THE PROBLEM OF THE RED LOCUST.

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Introduction.

It was with great diffidence that we accepted an invitation to read a paper on locusts at a meeting of this Association. We realised that it would be quite impossible at this stage to present anything at all complete in the way of original research, so that the following remarks must of necessity be of a very general nature.

The present invasion of this country by redwing locusts of the species known as Nomadacris septemfasciata is very recent history. Flying swarms entered the Union from the north through Rhodesia, Bechuanaland and Portuguese East Africa mainly during November and December of last year and continued to arrive but in smaller numbers well into January of this year. The swarms were for the most part not very dense compared to those of the brown locust and their flights were, comparatively speaking, discontinuous and haphazard. The general tendency, however, was definitely in a southward direction. The feeding of these fliers was another peculiar feature. At times it seemed as if they ate nothing and would settle in vast numbers at many places without doing a great deal of damage. To a certain extent these swarms tended to break up and leave stragglers behind. After laying their eggs these stragglers were often picked up by subsequent flying swarms. In this way many swarms were found to consist of locusts of varying ages and with females containing eggs in various different stages of development.

Life History.

The life history of this species is not known as completely as that of the brown locust, but the following are the salient features as far as is known. There is apparently only one generation in a year. Eggs are laid from November onwards but mainly in December. The females do not seem to show a distinct preference for any particular type of soil in which to oviposit, so long as it is damp. Eggs have been found on hill tops, and in valleys, in sandy soil and heavy soil, in fact anywhere. The females usually deposit their eggs in the early hours of the morning, very few being found ovipositing after about 6 o'clock. Pairing takes place just about egg laying time and is usually a very good indication that eggs are being deposited.

A single female is capable of laying more than one egg package. The first package laid contains anything up to a hundred eggs with an average of between 70 and 80 though subsequent packages, which are deposited at intervals of about two weeks, usually contain progressively fewer. It is difficult to estimate the usual number of egg packages laid by females in the field; but under cage conditions they deposit two or three times.

Under favourable conditions the eggs hatch out in just about 30 days, though this period may be prolonged in cool weather. There also seems to be a distinct possibility that hatching may be delayed by the drying out or partial drying out of the soil during incubation.

On first emerging from the egg the young locust is enclosed in a thin membranous sac and in this stage is known as the vermiform larvae. The little white objects in the ground mark the position of a hatching are the shrivelled membranes of the vermiform larvae which are discarded almost immediately the young locust comes to the surface. The shells of the eggs remain in the ground.

The hoppers are pale to begin with, but very soon darken to a brown colour on exposure. They can readily be distinguished from most other species by the presence of a black mark on the femur or thigh of the jumping legs. The young hoppers begin to feed on the second day after emerging and spend between two and three months as hoppers or voetgangers.

In this time they undergo six moults, that is to say, there are six distinct stages which can be distinguished partly by their size; but more accurately by the extent of development of the wing buds. These are almost invisible in the first stage. In the second and third and fourth stage hoppers the wing pads can be seen quite distinctly projecting downwards. During the fifth and sixth stages the wing pads become quite obvious and lie along the back in a more normal-looking position.

The hoppers of the second to sixth stages are very conspicuously coloured with red faces and bright orange yellow shields or pronota.

After the sixth and last moult the insect reaches the adult stages and is complete with functional wings.

Habits.

The most striking habit of these hoppers is perhaps the way in which they collect into bands or swarms. They are voracious feeders, though perhaps not much so as the brown locust. Their visual sense seems unusually well developed so that it is very difficult to approach a swarm without disturbing it. The hoppers seem to do a great part of their feeding at night which is unusual in most species of locusts.

Another very interesting feature is the migratory habits of a swarm of hoppers. To some extent these migrations are undertaken in a search for

food—when one patch is eaten the swarm moves on to another where more food is available. Some marches are, however, apparently not undertaken for this reason alone and exactly what determines their movements still remains a riddle. The direction taken seems to be entirely a matter of chance. It is certainly not determined by the position of the sun as different swarms may move in quite opposite directions at the same time on the same day.

Marching or trekking seems usually to take place more often when the majority of the individuals of a swarm have recently completed a moult. From general observations in cane fields at any rate it seems as if the periods just after the first moult and after the fourth moult are the most conducive to this urge to trek or migrate.

The red locust is apparently a shade-loving species. It is probably for this reason that the hoppers seem to prefer the older cane to plant cane. Once they have taken up their position in tall cane they very seldom leave it for younger and less dense growth.

Their habit of sometimes taking up a position high up in the cane and at other times on the ground, is probably determined by temperatures and humidity conditions.

From the late afternoon to about 10 o'clock the next morning they usually take up a position on the canopy of cane leaves. During the day they tend to descend to a certain extent either in search of shade or for some reason connected with humidity. They may very often be found in large numbers on the ground or on the trash that covers it.

The insects' development is usually completed by April or May. During their long life the adults undergo a series of gradual, though striking, colour changes which seem to correspond with the various phases of their existence. At first they present a rather mottled and striped appearance with a pale line down the back and another along each side. The underwings at this stage are colourless but as time goes on they become first purplish and finally the typical red from which the locust earns its name of redwing.

The fliers do not at first undertake long flights but seem to be content to stay near the place of their origin. With the advent of summer they undertake longer flights, their colouration in the mean time becoming more uniformly red. It is at this stage that the great migrations occur.

The insects are not usually sexually mature until about November and December when pairing and egg laying take place almost simultaneously. At this time the fliers are usually of a fairly bright yellow colour.

As the season advances they become darker with age—although the pale line down the back may make a reappearance—until they finally die off during February and March.

Periodicity and the Phase Theory.

