



DEPARTMENT OF AGRICULTURE AND FISHERIES, SOUTH AUSTRALIA

Agronomy Branch Report

THE AUSTRALIAN PLAGUE LOCUST CONTROL

CAMPAIGN OF 1955

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Regional Control Officer of
the Campaign.

Report No. 84

This report is the original report on the control campaign conducted against the Australian plague locust plague in South Australia in 1955.

The report is presented as an Agronomy Branch Report to provide a permanent record of the campaign.

THE AUSTRALIAN PLAGUE LOCUST CONTROL CAMPAIGN OF 1955

A Report on the measures taken
by the Department of Agriculture
to protect the Agricultural areas
of the State from devastation by
locusts.

By J.D. McAuliffe, District Agricultural Adviser:
and Regional Control Officer
of the Campaign.

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* The term Field Officer's has been used to include all Officers of the Department of Agriculture, District Clerks and Lands Dept. Inspectors who submitted Reports of their activities in the field.

THE AUSTRALIAN PLAGUE LOCUST (*Chortoicetes terminifera*)

A Potential Plague Controlled

There is no doubt whatever that almost complete devastation of the main Agricultural areas of South Australia would have occurred had nothing been done to combat the developing plague during the Spring months of 1955. The success of the control campaign is an outstanding example of the practical application of comparatively recent research. Since the last plague of similar proportions (1934) much factual information has been collected by our entomologists. This information made it possible to plan a campaign based on a knowledge of the habits of the locusts. On the other hand recent developments in the production of very efficient insecticides provided materials which were capable of killing locusts at a reasonable cost. At the outset therefore it must be acknowledged that fundamental research played a major part in the control of the 1955 invasion of locusts into South Australia. The application of control measures by landholders under the direction of Departmental Extension Officers, either directly or through organisations such as the District Councils, Agricultural Bureau and Stock-Owners Association, was a remarkable effort. The control campaign could well be described as a classic example of co-operative effort between landholders, Departmental Extension, Research and Government.

I. Climatic Conditions Preceding the Plague

It is generally believed that seasonal conditions in the pastoral country of New South Wales and Queensland decide the extent of multiplication of the Plague Locusts. In the more favourable seasons, conditions prevail which are suited to a rapid increase in locust numbers. Migration from these areas in a general southerly direction then takes place. Plagues develop when these greatly increased populations occur in the pastoral areas and adult locusts migrate to the fringe of the Agricultural belt in Autumn. Egg laying during this migration then extends through the pastoral country to within the Agricultural areas. These eggs do not hatch until favourable temperature and moisture conditions occur in the following Spring, when the crops and pastures of the Agricultural districts are most vulnerable to damage done by locusts.

Seasonal conditions were very favourable in the pastoral country eighteen months before this plague occurred. In rainfall divisions numbered 20, 46 and 47 good rains were recorded in the Spring of 1953, in both Autumn and Spring of 1954 and continued into the Autumn of 1955. The sequence of good rainfalls produced excellent feed growth but at the same time provided favourable conditions for locust multiplication.

When seasonal conditions preceding the plague of 1934 and 1955 are compared they are found to be somewhat similar. In each instance the plagues followed two successive seasons of good Spring rainfall in the pastoral country North-east of South Australia. The total rainfall in these areas for the fifteen months ending December of the year preceding the plagues was approximately the same. Although totals were slightly higher in 1954 better Autumn rains occurred in that season.

The following details of rainfall recorded in the pastoral areas of South Australia and New South Wales where it is considered plagues develop, shows the incidence of rain leading up to the development of locusts in plague proportions in 1934 and 1955.

Rainfall recorded in the Pastoral Divisions numbered 20, 46 and 47 from October 1932
to March 1934

Year	1932												1933			1934		
	Division/ Centre	Oct.	Nov.	Dec.	Jan.	Feb.	Mch	Apl.	May	June	July	Augst	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
20	16	78	14	28	12	30	13	62	33	53	69	55	19	357	23	10	82	46
46	55	107	20	18	27	19	45	75	11	23	54	19	35	166	271	20	137	1
47	28	105	32	67	10	27	32	49	13	66	71	86	20	444	93	53	47	37

Rainfall recorded in the pastoral Divisions numbered 20, 46 and 47 and in the North-Eastern recording centres of Curnamona,
Cockburn, O'Lary and Yunta from October 1953 to Mar. 1955

