would be very nearly the same as the percentage dying from eating unpoisoned grasshoppers.

Thus it is seen that the evidence that the poisoned grasshoppers were responsible for the deaths of the birds that died is far from complete. As before stated, it was necessary to handle the birds an excessive amount in conducting the experiments and therefore it seems probable that excessive handling had as much or more influence on whether or not the birds lived as did the eating of poisoned grasshoppers. If each nest of birds is considered as a separate experiment, 12 of them indicated that poisoned grasshoppers are not injurious and only 4 indicated that they are. In other words, in the 25 nests of birds fed, there were only 4 nests in which the check birds ma-

tured and those feeding on poisoned grasshoppers died. In 12 of the nests the birds eating poisoned grasshoppers matured normally, while in the other nests both check and experimental birds either died or disappeared from the nest. Viewing the problem from this angle there is much more evidence that poisoned grasshoppers are not harmful than there is that they result in injury to the birds eating them. In view of the fact that domestic fowls recognize any injurious effect from eating poisoned grasshoppers, and reduce the number eaten when they contain arsenic, it seems reasonable to believe that wild birds would do the same. Also, since the parent birds while feeding their young eat a portion of the food, they probably would cease feeding poisoned grasshoppers to their young after they themselves had eaten a few.

According to Judd[30], nestling birds in a large percentage of the cases consume a much greater proportion of animal food (largely insects) than do adult birds. Also, young birds are considered to be more susceptible to arsenical poisoning than are adults. These statements, together with the fact that so many of the nestling birds matured despite eating large numbers of poisoned grasshoppers, indicate quite definitely that the danger of adult birds being poisoned from this source is small.

A fact that has a rather definite bearing on the danger of nestling birds being poisoned from eating poisoned grasshoppers is that the breeding season of the song birds is practically completed at the time of the year when poisoning operations are usually conducted.

The data obtained in these experiments would give much more information concerning the danger of birds being poisoned from eating poisoned grasshoppers were it possible to answer the following questions:

How many grasshoppers will birds eat at any time or during any one day, under natural conditions?

Will birds pick up large numbers of dead grasshoppers from the ground for their food, or do they prefer to catch living grasshoppers?

How much will the answer to the first two questions be affected by the presence of a heavy grasshopper infestation and successful poisoning operations?

It is the writer's opinion that the answer to these questions would show that at least a great majority of birds would not pick up and eat or feed their young as many poisoned grasshoppers as were fed in several of the experiments where the birds matured normally. If this were the case, these experiments would indicate quite definitely that in most cases no

injury would result from the eating of poisoned grasshoppers.

A search of the literature, however, shows that the questions have not been answered. A very large number of stomach analyses of adult and nestling birds have been made, and many observations have been made as to the food the parent birds carry to their young; but the writer was able to find practically no data as to the numbers of grasshoppers wild birds eat or feed their young over any given period, and no data at all concerning the habits of birds in picking up and eating or feeding dead grasshoppers, poisoned or unpoisoned. Considerable time was spent in an attempt to see if birds would pick up dead grasshoppers, but in no case was such an observation made.

The experiments with domestic fowls and quail indicate that, even though wild birds were known to pick up and feed a sufficient number of dead grasshoppers to kill their young, in case the grasshoppers were poisoned the birds reduce this number after eating a few of the poisoned grasshoppers.

It is evident that so many factors are involved that it is impossible, from the information available, to arrive at any definite conclusions as to whether or not a few birds may be killed through grasshopper poisoning operations. However, it seems to the writer that sufficient information is now available to state with certainty that the danger of birds being killed through eating poisoned grasshoppers is exceedingly slight, and not of sufficient importance to make it a factor necessary to consider in planning grasshopper poisoning campaigns.

Possibility of Human Poisoning Through the Eating of Chickens That Have Fed Upon Poisoned Grasshoppers

The possibility of humans being poisoned by eating chickens that had fed upon poisoned grasshoppers appears at first glance so remote that it scarcely seems worthy of investigation. In a few cases however, rumors to the effect that people were thus poisoned have been circulated to such an extent that grasshopper poisoning campaigns have been seriously hampered.

During the summer of 1924 there was a serious outbreak of grasshoppers in the western and southwestern parts of Oklahoma, and in some communities reports that humans had been poisoned were very common. E. E. Scholl, who was extension entomologist of Oklahoma at that time, in conversation with the writer told of the following incidents: In Logan county, a woman's club had served boned chicken at one of their meetings. Soon after, a number of the women became ill. Since grasshopper poisoning was being conducted there at that time, it was assumed by a number of the people of the community

that this illness was due to the arsenic in the bodies of the chickens obtained through feeding on poisoned grasshoppers. This same year similar reports were circulated in Comanche, Jefferson and Stephens counties and resulted in destroying local markets for chickens. Persons ordering chickens in some of the restaurants were told that it was not considered safe to serve chickens at that time, and as a result the restaurants did not serve chicken.