The most interesting and, for us, most important habit of the locust is the way in which it makes sudden appearances in such vast numbers as to become a pest of enormous economic importance and then for some reason disappears again to all intents and purposes, so completely that no single specimen can be found. The periodicity of mass locust outbreaks is typical of practically every species of economic importance. In 1921, a Russian worker, Uvarov, formulated what is known as the phase theory to explain this phenomenon. This theory, in effect, postulates that a swarm locust is in reality a grasshopper that is capable under certain conditions of breeding up more rapidly.

A locust of any given species is not a constant biological entity but may exhibit a very distinct polymorphism. This means simply that in one and the same species, different forms may exist differing very materially from one another in actual morphological characters. These differences in form are so marked that extreme types have often been described as different species. Thus, in Russia there occurred a species known as Locusta migratoria, a swarm locust and another apparently quite different insect was known as Locusta danica. In addition forms intermediate between these were found, but were considered as hybrids between closely allied species. The importance of Uvarov's work lies in the fact that he put forward the definite theory that these apparently distinct species were merely different expressions, or phases, of one and the same species. In fact the best definition of a "locust" is that it is a solitary grasshopper, which has temporarily entered upon the swarming phase. Since this time many other entomologists in different parts of the world have accumulated information on other species of locusts which parallel the observations of Uvarov and corroborate his theory. In this country, Professor Faure, working on the brown locust, has shown that is exists in two very distinct extreme forms with intermediate forms linking the two together. By field observations he has established that a very insignificant looking grasshopper commonly found in parts of the North Western Cape and West and South West Free State is really nothing other than the brown swarm locust in a different form. What is more, he definitely proved that these solitary grasshoppers could, and did, under certain circumstances congregate and breed more rapidly in to their natural or permanent breeding grounds giving rise to the brown locust swarms that from time to time assume such alarming sizes that they become a national enemy, invading parts of this country and neighbouring territories where normally the species is

quite unknown. In cage experiments, Professor Faure found that by crowding of large numbers of hoppers—swarm locusts could be produced, whereas if a few individuals of the same origin were kept under less crowded conditions they developed on very different lines, both the hopper stages and adults exhibiting external features very different from those of the brown locust as it is known in its swarming phase. By different intensities of crowding and isolation a whole series could be produced ranging from the extreme solitary grasshopper type, which may be green, brown or grey, to the typical swarm locust with the uniform red and black hoppers and the longer winged and more uniformly large brown-coloured adults. Unfortunately information of this nature in respect of the redwing locust is very incomplete.

It is now generally accepted, however, that the native home of this species lies in some region much further north, in Tropical Africa, probably in Belgian Congo and Northern Rhodesia and more particularly the region between Lake Tanganyika and Lake Moero.

At the present time green and yellow coloured hoppers quite differrent in appearance from the hoppers in swarms are to be found, and these are presumably hoppers that exhibit the characteristics of the solitary phase. From cage experiments conducted by Prof. Faure in Pretoria there does not appear to be a striking difference between the swarm and solitary phases of the adults as there is between that of the hoppers.

Applying the phase theory to the case of the red locust it would seem reasonable to suppose that these green hoppers are the solitary phase of the red locust.

The present incidence of red locusts is not the first one of its kind. Red locusts were known, mainly in the coastal belt of Natal and Zululand between the years 1893 and 1909, that is for a period of about sixteen years although mass outbreaks did not occur on the same scale every year. Unfortunately information on this point is very scanty due largely to the fact that the brown locust also invaded the country at intervals and reports were badly confused on account of the superficial resemblance between the two species.

At that time the red locust was thought to be a native species and it is interesting to speculate whether the swarms occurring at intervals during those years were the result of fresh invasions from the north or whether they were built up by the congregating and accumulated breeding of solitary phase locusts actually present in this country.

In any case the subject is of such importance that it seems to warrant very careful investigation, quite apart from its academic interest.

Control Measures and Research.

Any permanent locust control work should ideally be directed at the suppression of the pest while in the phase of incipient swarming. This is actually being done in the case of the Brown Locust at the present time. Spotters are kept constantly in the field to mark any aggregations of incipient swarms which are in the course of being built up from more scattered solitary individuals. By destruction of these incipient swarms the insect is exterminated before it becomes a pest.

Whether this method of eradication can be applied to the case of Red Locusts is a possibility that is still to be explored.

The only alternative method of control is the one that is at present adopted—that is the checking of the ravages of the pest in the swarming and aggressive stage.

In view of the urgency of the locust situation during the present invasion a project was undertaken by which the Department of Agriculture through Prof. Faure, the Director of Locust Research at Pretoria, should co-operate with members of the Experiment Station Staff and Locust Committee to conduct some form of research with methods of locust control.

The main object of the proposed research was to discover, if possible, some means of controlling the locust menace in some way other than by the use of Sodium Arsenite, the present standard locust poison, which while being exceedingly toxic to locusts has the disadvantage of being highly poisonous to man and stock in addition to being injurious to valuable crops such as sugar cane.

Preliminary investigations were carried out on a field scale. Various insecticides were prepared which had been used against locusts in other countries were prepared and applied either as sprays or in baits to swarms of hoppers on sugar cane. In addition opportunities were given to private individuals to demonstrate the efficiency or otherwise of their own preparations.

It was realised at the time that it would be very difficult, if not impossible, to gauge the comparative effect of these treatments, in view of the difficulty of keeping different treated swarms under observation.

After this experience it was decided that preliminary investigations should be undertaken in a less extensive scale under conditions that could be controlled with a greater degree of accuracy.

For this purpose cages of various types were constructed and methods of collecting hoppers had to be evolved so as always to have conveniently available supplies of living material for experi-

mental purposes. This was necessary as the locusts had not laid on the Experiment Station.

The first undertaking was in the direction of investigating the possibilities of baiting with a special view to obtaining a suitable carrier in a cheap form. The most obviously available form of carrier was bagasse. This was procured in as many forms as possible—special consideration being given to the fineness of the water-holding capacity and also the availability of supplies.

