

CONTROL METHODS USED AGAINST LOCUSTS AND GRASSHOPPERS*

OWING to the widespread plague of grasshoppers in South Australia during 1933—34, it has been suggested to me that a short survey of the usual control measures adopted against grasshoppers and locusts in various countries would be helpful to farmers and others.

The species causing the present plague is known as the "wandering grasshopper" (*Chortoicetes terminifera*). The infestation extends over South Australia, portions of the northern districts of Victoria, and western districts of New South Wales. More than one species may be involved in this wide-spread outbreak. The outbreaks occur at infrequent intervals of several years. The grasshoppers occur in swarms which vary considerably in size. Compared with the locusts of the old world, the swarms are smaller and their range of migration is more restricted, so that organisation for a control campaign can be made on a more local basis.

Investigations on the ecology of the species in South Australia are being made by the Department of Entomology of the Waite Institute, in co-operation with the State Department of Agriculture. The present article gives a short general account of the chief measures which are adopted in various countries in order to reduce losses due to outbreaks of grasshoppers and locusts; many of them are applicable to the conditions existing in South Australia.

Grasshoppers and locusts belong to the same family of insects. With the former, many species live as solitary individuals, although actually they may be present in large numbers scattered over pasture areas; other species are gregarious in habits and move about in swarms. The habits of these gregarious migrating species closely resemble those of true locusts. In general however, locust swarms are larger and their range of migration is much more extensive.

The life-history of migrating grasshoppers and locusts is simple. The winged females lay their eggs in hatches in the ground, in suitable situations, to a depth of about 2 inches. From these eggs wingless hoppers hatch out; they gradually increase in size and eventually become winged males and females. The wingless hoppers and winged forms migrate in swarms, which latter vary considerably in size. The winged swarms congregate on suitable areas in order to lay eggs; these areas are known as "egg-beds", and vary in extent from a few square yards to several acres according to the size of the swarms.

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The characteristic feature of these insects is their periodic occurrence in plague numbers. In 1921, B.P. Uvarov advanced a theory to explain the reason for these periodic outbreaks; it is known as the "phase theory". According to the "phase theory" a gregarious species may be endemic in particular regions in a non-gregarious or solitary phase. Under certain environmental conditions not yet clearly understood, gregarious individuals develop in these permanent or endemic areas; these individuals multiply and form into swarms which migrate into surrounding areas. These secondary areas are only infested for temporary periods. The extent and intensity of the migration appear to be greatly influenced by weather factors. The phase theory fits well with the behaviour of certain species of locusts.

The exact locations of the permanent or endemic areas of the "wandering grasshopper" in South Australia are not known. They appear to be situated in the dry northern areas of the State, close to the line of the 10 in. annual isohyet. The general direction of migration appears to be to the south. In any case, observations made during the present invasion and those recorded during previous outbreaks show that the occurrence of the insects in numbers in the agricultural areas of the State is only temporary.

It is evident that a study of the ecology of the species of grasshoppers involved in the present plague in Australia is necessary. It is also important that research should be carried out on the causes underlying their occurrence in plague numbers.

1. *Organisation of Control Measures.*—When a mass outbreak of grasshoppers is indicated, it is essential that control measures should be organised on a communal basis if satisfactory control is to be obtained. One important aspect of such an organisation should be the survey of infested areas so as to demarcate situations where eggs have been deposited by flying swarms. A skeleton organisation should be maintained in those agricultural areas liable to infestation, so that early control measures can be taken when an invasion is threatened. Under South Australian conditions the district council appears to be the best unit for a control organisation. It is important that occupiers of land should mark and report areas on their property where the swarms of winged insects have laid eggs. If these "egg-beds" are defined, preparations can be made for dealing with the hoppers hatching out from them. Extensive "egg-beds" may occur on unoccupied land, surveyed roads, or State property; these should be dealt with by local councils or State organisations.

The aim in any control campaign should be the destruction of the swarms of wingless hoppers. It is generally recognised that control becomes increasingly difficult when the insects attain the winged stage. Any common-sense, practical methods may be employed in order to destroy swarms. In an organised State-wide campaign, however, certain methods are more practical than others. Of these, spraying with poison sprays or the distribution of poison bait are methods which are widely adopted. The cost of materials and appliances used in these campaigns may be borne by the Government or by district authorities; the necessary labour can generally be arranged by owners of the land or by district councils.