Year	1953						1954						1955						
	Division/ Centre	Oct	Nov.	Dec.	Jan.	Feb.	Mch	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mch.
20	1.12	0.33	0.69	0.89	0	0	1.40	0.09	0.30	0.15	0.60	0.16	0.76	1.08	2.42	0.17	2.26	2.12	7.99
46	1.87	0.18	0.27	0.49	2.73	0	0.37	0.02	0.58	0.63	0.75	0.19	2.35	0.65	2.08	0.72	2.31	0.58	8.29
47	1.16	0.50	0.30	0.64	0.01	0.01	1.81	0.14	0.22	0.28	0.76	0.14	1.40	2.01	3.44	0.25	2.89	2.19	9.67
Curnamona				1.41	0	0	1.12	0	0.20	0.07	0.58	0	0.68	1.28	1.53	0	1.01	2.31	
Cockburn				0.33	0	0	1.57	0.16	0.24	0.14	0.16	0.21	1.02	1.84	4.28	0.09	1.93	1.79	
O'Lary				0.93	0	0	1.20	0.05	0.10	0	0.49	0.13	0.75	1.26	3.33	0	2.90	2.01	
Yunta				1.31	0	0	1.42	0.20	0.55	0.30	1.11	0.25	0.91	0.85	2.39	0.10	2.60	2.77	

3.

II. Adult Locusts Reached the Agricultural Areas in Autumn 1955

Towards the middle of March locusts on the wing appeared in the Agricultural areas of the State. They were first noticed in the Baroota, Nelshaby, Napperby areas, the Willowie Plain, the Black Rock Plain and to the North-East of Peterborough. These invasions extended south to Laura, Crystal Brook, Gulnare, Yacka and Spalding districts. Later with somewhat less density they penetrated well into the Lower North and Yorke Peninsula Agricultural districts. At the same time locusts invaded the Upper Murray and Northern Mallee districts, the Murray Flats as well as most of the Agricultural areas on Upper Eyre Peninsula.

The swarms were comparatively dense but did not constitute plague proportions. They devoured considerable quantities of feed. Some individual landholders lost heavily but generally speaking feed conditions following the rains of February March and April provided plenty of feed for both the locusts and livestock and the overall losses were not felt by graziers.

The important happening at this stage was the prolific egg laying which took place. Wherever the adult locusts travelled they deposited eggs in very great numbers. Egg beds for the most part were not clearly defined. Generally the locusts preferred depositing eggs on slopes facing north whether these be creek banks, sheep pads or road sides. In these more favoured positions the deposition of eggs was very concentrated. A match box would cover up to twelve egg pods. Early egg laying followed more closely the expected pattern but later as temperatures lowered the locusts appeared to deposit eggs anywhere at all. There is evidence that many of these eggs perished during the winter through being deposited in unfavourable spots where the early deposited eggs, in selected positions, overwintered perfectly. Mating and laying continued from Mid-March to the end of May. A few live adults were still to be found in Mid-Winter.

Towards the end of May some minor hatchings took place, at Laura and Hawker this occurred, but it was unusual for the eggs deposited in the Autumn to hatch before the following Spring.

III. Preparation to Combat a Plague

The surveys made by District Agricultural Officers by the end of April 1955 indicated a plague of locusts in the Spring. Preparations were made to combat it but unfortunately we were not in a position to accurately predict the size of the plague that would develop.

In preparing to meet the future the following aspects of locust control had to be considered:-

1. The Law in relation to Locust Control.
2. Present knowledge of the Locust.
3. Present knowledge and availability of Insecticides.
4. A programme of Extension designed to educate District Councils and landholders.
5. Government assistance.

1. The Law in relation to Locust Control

The Noxious Insects Acts of 1934 provided a very sound basis on which a control programme could be commenced.

The regulations under the Noxious Insects Acts of 1934 are summarised as follows:-

The Occupier is required to:

1. Mark egg beds.
2. Report the locality and area of same, and when hatching begins, to the Clerk of the District Council or Municipality or Chairman, Pastoral Board.
3. Take measures as directed by the Clerk of the District Council.

The District Council of Municipality is required to:

1. Map egg beds.
2. Enforce control measures.
3. Supply insecticide to occupiers.
4. Inspect unoccupied lands to locate egg beds.
5. Inspect reported egg beds to check whether proper measures taken.
6. Report at end of each calendar month to the Director of Agriculture.

The Chairman of the Pastoral Board shall map areas and report to the Director of Agriculture.

The Director of Lands is responsible for Crown Lands including control measures and monthly reporting to the Director of Agriculture.