Several promising baits were obtained which were quite efficient under small cage conditions; but on further tests in specially constructed zinc enclosures surrounding growing cane the latter proved too attractive and the bait was not eaten.

It was then decided to concentrate more on the possibilities of dusting and spraying. A special technique was evolved whereby dusting and spraying were done on a small scale to obtain information on the comparative toxicity of various non-arsenical compounds using the government arsenite spray formula as a standard of comparison. It may be mentioned here that the standard is an exceedingly high one and it is very difficult to find any chemical that compares at all favourably with sodium arsenite for cheapness and toxicity to locusts.

For this type of experiment over 200 small cages are being used so that a series of at least twenty-five treatments can be applied in quadruplicate at one time.

Since the response of insects to poisons varies very greatly with such factors as temperature and humidity it is essential to apply all the treatments under consideration at the same time, so as to ensure uniform conditions under which reliable comparative data can be obtained. By means of these preliminary experiments the less promising substances are rejected and the more promising ones are then tested out on a larger scale in the zinc enclosures already mentioned. From here trials are further extended to field conditions. Here particular care has to be exercised in selecting as far as possible only isolated swarms that have not previously been treated by any other spray. Even so it is found desirable to keep a constant watch on the movements of the treated swarms as they may break up or be reinforced by other swarms where previous history is not known.

Research on these lines is being continued and hopes are still entertained of obtaining a non-arsenical locust poison which will be less dangerous to handle and harmless to vegetation.

Experiment Station,
South African Experiment Station,
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PRESIDENT: The subject is now open for discussion.

Mr. RAPSON: Might I just ask one question of Mr. Bechard? On page 1 he gives out: 'A large number of active, passive and dead locusts were collected. Active and passive ones were bred in captivity." Now I know the active type, but will Mr. Bechard explain the passive one.

Mr. BECHARD: There were a number that could be approached quite nearly. Those were the passive ones. There were some that appeared to be dying for some reason or other. A large number of those eventually died.

Mr. RAPSON: What eventually happened to that swarm?

Mr. BECHARD: I do not know. It looked very much as if those that did not die on the actual property died very near to it.

Mr. DYMOND: As a member of the locust committee that has been co-operating with the work at the Experiment Station, I would like to add a little more than Mr. Lea has given us. It is with certain feelings of regret I notice that the Experiment Station has not given us more detail of the enormous amount of work and research they have carried out with various poisons and baits, etc. One of the major problems with which we were faced was the attempt to get away from arsenic, and a lot of the work that was done there was with that point in view.

In my own observations of the experiments that have been conducted at the Experiment Station, I was very much struck with the possibilities of a by-product of the superphosphate industry called sodium fluosilicate. I think they almost gave up the study of this chemical at one time on account of the poor results that they got in the fields—on occasion, not always. That, I think, was due to mechanical difficulties in methods of application. It is very difficult to get results with moving swarms in the field unless you have them under definite control. In searching for other means of attack, we were faced with certain conditions to which such poison had to conform. It had to produce high mortality. It had to be reasonably cheap, non-poisonous in the ordinary sense, and produce no injury to cane. It also had to adhere to the cane through rain. It also had to be practically non-repellent. Following upon the original experiments with sodium fluosilicate, we incorporated this chemical with starch, and used it in an emulsion, and we found that by spraying this on to the leaves of the cane during an ordinary dry day, it adhered to the cane through very heavy rains, at least ten days. When that cane was eaten by hoppers we had a very high mortality, and the cane was not killed. I expect very much from this

method, which the company which I represent are going to take in hand. I do not want to detract from the use of the method proposed by Mr. Bechard, which I understand is excellent. There are no doubt many ways of attacking the hoppers. I only add this, as possibly another method of attack, from which we hope to get good results. (Applause.)

Mr. COATES: On page 5 of Mr. Bechard's report, the statement is definitely made that cane treated with sodium arsenite, or with sodium fluosilicate withers within 24 hours. I have understood from previous conversations with Mr. Dodds, and also from what you have said this morning, that that is not the case, and that sodium fluosilicate is not very damaging to cane crops. If Mr. Bechard's statement is correct, it would appear that the experiments that have been conducted at the Experiment Station have very little value.

Mr. BECHARD: As you are probably aware there is more than one grade of sodium fluosilicate on the market. I was not satisfied with one batch and have experimented with others. Some have given me very good results, others not, some indeed were very bad.

Mr. JOHNSON: On listening to Mr. Bechard, and looking over his paper here, I find in experiment 9 that he claims that in most instances he has achieved 100% mortality. Now what do we want more than that? When Major Wilkens was here the other day we met him in Durban. He was quite prepared to advise the Government to supply the material that would get this result if we could prove it was quicker. If we can prove that the mortality is such as Mr. Bechard claims, the better for us all. Certainly there is nothing from the Experiment Station to support Mr. Bechard's claims. They have been working on the matter for a very long time. If this matter could be cleared up, we could be absolutely satisfied.

Mr. BECHARD: Mr. Johnson mentioned that we have 100% mortality. We had that definitely in captivity. I think we should obtain 100% mortality under field conditions too. Perhaps Mr. Lea can tell us whether we can expect it.

Mr. LEA: I certainly think there is a great deal in Mr. Bechard's method. The only reason why I think we have to be careful is that it is still an arsenical like the Government spray. It has the same disadvantage of being poisonous, but it has an advantage in not burning the cane.

As regards results, I may say that with a great many experiments on poisoning locusts in captivity you can get 100% mortality; but you may not get the same results in the field. As far as our own experiments are concerned, we can also get 100% mortality with sodium fluosilicate in laboratory experiments, but when it comes to field conditions, it is not the same. We have tested out both. I think there is no doubt that Mr. Bechard's has killed more effectively in the field than has the fluosilicate with our present methods of application. So far, we have not had 100% results in the field, but up to 80%. Of course these are only estimates, not actual counts, which are impracticable in the field. It takes several days before the poisons take effect and requires a good deal of observation before you can be sure what has happened to a swarm which you have sprayed. The Government arsenite is much quicker. If you spray in the morning, a lot are dead at night, and before the next day, most of them die.