The amount of money which may be reasonably expended on control measures will depend on the value of the crops in the area threatened by invasion. It is evident that labour may be a heavy item of expenditure unless free co-operation is developed in the districts concerned.

2. *Survey of Control Measures Generally Employed.*—Various control methods are widely practised in many countries; certain of them are suitable for use in organised campaigns, others may be employed by smaller groups of workers.

(a) *Destruction of Eggs in "Egg-beds"*.—The insects lay their eggs in batches in the ground to a depth of about 2 inches; the "egg-beds" may be a few square yards to an acre or more in extent. Where practicable, shallow ploughing or harrowing over these areas will expose the eggs to their natural enemies, such as birds, etc., and also to the influence of weather. With some species, in certain countries, the egg-pods are collected and destroyed.

(b) *Destruction of Hoppers.*—1. Mechanical methods, such as destroying the hoppers by the use of rollers, chain or brush harrows, or other implements, are adopted. Their use is restricted to suitable situations and the efficiency of the method is unreliable.

2. Hopper-catching machines are sometimes used and various types have been designed. While they may be useful in local flat situations, their application is restricted and a high degree of control is not obtained.

3. The distribution of dry material over an area where a swarm of hoppers is present is commonly practised; the hoppers tend to shelter in the material at night and the latter can be fired at appropriate time. The limitations of the method are obvious. Flame-throwers of various patterns have been used, a common form being of the knapsack sprayer type; kerosene and fuel oil may be used as fuel. The method is convenient for small swarms of hoppers; owing to fuel costs it has only a restricted application.

4. The method of digging trenches to intercept swarms of advancing hoppers is widely used in certain countries. It is particularly appropriate against those species in which the hoppers advance steadily and do not readily change their direction; the hoppers may be destroyed in large numbers by this method. Following on the method evolved originally in Cyprus, barriers or screens made with suitable material are used in order to direct swarms of hoppers into pits or trenches. Sheets of smooth galvanized iron or zinc about 18 inches wide have proved effective for this purpose. Barriers may be used to protect a crop from an advancing swarm of hoppers; the latter may be destroyed as they bank up against the barrier, or they may be directed into trenches. The use of the method will depend upon local conditions. Labour costs may be high where frequent changes of the position of the barriers are necessary, owing to the irregular movements of the swarm of hoppers. In suitable situations deep plough furrows will retard the advance of a swarm of hoppers into a crop.

5. Liquid contact sprays for killing young hoppers are frequently used; they are not very effective against older hoppers. Owing to the

strength of the spray required, the method is costly, and contact insecticides, such as kerosene emulsions, are harmful to vegetation. Kerosene-soap emulsion, mineral oils, and carbolic-soap emulsions may be used for spraying newly-emerged hoppers on the "egg-beds".

6. The use of arsenical compounds as stomach poisons in the form of sprays and baits have been widely developed in many countries. Spraying has a limited application in areas where dry farming is practised; it may be used to advantage where water is readily available and the occupier of the land has adequate equipment. It is particularly useful where the herbage growth is vigorous, since baits are not suitable in such situations.

Paris green and sodium arsenite are chiefly used as the poisonous ingredients in these sprays. Molasses added to the spray enhances its attractiveness, but its presence is not essential. The following poison spray has been shown to be effective in Australia:

Arsenite of soda	...	...	1 lb.
Molasses	...	...	2 lb.
Water	...	...	16 galls.

The spray should be applied on a strip of vegetation about 30 ft., wide in front of the advancing swarm of hoppers. It may be also sprayed directly on to the hoppers, since it kills both by contact and as a stomach poison. It is necessary to know the arsenious oxide content of the arsenite of soda which is used; the above formula refers to an 80 per cent. arsenious oxide content.

Other forms of arsenic, such as white arsenic, are sometimes used. Stock should not have access to sprayed areas. Sprays containing soluble arsenic are liable to burn foliage. The disadvantages of the spraying method are obvious, but with heavy pasture growth good results should be obtained. In the case of a pasture crop like lucerne, it is advisable to protect the crop by spraying a barrier area around it, rather than spraying the crop itself.