Whilst this Act is not administered by the Agricultural Department very close liaison had to be established between the Department and Local Governing bodies, who

administer the Act, for a control programme to function. The reasons for this were organisation on the one hand and extension on the other. The District Councils have a state wide coverage of agricultural areas, an intimate knowledge of their localities, and close contact with landholders. The Agricultural Department functioning as an extension service was in the best position to obtain and disseminate the information available, not only to the District Councils but to landholder groups and organisations and to individual landholders.

During the 'hopper stage' of the campaign it was found necessary to amend the 1934 Act to enable District Councils to enforce control measures. This was necessary to enable District Councils to handle a small percentage of non-co-operative landholders.

The following copy of a circular issued by the Minister of Agriculture to all District Councils clearly sets out and explains the Amendment.

"CIRCULAR TO COUNCILS:

21st Oct. 1955

Dear Sir,

NOXIOUS INSECTS ACT AMENDMENT ACT, 1955

Because of its urgency, a special meeting of Executive Council was held today for the purpose of obtaining Royal assent to the above Act. This assent and the new provisions are now law.

Section 6 (2) of the original Noxious Insects Act gives a council power by notice in writing to the occupier of any land to require him to take measures prescribed by the council for the destruction and suppression of noxious insects on the land within the time specified in the notice. Under the new legislation assented to today, the Council may now take practical action if an occupier fails to comply with such notice. The authorised officer of a council may enter upon the occupier's land and take all such measures and do all such things as appear to him to be necessary to carry out the measures specified in the notice. Provision is made for a council to recover the cost of any such action taken.

An occupier is deemed not to have complied with the council's notice if:-

- (1) he does not, after the service of the notice upon him, forthwith commence to comply with it; or
- (2) having commenced to comply with it, does not continue such compliance.

Formerly the council could only prosecute the occupier if he failed to comply with the notice. It is expected that these wider powers will enable councils to deal more effectively and expeditiously with the grasshopper menace.

YOURS TRULY,

MINISTER OF AGRICULTURE"

2. Present Knowledge of the Locust

The Australian Plague Locust (Chortoicetes terminifera) was known to have caused serious South Australian plagues in 1890 and 1934. During the 1934 plague and subsequently in States troubled more frequently by plagues useful information had been collected about the locust. The information generally known or available was as follows:-

1. The locust is of medium size ($1\frac{1}{2}$ - 2" in length) at maturity and generally brownish grey in color. Often a lighter strip extends down the back and sometimes the females are green. The lower shanks of the jumping legs are red. Wings have a distinct black tip to an otherwise transparent wing.

2. The locust is capable of migrating very great distances and usually in a southerly direction.

3. The female deposits eggs in batches of 30 - 40 in holes made in the ground with a specially designed ovipositor. The eggs are surrounded by a frothy secretion which dries to form a protective covering and cement the eggs together in a group known as an egg pod. The eggs are usually deposited in defined egg beds in bare ground or scalded patches of hard soil.

4. The eggs need certain moisture and temperature conditions. As these conditions occur during September and October the approximate time of hatching of eggs laid in the Autumn could be anticipated. Progressive or simultaneous hatchings can occur. The time from hatching to the winged stage is about six weeks and during this time hoppers pass through five instar stages becoming more like the adult with each change.

The young hoppers at a week to ten days old congregate and move from the egg beds in masses to feeding grounds, where they continue to feed until reaching the winged stage.

The above information was most important to organising a control campaign. In particular having identified the locust it was invaluable to be able to predict approximate date of hatching. It was of vital importance to know of

the habit of congregating as "hoppers" as this provided a knowledge of the most effective and economical time to destroy them.

Further information was kindly supplied by Dr. Andrewartha of the University of Adelaide (29/10/55) concerning the habits of adult locusts and is itemised as follows:-

- (1) Flight is governed by maturity and there will be several waves governed by length of hatching period.
- (2) Flights are not governed by food attraction as regular satisfaction of hunger does not appear important and feeding usually takes place in the morning before flight, or on flightless days.
- (3) There is some attraction from dry to moister atmosphere, but this is apparently over a short range, and not very strong.
- (4) Size of swarm depends on density of hoppers in any given area. Dense masses make big swarms, while scattered hoppers make a number of small swarms.
- (5) Coalescence of swarms may take place either on the ground or in the air, but is probably accidental although gregarious instinct is strong. Swarms may come together while feeding or in pre-flight milling about and join up (perhaps over $\frac{1}{4}$ mile). In flight small swarms crossed by larger ones are usually absorbed therein.
- (6) Locusts fly at approximately 7 m.p.h. and are not likely to take off if wind velocity exceeds this.
- (7) Flight ideal may be 15 - 20 feet but is known to occur as high as 6,000 feet.
- (8) At from 14 - 15 feet locusts can recognise ground pattern and will either descend, or attempt to maintain original flight direction if wind velocity increases while they can still see the ground.
- (9) Above 20 feet they are often caught up in stronger winds which influence direction, distance and speed of flight.
- (10) High flights are always with prevailing winds.
- (11) Swarm flight is brought about by temperatures rising and/or convection currents in air.
- (12) As temperatures and convection currents are usually reduced during and following rain, this usually means flightless day or days.