Mr. DYMOND: What methods have you adopted in the use of sodium fluosilicate under field conditions?

Mr. LEA: As regards sodium fluosilicate, we were at first very keen on dusting, but found that it was not always sufficiently effective. Then we tried spraying. 1% we found was quite effective with young hoppers. As they get older, it seems to me, you have to increase the strength considerably. You can do that without it becoming very expensive, although if you use up to 2% it amounts to double the cost of the Government arsenite, which is really very cheap indeed, about a farthing a gallon.

Mr. MARTIN: You stated that in dealing with the locust campaign generally in other countries, they have tried the method of aeroplane destruction of the flying swarms. You did not say whether they had been successful or otherwise. The Union Government are trying experiments. If in other countries they were successful, it is not a case of experiment, it is a case of getting on with the work.

Mr. LEA: They are going to experiment up in the Northern Transvaal with aeroplanes and dusting. But I must say that conditions are very different in different parts of the world. In Russia, they have great swamps in uninhabited parts of the country, where they can spread calcium arsenite or other arsenicals without danger to animals and human beings. It is a rather dangerous thing, in the first place, to spread poisons more or less indiscriminately over the country. They are certainly going to try that out in this country too, but mainly, I should imagine, in areas that are not populated to a great extent.

Mr. MOBERLY: I think I can add something to that. When these experiments were being conducted up in Northern Rhodesia just recently, it was reported that the experiments had to be discontinued, because the flying locusts had all left. There was nothing left to continue the experiment on.

Mr. EADIE: What interests me here is whether fluosilicate does or does not injure the cane. Here we have an experiment by Mr. Bechard in which with fluosilicate the cane withered in 24 hours. The next experiment, with a ½% solution, the cane also withered in 24 hours. With ½% calcium arsenate, the cane was fresh to the end of the experiment. One of the advantages claimed for fluosilicate is that it does not poison human beings or stock, and another advantage claimed for its use is that it does not injure the cane. But here we have an experiment showing the directly opposite conclusion.

Mr. LEA: I, for one, never claimed that the fluosilicate was absolutely non-injurious. It may burn the cane to a certain extent. There is, however, a very great difference between burning and withering. Arsenate, to a certain extent, too, causes a slight browning of the edges, especially where the edges of the cane leaf have been chewed by locusts. There are several qualities of fluosilicate on the market, and the best of them mark the cane causing a reddish discolouration; but in no case was this a destructive effect and the cane was never withered.

Mr. DYMOND: I should like to add these remarks. The quality of sodium fluosilicate is very important, as Mr. Bechard and Mr. Lea have pointed out. Sodium fluosilicate is an acid salt and therefore as an acid it does burn cane. But it is largely a matter of technique. The use of starch in an emulsion tends to protect the leaf from the effect of that acid, and gives adherence to the leaf, throughout rains, and later on, when hoppers come that way, it will be found to be still very effective. I am satisfied that the use of sodium fluosilicate is an excellent thing, provided the technique is correct.

Mr. PALAIRET: There is one noticeable thing, that the Experiment Station are exceedingly reluctant to claim results which they can call definite. There is no doubt that both parties concerned are putting in very good investigation, and we must leave it to them to carry on this matter to finality. It is in the hands of very able scientific men, and I think we can rest assured that they are going to get the desired results in time. But I do feel that it is essential that some record of the position we have arrived at, should be made. There is no doubt the Government poison is the result of very varied experience throughout the Union, and is undoubtedly the thing under a very wide range of Union conditions, including part of the sugar belt. When we can get the locusts on trek and catch them in the fire breaks, there is no doubt, the Government poison is the thing—a contact poison. But it is the tall and close nature of our crop that gives us certain conditions different from others, and for those conditions we do need something different. I will ask you, therefore, Mr. Chairman, if I may put forward the following motion:

> This meeting recommends to its parent body that they represent in the proper quarter the following facts: When locusts are in growing cane, the difficulties of attacking them with contact poison are so great that it is essential that some effective form of poison for use in growing cane, as a bait, be made available; further, this meeting hopes that all necessary experiments towards finding such poison will be pushed on with all rapidity to finality, such poison then to be provided at the earliest possible moment.

Mr. ARCHIBALD: I wish to throw out a suggestion to the Locust Committee. I only thought about it in the last few days, because, apparently the great question is not so much finding poison to kill locusts, since that is already found, but to find a solution that you can place on your crops without doing damage to them. Now there is a plant which grows in this country. It is known by every fisherman—Mr. Hulett will know it—a plant that grows by the beach. Anybody knows that the action of this plant—it is called "Ilozane"—placed in the water where fish are kills those fish. But it is not poisonous to human beings, because the natives eat these fish. My suggestion is this—that some of you planters who live close by the beach should get that plant and pound it up and make a concoction and spray your locusts, and observe the effect. If it has the desired effect, then that plant should be taken to the Government laboratories and analysed to find the poisonous principle. From that you may be able to devise a poison which will be absolutely fatal to locusts while not being poisonous to human beings.

Mr. BECHARD: That has already been tried.

Mr. HULETT: Ilozane is a root of a species of pea and is a deadly poison. You pound it up and put it in water and it gives a milky fluid. We have used it on locusts and it certainly kills them. The difficulty is to collect sufficient quantity.

Dr. McMARTIN: I believe Ilozane is a very active insecticide, but no one has yet succeeded in extracting and retaining the toxicity in the extract. Any extract which has been made has been not toxic, but the root itself, if eaten is very toxic.