7. The poison bait method is widely used. A bait consists of an inert carrier, a poison, and an attractive substance. Bran is a useful and efficient carrier, but other convenient materials, such as chaff, chopped fodder, or sawdust may be used where bran is not available. The carrier should break readily into small pieces when the bait is distributed; it must not deter the insects from feeding on the bait. Bran has many advantages as a carrier and its high efficiency offsets its cost. Experiments should be made with suitable local materials.

Arsenical poisons have given the most satisfactory and consistent results; Paris green and sodium arsenite are generally used. The soluble forms of arsenic compounds kill the insects quicker than the insoluble forms. The solubility of certain compounds in 100 parts of cold water are given below:

White arsenic (Arsenious oxide) As_2O_3	...	1.2 parts
Sodium arsenite Na_2HAsO_3	...	Very soluble
Sodium arsenate $Na_3AsO_4 \cdot 12H_2O$	...	26.7
Calcium arsenate	...	Insoluble
Lead arsenate	...	Insoluble.

With soluble poisons the solution of the poison is poured over the bait carrier and thoroughly mixed; with insoluble poison the bait should be mixed dry with the carrier and then made into a mash with an appropriate amount of water.

The attractive agent in the bait greatly increases its efficiency. The evidence regarding the value of the use of molasses is conflicting; where this material cannot be obtained it would appear to be justifiable to use the bait without it. In addition to being attractive to the insects molasses assists in keeping the bait moist for a longer period. Damp baits are more attractive than dry ones; salt is sometimes added to baits in order to assist in keeping them damp.

Other substances have been used in baits as attractants, such as crushed fruits. Further experiments are necessary on this aspect of baits.

The following formula has proved to be an effective bait in Australia:

Arsenite of soda	...	...	$\frac{1}{2}$ lb.
Molasses	...	...	4 lb.
Bran	...	...	24 lb.
Water	...	...	$2\frac{1}{2}$ galls.

The arsenite of soda is dissolved in the water and the molasses added to the solution. The mixture is sprinkled over the bran, the whole being thoroughly mixed to form a crumbly mash. The amount of arsenious oxide present in the arsenite of soda is important; the formula refers to an arsenious oxide content of 80 per cent.

The bait is scattered over an area of about 30 ft. wide in front of advancing swarms of hoppers. The amount of bait required per acre will vary with the character of the area. About 10 lb. of bait (dry) should be sufficient, but in practice the amount used may be greater than this; if laid too thickly there is undue wastage of bait. The risk of poisoning stock is negligible if the poison bait is spread thinly as directed. Operators handling poison bait must observe common-sense precautions. Baits should be spread early in the morning; the hoppers become more active later in the day as the temperature increases. On cold days baiting is not so effective since the hoppers are sluggish.

(8) The application of poison dusts, both as stomach poisons and contact poisons, has been widely developed in several countries against certain insect crop pests. During the past few years experiments have been made on the use of arsenical dusts for the control of grasshoppers and locusts. This work is in an experimental stage and would appear to have a promising future.

A dust consists of an inert carrier and the active poison lime gypsun, talc, etc. are generally used as carriers. Arsenical compounds have been chiefly used as the poison.

Appropriate dusting machines are necessary. For small swarms the knapsack or hand rotary duster may be suitable. For large areas the use of the aeroplane is gradually being developed; suitable apparatus for distributing the dust is attached to the aeroplane.

The aeroplane method appears to be particularly suitable for large areas of unoccupied or sparsely-inhabited country. It will have only a restricted application in settled areas, owing to the difficulty of efficient localisation of the dust cloud. The latter is considerably affected by weather conditions, particularly wind.

Where swarms of hoppers are scattered, as is the case of the wandering grasshopper in South Australia, the areas requiring treatment would have to be clearly defined in order to reduce wastage in materials and loss of time. In order to manoeuvre the plane over these areas considerable ground organisation would be necessary. Under these conditions the method would be costly.

Experiments have been carried out more recently with a view to testing the effect of dusting flying swarms of locusts with dusts containing sodium arsenite. It is thought that the dust will effectively kill the insects by contact.

(9) Few experiments have been made on the effect of poison gases against grasshopper swarms. The method can have only a restricted application owing to the danger to animal and plant life.

(c) *Destruction of Winged Swarms.*—Certain of the methods referred to in section (b) may be used. Of these, the use of poison baits and poison sprays are generally adopted. In some instances destruction of winged swarms when resting at night is possible.