- (13) Cumulo-nimbus cloud development while locusts are in the air brings about early movement and late settling, or even all night and long flights.
- (14) Flights usually commence at temperatures between 17° - 22°C (say 63° - 71°F) and may commence as soon as thermal uplift of air begins after temperatures have reached 17°C (63°F).
- (15) As flight probably depends on thermal uplift low temperatures on preceding day indicate likelihood of flight beginning at lower temperatures on next day, and vice versa.
- (16) Increasing activity in swarm, milling about with greater numbers making short, quick flights goes on until enough are in the air to stimulate the main flight.
- (17) Movement of swarm begins with early fliers streaming away followed by the mass of the swarm. This "streamaway" beginning is a usual feature.
- (18) "Streamaway" usually begins about 4 hours after first flight.
- (19) In settled flight swarm is oval in shape with greatest mass of locusts in sickle shaped formation in the leading edge and quickly decreasing density to rear end.
- (20) Migratory swarms usually descend and land when temperature falls to 19° - 23°C (66° - 73.5°F).
- (21) Possible times of flight movement are "streamaway" not before 8.30 - 9.00 a.m. and descent by 5-5.30 p.m.
- (22) Full feeding induces sluggishness and "streamaway" from good feeding grounds usually begins later than from poor feeding grounds.
- (23) Descent may be in somewhat similar pattern to the flying swarm.
- (24) As temperature falls in evening there is a marked huddling together for warmth.
- (25) Swarms are usually closely huddled together at first light and this is ideal time to spray, to catch densest gatherings of locusts.
- (26) Swarms on ground remain huddled until after basking in the early sun.
- (27) Rising temperatures then induce activity followed by feeding, and later milling about until the short quick flights begin.

- (28) Spraying can go on from demarcation of swarms until beginning of "streamaway" as a rule, because early flight is often not high or dense enough to worry aircraft.
- (29) If whole swarm can't be sprayed, hitting the sickle shaped spear head mass will greatly reduce numbers.
- (30) Gregarious instinct is strong and spray attack on main part of swarm is probably followed by a closing of the ranks.
- (31) Experience in aircraft spraying in Kenya has shown that the major difficulty is in locating and marking out swarms on the ground before darkness sets in, so that spraying can be organised and carried out prior to the next day's temperature rise and migration. This may be better in S.A. because of more inhabited country in area of attack.
- (32) Grounded swarms are not very easy to sight from the air but sometimes large swarms of 1000 acres in extent in flight (and swarm covers much larger area in flight than on ground) can be seen by air observer at 2 - 5 miles.
- (33) One danger to plane in swarm is less of visibility for piloting either by sheer denseness of locust mass, or by blurring of perspex by contact and squashing of locusts thereon.
- (34) Localised information of temperature, wind direction and velocity, and possibility of convection current development would help.
- (35) First feeding is usually close to ground with priority to granimaceous plants before broadleaf.
- (36) Hunger will induce climbing and eating nearly everything green.
- (37) Baiting is chancy but effective when baits are taken. Appears to vary with thirstiness of locusts. Sometimes sawdust based baits are taken when bran based are not. Sometimes, perhaps when locusts thirsty, damp bait more effective than dry. Regarded as very secondary to spraying in any manner.
- (38) Egglaying may commence about one week after first flight, these eggs would take 3-4 weeks plus to hatch out, depending on weather. Young hoppers of this generation will need enough green feed to grow to winged stage and this may not be available in mid-December so that these could hatch out and not lay eggs.

- (39) Week of drizzle and high humidity would be likely to develop diseases which could kill off most locusts in a given area. No other weather effect now likely to be effective in killing out swarms, except aridity and lack of feed in later stages.