Mr. TOWNSEND: Gentlemen, I speak as one of those who had experience 35 years ago with locusts, over five years of it. Probably I know something about locusts which many present to-day do not. We have been told that the locust to-day differs from the locust that came down 35 years ago. We have been told this is the red locust, and that it is not in any way connected with the locust that invaded South Africa 35 years ago. But from my

own experience, I say there is not an iota of difference between the two, they are typically the same. I have examined many locusts closely. I can see no difference between those of to-day and those of years ago. Their habits, their breeding, are identical. Their hoppers and the treatment of the hoppers is absolutely identical. The only difference is that the early invaders when they first settled on the crops simply wiped out a field. The peculiarity of this last invasion is that they did no damage at that stage. They went throughout the belt without doing much damage, except where young cane had been eaten in the night time. The visit was really for the purpose of mating and hatching. Immediately they had done that, they disappeared, as we all know. What has probably astonished most of us is this—35 years ago we worked under very crude conditions. We did not know of a suitable poison until some three years after the first invasion. Then it was discovered by accident by Mr. Wilkinson. To-day, although we have a Technologists' Association, I do not believe we are a bit in advance of the position as it existed 35 years ago. We have had Mr. Bechard to give his experiments. They are very interesting. There is no doubt they are leading in the right direction. We are still using the same methods and the same poison, and still experimenting as we did in those days, and yet, to my mind, we are no further forward than the position in those days. At that time I went to town and bought a hundredweight of arsenic and some caustic soda, and a ten-gallon kaffir pot, and started my own factory in the mill. I had molasses to mix with the poison. The result was, in every case, 100% mortality. I think if you can obtain first molasses from the mill, that the locust cannot possibly resist it. That is shown by Mr. Bechard's experiments. They taste all substances. As long as you give them something attractive and work on their sense of smell, they will come to that poison and take it. In those days we had 100% mortality with porridge and treacle as a bait. Some porridge was put in amongst the swarm in little tins with poisoned treacle. They left the cane and travelled to the porridge, ate it and died on the spot. That is from my own experience. To-day we are still looking for what you might call non-destructive poison, which, of course, is the end we must aim at. But we must go further. It is asserted you destroy the cane. If you consider the amount of cane destroyed, it is very small indeed, compared with the actual beneficial results where you spray it heavily on cane. But the organisation is faulty, and that to my mind is the most essential part of the whole business to-day. Until you get the organisation right, all the poison you get is not going to help you. Some people destroy locusts, others are not destroying them. Until you get a law compelling every man to destroy every locust that is hatched out on his property, we will have this trouble.

I congratulate both these gentlemen who have given papers. I would like them to work for the better administration of locust destruction, where every man will have to do his part.

Mr. ARCHIBALD: I would endorse every word that the last speaker has said. During the last locust invasion I was Locust Officer. I dished out thousands of gallons of the mixture he mentions. As he says, locusts would go far to get that mixture I have always found wherever they get the smell of fresh molasses, there they go.

PRESIDENT: With regard to Mr. Townsend's remarks that this Association should take up this matter of better organisation, it is without our province. We are merely part of the Millers' Association, and it is for the South African Sugar Association to take up that matter.

Mr. RAPSON: I claim that in Natal, we must not confine ourselves only to finding a bait. If we look through what Mr. Bechard has done—and I must thank him for his experiments and the information he has given us—we find that it points to one thing—that he is left with arsenic. He has certainly transferred it from the sodium form to the calcium form, making it a non-contact poison. He claims that there will be less damage to the cane. I believe that is quite true, but can you imagine the position where we spray locusts? We have perhaps a swarm of locusts on the cane and another swarm on the grass. They are eating the cane, perhaps intending to shed their coat on the grass. Are we then to carry two sets of poison, one as a bait, and the other as contact poison? Let us have something that will be both contact and bait poison to the locusts without injury to the cane. But to give us bait poison in any form without one that is also deadly to the locust hoppers as a contact, will give us no results at all. We want to protect the cane all we can. If the Government sodium arsenite is applied in the right way at the right time to young locusts—when the hoppers are small, in the evening when they are going to feed on the canopy of the cane, then the damage done to your cane will be small. The cane will very soon recover, and the mortality will be 100%. To give us the results of bait poison for locusts that are in a confined space in a cage, and to claim that those are definite results, to me cuts no ice whatever. If you lock locusts up and give them nothing else to eat but poison, they will only eat that poison. I want to see the man who will tackle a swarm where it stands. I do not want to hear any more about this cage business.

We have Mr. Townsend and Mr. Archibald telling us how they did it in years gone by. Both these gentlemen have hoppers to-day, but they have not put them out in the old way! But that is not the point. We want to get on to the business Unless our scientists can produce something for us that

will be destructive to locusts, both in contact and in bait they will be wasting their time. Mr. Bechard's paper proves to you that the cane is the bait for the hopper. He tells you in colouration they prefer green. Once hoppers get on to the cane, they will feed on the green leaf. There is your guide. Green, we know, is the natural feeding colour, so we have discovered nothing. We have been told that locusts will leave cane and go on to the grass. I have seen the position when the locusts did leave the cane and went on to these wide patches of grass, but there were times when even I did not know which was supposed to be the cane and which was the grass, so how did the locust know? On another occasion the men had so completely cleaned up the grass that the locusts had nowhere else to go if they did leave the cane, so they did not leave it. I ask our scientists to say if they have got a poison now, not to throw out some hope that they will get something. I have seen more damage done with these patents being advertised in the press than ever arsenite of soda did to locusts. We have been asked to wait a week for a supply of poison, and that week has been a very disastrous one. If you have promising experiments, try and conduct them in a field, and let us have something comparable to plantation conditions, and the experiment will be more valuable.

Mr. TOWNSEND: With regard to Mr. Rapson's remark about my having locusts to-day. It bears out what I have said, that we are using the wrong type of poison. The poison we used in the old days would have destroyed all the locusts. But now, we have 90% surviving. You will give one swarm a spraying, and the next morning you will find them still all alive. It is not because we are not spraying properly. My assistants know how to spray, but the poison is not attractive. Therefore it means that until you do get an attractive poison, you are going to have this inefficient destruction of locusts. The young locust will go and settle out on any rubbish that is lying about. They do not eat for two or three days. Any rubbish that is lying about, so long as it covers them, is good enough for them; they will never go on to the cane. It is an easy matter to destroy those locusts; then, one dressing will kill them. If you allow them a week, it is a different matter.