Barber[1] tells of similar reports being circulated in the vicinity of Oakley, Idaho, and Professor R. B. Thompson of the Poultry Department of the Oklahoma A. and M. College, told the writer that a few years ago while working in New Mexico he heard similar reports in the communities of Alamagorda and Portales.

In this connection it is interesting to recall that whereas only a few years ago we practically refused to consider the possibility of persons being poisoned through eating fruit that had been properly sprayed, now the officials of various governments, including our own, have considered this possibility of sufficient importance to pass strict rulings requiring the arsenical residue on fruit to be drastically reduced from the amount commonly found. In view of the foregoing facts, it was felt the possibility of human poisoning from this source should be investigated.

According to Holland[26], 2 grains of arsenic is the smallest known dose of arsenic fatal to humans. This is equal to 129.6 mgs. In order to determine the amount of arsenic likely to be found in the bodies of fowls, daily records of the amount of arsenic eaten were kept while carrying on the previously described experiments. The greatest amount eaten in any one day by chickens was 37.7250 mgs. (no. 41 on Aug. 4) wt. 1 lb. 7 oz.; by turkeys was 28.0623 mgs. (no. 55 on July 30) wt. 1 lb. 13 oz.; by ducks was 101.9373 mgs. (no. 57 on Aug. 27) wt. 4 lbs. 12 oz.

Since 2 grains or 129.6 mgs. of arsenic is the minimum lethal dose for humans, and since 37.7250 mgs. was the greatest amount eaten in any one day by chickens, it may be seen that it would require 3.44 chickens (129.6÷37.7250=3.44) weighing 1 lb. 7 oz. and eating the maximum amount of arsenic to eat 129.6 mgs. of arsenic. In other words, a person would have to eat almost 3½ chickens, in their entirety, including the contents of their digestive tracts, to receive a lethal dose. Furthermore, it seems probable that a part of this arsenic would be eliminated

by the chickens before the final portion of it was consumed, in which case the amount required to be eaten would be increased in proportion to the amount eliminated.

By this same method of reasoning, it will be seen that it would require 4.62 turkeys weighing 1 lb. 13 oz. or 1.27 ducks weighing 4 lb. 12 oz. to contain a lethal dose of arsenic.

Since it is not even in the range of possibility that anyone would consume, in their entirety, the above number of birds, the only other chance of receiving a toxic or lethal dose from chickens would be for the chickens to store up the arsenic in the edible portions of the body.

In order to test this possibility, portions of a number of these experimental birds were analyzed for their arsenical content. Table XI gives the results of these analyses.

TABLE XI.—Arsenical Content in Portions of Chickens Fed Poisoned and Unpoisoned Grasshoppers

Sample No.	Portion of chicken	Chicken No.	Type of hoppers fed	Arsenic as As_2O_3 (parts per million)
1	Liver	29, 30, 33, 34	Poisoned	0.5
2	Gizzard	29, 30, 33, 34, 37	Poisoned	63.4
3	Heart	29, 30, 33, 34, 41, 3, 4	Poisoned	1.8
4	Kidney	29, 30, 33, 34, 37, 41, 3, 4	Poisoned	0.7
5	Flesh	29, 30, 33, 34, 37, 41	Poisoned	1.5
6	Intestines	29, 30, 33, 34	Poisoned	1.1
7	Liver	31, 35, 40	Unpoisoned	0.5
8	Gizzard	31, 35, 38, 40	Unpoisoned	0.3
9	Heart	31, 35, 38, 42	Unpoisoned	0.7
10	Kidney	31, 35, 38, 42	Unpoisoned	1.0
11	Flesh	31, 35, 42	Unpoisoned	0.6
12	Intestines	31	Unpoisoned	3.4
13	Liver	38, 42	Unpoisoned	0.5
14	Liver	37, 39, 41	Poisoned	1.4
15	Liver	3, 4	Poisoned	9.9
16	Gizzard	3, 4	Poisoned	7.9
17	Flesh	3, 4	Poisoned	4.2

This table shows that sample no. 2, which was chicken gizzards, had an exceedingly heavy arsenical content as compared to the other portions of the chickens. These gizzards were not opened and cleaned as they would be in preparing them for human food, and since this sample varies so widely from all others it seems probable that a small amount of arsenic must have been lodged in the folds of the lining of one of the gizzards rather than in the tissue proper. For the present purpose, however, it may be assumed that the arsenic was incorporated in the tissue of the gizzard and would be eaten if the gizzard were eaten.