3. Knowledge and availability of Insecticides

A review of the insecticides and methods of application for locust control in Australia was supplied by Mr. D.C. Swan, Head, Department of Entomology, Waite Agricultural Research Institute. This contained the basic information on which insecticidal control was planned. Mr. Swan's review was as follows:-

"A considerable variety of methods and materials for locust control has been employed in various countries in the past ten years. Of these the following are available in Australia and have been found effective in recent Chortoicetes outbreaks in N.S.W. and Victoria.

(1) Insecticides

benzene hexachloride (B H C)
 aldrin
 dieldrin
 chlordane
 toxaphene

Dinitro-ortho-cresol (N N O C) has been used extensively in Africa and elsewhere, but its toxicity to plants and unpleasantness for the operator appear to disqualify it while the above materials are available; it does not seem to have been used for locust control in Australia.

Arsenicals have been virtually displaced by the above insecticides and are unlikely to find any favour with landholders under conditions encountered in this State.

Dieldrin, while an effective killing agent for locust control, is regarded as unduly toxic to man and animals to be recommended for general use. It does not find a place in the present list of insecticides recommended for this purpose by the N.S.W. Department of Agriculture. It has however been shown to be effective against Chortoicetes; it would appear desirable that it should be employed by experienced operators using recommended safety measures. Its exclusion from recommendations to landholders might therefore be considered appropriate.

BHC, in spite of the recent publicity accorded to aldrin, remains a highly effective locusticide, and loses little in competition with it. It will be desirable that specification of its gamma-isomer

content should be clearly stated in any recommendation, due to the variety of formulations and of sources from which it reaches the market. The following is the current table of materials and dosages recommended by the N.S.W. Department of Agriculture:

Quantity of Insecticides to apply per acre of hoppers.

<u>Insecti- cide</u>	<u>Quantity per acre*</u>	<u>Quantity Knapsack</u>
BHC	(a) 5 pints 3.5 per cent BHC emulsion (equivalent to $3\frac{1}{2}$ ozs. gamma-BHC)	3 fl. oz
	(b) $2\frac{1}{2}$ pints 7 per cent BHC emulsion (equivalent to $3\frac{1}{2}$ oz gamma-BHC)	$1\frac{1}{2}$ fl. oz.
	(c) 3 lb. 50 per cent BHC dispersible powder (equivalent to 3 oz gamma-BHC)	$1\frac{1}{2}$ oz.
Chlordane	1 pint 80 per cent emulsion (equivalent to 1 lb. Chlordane)	5 teaspoonfuls
Aldrin	$\frac{1}{2}$ pint 40 per cent emulsion (aldrin) (equivalent to 4 oz. actual aldrin)	2 teaspoonfuls
Toxaphene	$1\frac{1}{4}$ pints 100 per cent emulsion (equivalent to approx. $1\frac{1}{2}$ lbs toxaphene)	6 teaspoonfuls
	2 pints 65 per cent emulsion (equivalent to approx. $1\frac{1}{2}$ lb. toxaphene)	9 teaspoonfuls

*The amount of water to be used with any of the above must be adjusted to the delivery rate of the particular machine used for applying insecticide. It is necessary in all cases that the amount of active ingredient specified should be applied to each acre treated.

(2) Methods of Application

- (a) Spraying either from the ground or from the air.
- (b) Fogging the misting machines

(c) Baiting

(a) Spraying. Low-volume equipment is usually employed, but high volume sprayers of orchard type, or knapsack sprayers could be used when available. Low volume sprayers may be adjusted to deliver about five gallons per acre diluted insecticide; for this purpose the above emulsions are suitable but dispersible-powder type sprays should not be used with low-volume machines.

Sprays should be applied along the margins of hopper bands and on the massed swarms themselves; spraying on a fieldwide scale is not usually undertaken. In general sprays are most effective when applied to vegetation that is being eaten; they all rely for their principal effect upon being ingested by the insects.

Knapsacks sprays have proved useful, but with a capacity of 3 gallons can treat about one-thirtieth acre at each filling. They are particularly useful for small and scattered local aggregations, or young hoppers on egg beds, in areas too small or inaccessible for the employment of larger machines.

Air-spraying has been used in recent years in Victoria to deal with extensive swarms which threatened irrigated areas in the Murray Valley. It offers the best means of dealing with large uniformly-affected areas where these are flat and suited to low-flying aircraft. The cost per acre for large acreages is relatively low. It must be employed in conjunction with adequate ground facilities, and requires a fairly elaborate organization for scouting, marking targets, and providing flight-indicators, and two-way communication between ground and the aircraft. Large-scale operations of this kind have been conducted by the Victorian Department of Agriculture, using DC3 aircraft modified for the work, and supplied under charter from either R.A.A.F. or private airlines. The latter arrangement proved more satisfactory.