Mr. MOBERLY: At this season, at any rate, it was not feasible to use first molasses. We had none available. How did it become available in former times? Did the locusts arrive before the mill stopped, or had first molasses been put aside?

Mr. TOWNSEND: In those days we did a big native trade in molasses. We kept a large stock of first treacle all through the winter, so when we required it for locusts, it was available.

Mr. JOHNSON: We have been listening all morning to different views. I have been impressed by our scientists. I think they are working very well and on the right track. I would like them to continue the work. What we should concentrate discussion on now is what is the best method to be adopted to use the poison that we have at the present time. We know it has worked well, only it destroys a bit of cane. We have come to the conclusion that it is better for us to destroy cane and locusts together than for the locusts to destroy the cane and not be destroyed themselves. Some have sprayed right on the cane. We have seen cane with brown patches, but the locusts have been destroyed. Others have knocked the locusts off and have sprayed in the rows. We find that quite successful. There are several here who will tell us how successful they have been with trenches. What is the best result that we can obtain from the present poison? We are getting that poison cheap. You can use it fairly reasonably, ad lib. as it were; you have only got the expense of using it. The other poisons you have got to purchase, and the expense to-day in destroying locusts is so great that we want a cheap article. Then the future. We have not killed all the locusts. We are none of us aware of the best way to handle the flyers when they come. I would like to hear an expression of opinion from men who have had experience in dealing with the flyers. I think we will have to come to some arrangement that when a flying swarm settles on a field, that field should be burned, and that the industry as a whole should stand in to compensate the owner for destroying the field. I think it would be a very good thing if the Government stood on a 50-50 basis, it is a community benefit. I think we ought to discuss the future as much as the present, because these flyers are coming, and we do want some instruction how to deal with them. I would like this discussion to give us some practical help. I am not minimising the work that the scientists are doing. Given time, they will evolve something, I am positive of that. I can quite sympathize with Mr. Lea and Mr. Dodds and the other workers. It is useless for them to come out and state that a certain poison will do the work, and afterwards find that it is not so satisfactory as they would like, and then for people to say "Oh, but you told us that this was the right thing!" I should be glad if we could get some definite instruction as regards the best use of the present poison, and how we are going to tackle the flyers.

Mr. TOWNSEND: I presume Mr. Johnson is referring to the flying locusts which are being hatched out, and which will be here shortly. I mentioned just now that the present locust was identical with the old one of 35 years ago. You will find that the locusts are growing wings, and they will remain in the particular district in which they have winged until it is mating season, so

that the Zululand locusts will not come here and our locusts will not go south. They will remain in their own district during the winter. About September or October, they will begin moving about more rapidly, and eventually they will take wing and move south. That is what is going to happen.

Mr. Johnson mentioned the question of burning. We tried that in the early days, but they flew away before the fire reached them. Has Mr. Johnson ever tried to catch a locust on the cane? How near can he get to him? He cannot get within a few yards. Before the fire reached the locust he would be away out of the field. I am in hopes that if our district destroys its locusts to the extent of 80 or 90%, there will be very few flying, and that those will not be able to do much damage.

Mr. CAMPBELL: I should like to make a few remarks on the point mentioned by Mr. Johnson. When the locusts arrived last year, I had three or four good tries to burn them. The first time I tackled it in the evening, and I certainly got about 75%. I followed them up with my tramline and endeavoured to get a good knock at them, but when I thought I had them all right, they would move just out of my reach. I eventually got them one morning. There are certain conditions which you have got to contend with, over which you have no control. Those are weather conditions. Everything may be right for you, say, early in the evening. You propose to make an early start, and at one o'clock a big wind comes up and you cannot do it. Those are the difficulties that one has to contend with in burning.

Referring to Mr. Bechard's paper, paragraph 3 of No. 1, I should like to relate a little experience that I had in connection with the adult. I had collected a few live locusts in a bag. These were put aside, and about a week later they were all dead. A few days afterwards a friend wanted a few live ones. I told the boys to throw out the dead locusts, and get what live ones they could and put them in the same bag. We then found next day quite a number of them were affected with fungus. Mind you, they were in the infected bags from early evening until about nine o'clock the next morning. In yesterday's paper I noticed an article which bears out the same fact—that in the earlier visitation they caught locusts affected with fungus and released them amongst the swarms. Certainly towards the end of the visitation, there was a tremendous lot of good effected with the fungus, and the locusts died off very quickly.

Mr. BECHARD: I should like to answer Mr. Rapson and Mr. Johnson, on the point of what poison to use now. There is no question about it, if you have got nothing else, use sodium arsenite. It is effective. When we use Government stuff, we use it at a concentration of one in seventy, which is very good. Mr. Rapson is evidently under the impression that we tried nothing else but baiting. I have only given you a sort of precis of the experiments we have made. We have tried not only this, but a good many other proprietary locust poisons. Some of them you would imagine contained enough wintergreen to cure everybody in Zululand who is suffering from rheumatism. In tall cane, contact work is not effective, baiting is the thing, using the cane itself as the primary attraction.

I am afraid I cannot agree with Mr. Townsend as regards molasses. I cannot make them travel two inches for molasses. Whether they know the difference between first molasses and other molasses, I cannot say. Perhaps we are using more sulphur to-day than was used then. They will move for a mechanical attraction—something they can cling to—they will move for moisture; they will move for colour; but they will not move for taste. If I am asked whether there is any reason for using two kinds of poison, I definitely say no. On our estates we use nothing else but calcium arsenate in grass or cane. We have used arsenite when we could not procure arsenate. I want to take a special instance of knocking the locusts down and spraying the row. Everybody has tried that, with no success. We came to the conclusion that as far as tall cane is concerned, baiting is the only thing. When we first started with calcium arsenate we sprayed a swarm of very young locusts at the time the flyers were about; the flyers ate the stuff and died in great numbers; we were not attacking them, we were attacking the hoppers. We have great hope that before they get to the migratory stage, we shall be able to get them in the cane.