Since this tissue contains 63.4 parts per million, 1 million mgs. of gizzard would contain 63.4 mgs. of arsenic. Since 129.6 mgs. is a lethal amount and 63.4 mgs. is 48.92 percent of it, 1,000,000 mgs. contain 48.92 percent of a lethal amount. Therefore, 2,040,000 mgs. of gizzard would be required to contain this lethal amount. This is 2,040 gms. or 4.49 pounds. This would indicate that a person in order to receive the minimum lethal amount of arsenic through chicken gizzards would first have to obtain gizzards, each of which contained an exceptionally great amount of arsenic, and then consume 4.49 pounds of them.

The next highest arsenical content was in sample no. 15, which was chicken livers. By the same method of figuring as used before, it is found that in order to obtain a lethal amount of arsenic from chicken livers, 28.86 pounds of them would have to be eaten.

These figures also show that 68.03 pounds of flesh would have to be eaten to obtain the minimum lethal dose.

From the above data it is concluded that there is no danger at all of receiving a lethal amount of arsenic from eating chickens that have fed on poisoned grasshoppers. The margin of safety is so great that the possibility of receiving a slightly toxic dose is so extremely remote as to be of no consideration.

IV. SUMMARY AND CONCLUSIONS

A review of the literature shows that ever since poison bran mash has been used for the control of grasshoppers it has been thought by some that its use endangered domestic fowls and wild birds. It also shows that, although the question has been argued for years, an extremely small amount of experimental work has been carried on to determine the facts of the case.

This paper is the report of experiments carried out in an attempt to answer the following questions:

Will birds be injured from picking up the poisoned bran?

Will they be injured from eating the poisoned grasshoppers?

Is there any danger to humans or other animals from eating chickens that have fed on poisoned grasshoppers?

Domestic fowls and quail were confined in pens and left without food for 24 hours. Poisoned bran was then scattered in the pens at the rate of 100 pounds per acre and the fowls were left another 24 hours without other food. No indications of poisoning appeared. From this it was concluded that birds will not be injured through picking up well scattered poisoned bran.

Feeding experiments in which poisoned bran was force fed to chickens indicated that 74 mgs. of white arsenic (As_2O_3) constituted a slightly toxic dose for a 22-ounce chicken. From this it was assumed that 3.363 mgs. per ounce of bird weight constituted a slightly toxic dose.

Other experiments and chemical analyses were conducted to determine the amount of arsenic contained in poisoned grasshoppers.

A series of experiments was then conducted in which 144 birds, including chickens, turkeys, ducks, quail, and the nestlings of various species of song birds, were fed 17,377 poisoned and unpoisoned grasshoppers. These experiments were continued from 5 to 66 days.

From the experiments, the following conclusions were drawn concerning domestic fowls:

1. They readily recognize the fact that poisoned grasshoppers are not as desirable a food as unpoisoned grasshoppers. As a result of this,
2. They will eat less than half the number of poisoned grasshoppers that they will of unpoisoned grasshoppers.
3. The amount of arsenic consumed through feeding on poisoned grasshoppers averages much less than one-half of a toxic dose.
4. Even though no other food is available for a period of 10 days, the fowls will not eat a sufficient number of grasshoppers to obtain a toxic dose.
5. The arsenic obtained through eating the poisoned grasshoppers does not have a cumulative effect even though the fowls were fed for a period of 66 days.
6. Feeding on poisoned hoppers does not materially affect the weight or growth of the fowls.

Concerning quail, the following conclusions were drawn:

1. Even if quail were to eat the maximum number of grasshoppers they have ever been recorded as having eaten, they will not be noticeably injured though each of the grasshoppers was killed by feeding on poisoned bran.
2. Quail eating the number of grasshoppers normally eaten probably receive only from 1 to 7 percent of a toxic dose.

Concerning wild birds, it was concluded:

1. Nestling robins, and presumably other species of a similar size, can consume as many as 134 poisoned grasshoppers containing 39.986 mgs. of As_2O_3 and still mature normally.
2. Poisoned grasshoppers may be somewhat injurious to nestling birds, although the evidence is incomplete.
3. There is very little danger, if any, to adult wild birds.
4. It must be shown that the parent birds pick up dead grasshoppers and feed them to nestlings before any danger to nestling birds can be claimed. The few observations made do not indicate that such is the case.

Figures taken from the above work showed that chickens never consumed a sufficient amount of arsenic at any one time to constitute a dangerous dose for humans, and therefore the only possibility of humans receiving such an amount from eating chickens was for the arsenic to be stored in the edible portions of the body.

Chemical analyses were made of the bodies of a number of chickens that had eaten large numbers of poisoned grasshoppers. These analyses showed definitely that there is no danger of humans being poisoned from eating chickens that have eaten poisoned grasshoppers.

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