It is difficult to assess costs since these depend upon the extent of assistance from such groups as R.A.A.F., and Army Signals.

Hogan (Jl Dept. Agric. Victoria 1950) gave a cost of 14s. per acre; in a recent report A.I.A.S. Journal March 1955) he gives the total cost per acre of the aircraft at 2/11 per acre; if cost of spray materials remained the same, (namely, 8/6), this represents a substantial reduction from the earlier figures.

In these operations BHC was used, dissolved in diesel fuel oil, and applied at the rate of 2 gallons per acre.

Air-spraying of locusts may also be directed against flying swarms; it offers a powerful control weapon provided adequate knowledge of locust distribution is available, and suitable co-ordination of operations is maintained. The method is now extensively used in U.S.A.; an operation was observed in 1951 where 800,000 acres were sprayed, under the direction of the U.S.D.A. About 30 commercial spraying aircraft were employed under contract, with a single ground headquarters which supervised and co-ordinated the programme. In this case aldrin was used, and the costs were met from equal contributions from Federal and State Funds, and the affected landholders.

In general, aldrin, BHC, and DNOC are being used for aerial spraying of locusts in various countries at present, and are used as solutions in light mineral oils.

(b) Fogging and misting. Various machines that are on the market in Australia can be employed to deliver insecticides as fogs or mists, which drift considerable distances before the particles settle. These machines may be used to apply insecticides directly upon locusts, both as hoppers and fliers, and have given good results.

They are operated while mounted on a vehicle driven at about 3 m.p.h. across the direction of the prevailing wind. Winds of low speed are desirable, and best conditions usually occur in the early morning or evening.

Machines of the "Milmist" or "Tifa" types may be used in this way. They are set to deliver large particles (90 to 120 microns), and the fog stream is directed downwards to reach the ground surface near the machine. The band that is fogged varies in width according to the wind speed, and may be from one to five chains. Parallel traverses and suitable spacings will deal with large aggregations.

The N.S.W. Department of Agriculture recommends fogging with BHC, using a 1 per cent solution of gamma BHC in diesoline and sovacide. This is prepared as follows:

Take 1 part of 3.30% gamma BHC (as used for fogging sheep) dilute with 2 parts of sovacide.
2 gallons of the mixture is used for each 3 minutes of fogging time.

(c) Baiting. Poison baiting has declined in popularity as a means of locust control, in view of the relative ease and convenience of the methods mentioned above. It remains however an effective procedure against hoppers, and is still included in the recommendations of the N.S.W. Department of Agriculture.

Baits are particularly useful when hoppers are present on bare or lightly-vegetated ground, and where an internal poison would not be ingested with natural food. Conversely, bait is unlikely to be effective among pasture or green crops.

Baits will usually be taken dry, and the moistening of baits is no longer regarded as essential. Hoppers vary in their appetite for bait, however, and it is desirable before large-scale baiting is undertaken, to scatter trial samples if these are rejected, the admixture of water usually makes the material palatable.

A method has been developed in Africa, in which dry bait is run in lines by pouring it through a large funnel attached to the back of a Landrover, which travels at 15 m.p.h. The funnel has a cylindrical upper part, about 15 inches in diameter and 12 inches deep, with a 12 inch cone tapering to a short cylindrical orifice 3 inches in diameter. The funnel is kept filled by a passenger riding in the rear of the truck.

Bait should be spread thinly over a strip a few feet wide in front of advancing hopper bands; it can be scattered by hand from a slowly moving vehicle. Further bait should be distributed in strips through large aggregations. Hoppers do not feed actively on cold, windy or overcast days, and bait should not be spread in such conditions. On hot days it is desirable to apply bait early in the morning, since feeding activity is greatest before noon. In general baiting must be adapted to local conditions and to variations in feeding response of hoppers. It would seem that bait would find a place chiefly in drier districts where ground cover was sparse or more widely in drought conditions.

The recommended formula is:

Bran	110 lb.
20 per cent BHC dust	1½ lb
(or 26 oz. BHC dust per 120 - lb. bag of bran.)	

To make damp bait, add 10 gallons of water to the above quantity of bran.