I cannot say too much about the burning question. There is not one single way of tackling locusts, there are dozens. The thing has to be done at the right time. Burning certainly has despatched a great number of them. I am pinning my faith in being able to bait the young adults, that is before they reach the migratory stage, especially in young cane, baiting them with arsenate. I personally think it is not possible to do it with arsenite. You all know the kind of sores that your labourers have got. I can definitely state that after working with arsenate for ten weeks, not a single scratch or pimple or anything of that sort has occurred with anybody concerned.

On what Mr. Campbell said as to the question of fungus, I would not like to say anything. I would rather Mr. Lea answer that.

Mr. LEA: The question of cultivation of locust fungus has often been considered and tried. Years ago in the Transvaal, a fungus was cultivated artificially and distributed to farmers, and at the time it seemed to many to be a great success. It was subsequently found that a different fungus—quite

a harmless one had been propagated and the cases where success had been claimed from this method were no doubt due to the true locust fungus having made its appearance of its own accord. Up to the present no one has succeeded in making use artificially of the locust fungus. It is a natural agent over which we have no control.

Mr. RAPSON: Mr. Johnson has set us rather a big problem in asking us to tell him the methods of handling locusts. I could tell you a few things that might help. The first one I advise is early tackling of these hoppers. In tackling the hoppers, too, the work should be as widely spread on any farm as it is possible. That is, a man owning a very large farm should not concentrate his sprayers all in one section of the farm. It pays much better to have four individual pumps working on four separate parts of his farm, rather than have four pumps in one part of the farm. One pump will destroy a large number of swarms without the assistance of any additional pumps.

A third essential thing is personal supervision of the farm. You want to have a man there who has got sufficient interest in his business to realise that it is his livelihood, and not only that, the protection of his neighbour and his neighbour's cane. When I go round, to see these farms, I come time after time to certain farms, and the men are not even there on the property, when the work is being done. They have allowed this thing to carry on until the locusts are in the fifth stage and as wild as game. Had they done their duty, they would not have had half that trouble. (Hear, hear.) In spraying, too, there are two different types of pumps that can be used. In the early stages the atomization of the Government pump is sufficient to destroy any locust that comes along. That is the first and second stage. Then when you get past the second stage, a heavier application is required, and you must either use the atomiser, if you have compressed air pumps, or else use one of the Government pumps reduced to as fine a spray as possible. If you let them get to the fourth, fifth and sixth stages, then you will find that trenches are as good a thing as you can use, without using poison at all. But in the making of these trenches a certain amount of care should be taken that the upper section is not as wide as the lower section, so that the locusts cannot climb out of the trench. If you have your trenches with absolutely perpendicular sides they can climb up. There are certain different types of trenches. In some we use the dipping tank principle. That is where you find the locusts are on a definite trek on a narrow front. Take old 44 gallon oil drums, cut them long-ways and put them right across the track of the locusts. Then they go in and dip themselves automatically and clear the trench. Locusts will pass over that for four and five days. Continuing down one narrow course, perhaps a cane break. Then there are other methods and ways of approaching locusts. It would take me far too long to go through them all. If you people would like, we will have a pamphlet prepared, dealing with the various ways of handling locusts. The thing I do suggest as essential is personal supervision. That is absolutely necessary, because you may have to vary your method according to the situation you have got, and to handle the situation immediately and promptly.

Mr. DODDS: I am glad that Mr. Johnson directed this meeting into the more practical channels of deciding what we shall do with the means at present available. I think we must realise that the only locust poison we have in sufficient quantity available in the field is sodium arsenite, the Government spray, and our most immediate anxiety should be the best ways and means of using this material, whatever materials may eventually supersede it. For the present season, we are going to be largely dependent on the Government spray. The circular that was issued by the Sugar Association last week had in view primarily the best means of using that spray, and I do not think we have anything to add to that at present. As soon as we have, we shall lose no opportunity of publishing it. There is no doubt that sodium arsenite is an excellent locust poison. Although, as Mr. Townsend said, it was known 30 years ago and more, and used for the same purpose, it is still a very difficult poison to beat at the present time, in spite of its many disadvantages.

There are one or two points I should like to refer to again, regarding possible alternatives to sodium arsenite, that were not cleared up in the earlier discussion. The effect of any chemical on a living plant is largely a factor of its solubility, in the case, at all events, of mineral salts such as we are dealing with here, and the more highly soluble the substance is, the more destructive its effect is likely to be on the growing plant. Hence the effect of sodium arsenite, quite apart from its arsenical content, and this explains why sodium arsenite is more destructive than calcium arsenate, which does not harm cane apparently at all. Sodium fluosilicate is soluble to the extent of about one-half per cent in water. We have found in the great majority of our experiments that the damage caused by sodium fluosilicate to cane is practically nil, but there have been a few occasions, mainly when the cane was exposed to a hot sun immediately after application, when there was a considerable amount of scorching of the leaves. In no case have we had any cane killed by sodium fluosilicate. Another factor a speaker mentioned is the possibility of some soluble impurity occurring in the sodium fluosilicate. Sodium fluoride might occur, which is a very soluble salt and very destructive to plants. That is one thing that might account for the experience of other workers. But with the sodium fluosilicate that is likely to come on the market in the near

future, I do not think we shall have any disadvantage occurring from impurities. I feel strongly that we must get away from arsenic altogether, and that should be an ultimate object of our research. But in the meantime we are dependent on sodium arsenite, and it is largely a question for the present of what is the best means of using it.