(3) Protection of valuable crops

Crops such as cereals, vegetables, lucerne and irrigated or improved pastures, and even orchard trees may be threatened by hoppers or by flying swarms. The insecticides BHC, chlordane, aldrin, or toxaphene, used at standard rates of application, have been found in past outbreaks in Eastern States to give protection to such crops for as much as three weeks. Application by air-spraying, low-volume boom, or other spray equipment gives best results; fogs give temporary protection but leave little spray residue for prolonged effects.

Lucerne may be cut if long enough, and the young growth protected by spraying.

(4) Precautions in using locust control methods

Stock should be kept off treated pastures for a few days after spraying, and milking cows or animals being finished for slaughter should be kept off treated pastures for two or three weeks. Baits if applied dry, or as loose flakes when wet, do not constitute a danger to grazing stock or wild life.

All precautions recommended by the makers of the various insecticides should be followed at all times, particularly when handling concentrates. Splashing of the latter on clothing or skin should be avoided in the presence of insecticides and food should not be handled unless hands have been washed."

D.C.S. 24/6/55
(Waite Institute)

Largely as a result of the for-going information and availability of material the control measures recommended by the Department during the 'Hopper Stage' were:-

Sprays:-

Insecticide	Amount per acre	Quantity per Knapsack
BHC	(1) 2½ pints 7% BHC emulsion (= 3½ oz. gamma isomer)	1½ fl. ozs.
	(2) 3 lbs. 50% dispersible powder (= 3 oz. gamma isomer)	1½ oz.
Aldrin	½ pint 40% emulsion (= 4 oz. actual aldrin)	Not recommended for knapsack spraying

Dieldrin	2/5 pint 25% emulsion (= 2 oz. actual dieldrin)	Not recommended for knapsack spraying.
Chlordane	1 pint 80% emulsion (= 1 lb. Chlordane)	5 teaspoons
Toxaphene	1 1/4 pints 100% emulsion (= 1 1/2 lbs. toxaphene)	6 teaspoons

Of these insecticides the first three are the cheapest per acre. Aldrin is usually about a shilling cheaper than dieldrin with BHC at present 4 or 5 shillings per acre dearer. Prices vary with fomulation.

BHC is a much safer chemical to use through a knapsack spray. Aldrin or dieldrin are regarded as appreciably less toxic to mammals than parathion, but similar precautions against ingestion, skin contact and inhalation should be observed. The N.S.W. Department of Agriculture does not recommend the use of dieldrin for locust control because of its toxicity.

This Department's recommendations are:-

- (1) To use only BHC through a knapsack spray.
- (2) To use BHC, aldrin or dieldrin through low volume sprays.
- (3) To observe the above precautions when using aldrin or dieldrin.

Spraying Methods

With L.V. Sprayers, about 5 gallons per acre should be applied. Sprays should be applied along the margins of hopper bands and on the massed swarms themselves. The poisons are more effective when applied to vegetation on which hoppers are feeding than to the hoppers direct.

Knapsack sprays are useful for small or inaccessible egg beds.

Fogging and misting machines may also be used. They are driven at about 3 m.p.h. across the direction of the prevailing wind. Low wind speeds are desirable for their use.

The N.S.W. Department of Agriculture recommends the following:-

- 1 part of 3.30% gamma BHC with 2 parts of sovacide;
- 2 gallons of the mixture used each 3 minutes of fogging time.

Poison Baits

These are useful when hoppers are on bare or sparsely covered areas but are unlikely to be effective if plenty of food is available.

Dry baits are usually satisfactory. $1\frac{1}{2}$ lbs. of 20% BHC dust mixed with 100 lbs. bran is the recommended recipe.

Hoppers vary in their appetite for bait and test baiting is advisable before large scale baiting is commenced. Adding 10 gallons of water to the above mixture may increase its palatability.

Spread the bait thinly over a strip a few feet wide in front of advancing hopper bands. If bands are large, spread more bait through them. Little feeding is done on cold, windy or overcast weather; choose the right weather conditions. On hot days, spread bait early in the morning.

Baits may be spread by hand or through a large funnel attached to the back of a utility. A funnel 15" x 12" with a 12" cone tapering to a 3" orifice has been used in Africa. The rate of application is about 30 lbs of dry bait per acre.

Protection of Crops, Orchards Etc.

Chemicals with a high residual effect give better protection. N.S.W. figures for duration of residual effect are as follows:-

BHC	10 - 14 days
Aldrin	2 - 3 weeks
Chlordane and toxaphene	- up to 3 weeks

The residual effect of dieldrin is considerably greater.