Mr. CAMPBELL: In connection with the matter of spraying, I received my first supply of poison from Bloemfontein, which was in three-gallon drums, and I used the treacle mixture. I had a fair supply of it, and my sprayers who made the first application did not complain at all. As soon as I used the later mixture, my sprayers complained. I had boys there who had been constantly on the job, and they complained straight away. Since then I have been mixing molasses with the new poison, and now there is no complaint whatever. Those who have not got a sugar factory or other source of molasses nearby simply receive the Government mixture and have got to use it as it is. There is nothing to protect from or relieve the ravages of the spray, and I think it should be a recommendation that in future the Government should go back to the old mixture, which is not so injurious to the worker.

Mr. COATES: I am told on very good authority that the damage to people who are using this poison is mainly caused, not by the arsenic, but by the caustic soda. 25 years ago, when the locust infestation took place, the people dealing with it then used ordinary washing soda instead of caustic soda. By using ordinary washing soda the damage to the people who were using the poison was negatived. On the other hand, it killed the locusts as well as the present poison. The Government solution has caustic soda in it, I understand.

Mr. LEA: I do not think so, as far as I know the present Government solution is simply a very concentrated solution of arsenite of soda. It has no molasses, but it has no caustic soda either, and no sugar. It has got as much arsenite of soda in it as the water will dissolve, it is a saturated solution.

Mr. BECHARD: One last word, if I may. As far as the question of molasses in the Government mixture is concerned, there is no question that molasses is needed for several reasons—to adhere to the canes, for instance. But to my mind the best advantage of it is as bait. Unfortunately there is not quite enough molasses. A three-gallon drum has got to be diluted to 150 gallons, or more, so, as general advice, I should say add molasses to the Government mixture. In any case you want at least double the quantity of molasses. The Government could not put it in, otherwise transport would be too heavy.

The next question is about supply. There is no question that to-day sodium arsenite is the only thing that is actually available to planters, but my point is that if, ten weeks ago, when we offered our methods to the Government, they had investigated the method then, and if the Field Locust Division had come when they promised to do so, and investigated the matter, calcium arsenate would have been available now. It is available in moderate quantities to-day. It can be made more available. The existing plant can turn out 800 lbs. a day. We want four tons a day. I have the assurance of the manufacturer that it can be turned out.

The question of burning is a very important point. I have seen a planter who was burnt. I can assure Mr. Coates that it was not caustic soda burning, it was arsenical burning. They have tried the usual method, which is to use ferric hydroxide, to get it out of the blood stream. To get it out of the system is an absolute essential. I think the practice of going after the locusts with arsenite is too dangerous; there is too much danger of burning to the worker. We can go after them with arsenate, and we are getting results. At present there is not such a great demand for arsenate, and the supply is keeping pace with the demand. The demand is not going to be there unless the Government will give us some help. The planter is not going to buy where he can get free. We have 20 to 25 planters using it in our district. We have bought it and supplied it to them. Up to the present we have used about a couple of tons. There is another 3,000 to 4,000 lbs. left in the country, already prepared. Why can not the Government make it available?

Mr. HAMMOND: Has the question of gassing locusts ever occurred to your Association?

Mr. LEA: I do not know. So far very little has been done. We did try out chlorine. It is really wonderful what amount of chlorine even the small hoppers will stand without dying. It is of course dangerous to use, as well as being ineffective.

Mr. RAPSON: Only two days ago we had a demonstration with chlorine gas, and the only thing that was gassed was the man that was demonstrating.

Mr. HAMMOND: May I suggest that the question of bombing flying locusts be gone into? It sounds ridiculous, but we have heard a lot about these waste spaces where there is no habitation, and it seems to me that is an ideal place for that sort of thing. If you had time-bombs dropped from an aeroplane, with five pounds of explosive, I guarantee that would kill every locust round about. Of course you want people who know their job. With a very high explosive I will guarantee it will blow the wings off the lot.

Mr. LEA: I should imagine it might blow the locusts away and not affect them seriously.

Mr. PALAIRET: I might be able to throw some light on that. In naval work, at different times, we have dropped depth charges, which are probably 30 to 40 times the weight of any ordinary bomb. Despite the very high incompressibility of water, the mortality among fish has been very small, except in the immediate vicinity. I do not think there is any possibility of the concussion effect travelling any distance.

Mr. HAMMOND: What distance do you call the immediate vicinity?

Mr. PALAIRET: 20 to 30 feet.

Mr. MARTIN: Some time ago Mr. Johnson drew our attention to the fact that we should deal with the present and make the best of it, but that we should also deal with the future. We have dealt with the present, as far as we can deal with it. Have we dealt with the future? It seems to me that the real solution of the problem is by aeroplane on the Northern borders of the Union. I think it is up to the sugar planters and all farmers generally to see that whatever experiments may be conducted by the Government with aeroplanes are not allowed to stop at a few trials, but they should go on until such time as they find some effective method of protecting our borders.

PRESIDENT: I am sure we must be very grateful to these three gentlemen who have written these two papers. It has led to a very great deal of discussion. We have not much time to do anything further to-day. I would ask you now, gentlemen, to signify in the usual way your approval of the papers read by these gentlemen. (Applause.)

Mr. B. E. D. Pearce, the President, resumed the chairmanship and asked Mr. Fowlie to read the paper standing in the name of Mr. Garland, as Mr. Garland was absent.

Mr. FOWLIE: I would like to apologise for Mr. Garland's absence. Mr. Garland is a very busy man these days, and with his ordinary busy job and locust eradication, as well, he cannot be here. I am sorry I have have had no chance of discussing this paper with him, or in any way to make myself specially acquainted with the matter in it, so I hope you will excuse me if I cannot add anything to it afterwards.

Mr. Fowlie then read the paper on "Irrigation in Puerto Rico, and a comparative study of the application of Irrigation in Natal."