Precautions

- (1) Grazing Stock. Milking cows or animals being topped for slaughter should be kept off for 2-3 weeks; other stock for a few days.
- (2) Operators. Observe maker's precautions, particularly when handling concentrated solutions. Avoid skin contact; wash off promptly if it occurs. Wash hands and face before smoking or eating.
4. A Programme of Extension designed to educate District Councils and Landholders

From the time the adult fliers appeared in the Agricultural areas in March 1955 District Agricultural

Advisers assisted in some cases by Field Officers were occupied to a very large extent on extension work in relation to the locusts. At first, the task of assessing the extent of the egg-laying was most important as this would determine the magnitude of the plague. At this stage one of the greatest difficulties of the whole campaign presented itself.

Landholders, it was found, were completely ignorant of what egg beds were like, very few had observed mating or laying and consequently were not reporting to District Council Clerks. In very many instances, too, there was complete ignorance as to Landholders responsibilities in the matter. At the very outset then a situation had to be faced and overcome in order to establish the seriousness of the situation. Had all District Councils been in a position at the end of May to furnish a statement of the approximate area of egg beds in their districts it would have been plain to see the seriousness of the potential plague. A further difficulty at this stage was to convince many of the Landholders of the North "who had lived with grasshoppers for forty years", that in this instance they had locusts.

An intensive extension programme had to be conducted during the winter months. This took place in the form of addresses to three Bureau Conferences with Press Publicity towards the end of June. Then followed a comprehensive series of talks to Bureau Branches and District Councils as well as making contact with every District Clerk in the infested areas to advise them generally on locust control and to urge them to secure quantities of insecticide for distribution to landholders after hatching had taken place. By the time hatching commenced a wide interest in the situation had developed and District Councils were fully aware of their own responsibilities and that of the landholders. The only assessment of the extent of egg laying up to the hatching stage was that made by District Agricultural Officers. This was secured under difficulties of travelling long distances over vast areas and consequently was not as accurate or as detailed as was desirable.

5. Government Assistance

At three periods during the campaign the Government stepped in to help the efforts of the individual. Each time with substantial assistance which gave the necessary stimulus to ensure success. The three instances of assistance from Government were, the issue of free insecticide, the provision of Army Jeeps fitted with Sayer Spray Units to assist pastoralists, and later aeroplanes and ground equipment to handle flying swarms which had survived the 'hopper stage'.

So far as preparation for the campaign was concerned, the announcement by the Government in August that insecticide used for locust control would be issued free of charge, changed the outlook of many landholders. An immediate reaction was the increased interest in the possibility of controlling the plague. More egg beds were reported than before and generally a more co-operative view taken of the situation.

IV Hatchings in the Spring of 1955

The first hatchings of eggs in the Agricultural areas took place during the third week of September. The young 'hoppers' appeared first in the earlier Agricultural Districts and in the pastoral country. Some hatchings must have been earlier in the pastoral country as young 'fliers' were observed East of Terowie on 5:10:55 and at Kallioota on 25:10:55.

Hatching continued until early November. Some of the hatchings were simultaneous when whole paddocks appeared to become moving masses of tiny hoppers. Instances of this were noted on the Western side of the Flinders Range in the Nelshaby and Baroota districts. Other hatchings were progressive and the Laura district provided one of the best examples of this. Four and five successive hatchings occurred along the creek banks in this area.

Temperature was the controlling factor for the first hatchings. Sufficient soil moisture was available at this stage. As the season progressed hatchings depended more on moisture conditions and invariably followed falls of rain. It was possible in mid October to find winged locusts and freshly hatched hoppers in the same area. In the pastoral country East of Terowie all stages from freshly hatched hoppers to winged adults were observed on 5:10:55.

After hatching the young locusts behaved very much as expected. They moved from the hatching grounds in swarms and appeared to be influenced by temperature and food supply. Early in the life of the hoppers, swarms remained well defined and their activity depended on temperature. In the cool of the evening, through the night, and early in the morning they congregated in dense masses. In cold weather they would remain for days in this position. During the warm hours of the day movement would take place over short distances.

The movement habits seemed to change somewhat with age of the hopper and drier feed conditions. These factors coincided in many areas. At this stage, in warmer weather the swarms spread out, and moved appreciable distances congregating again as temperatures lowered. During this period when natural fodders were drying off the swarms would remain in places where feed was still green for considerable periods, often until they had

eaten out all green material.

In the hopper stage while grass remained green it appeared to be the favourite feed. As the grasses dried off Medics were readily eaten and it was not uncommon to see only the barrels and basal stem left of a barrel clover stand. Later again the young hoppers would consume almost any green material available.

In practice this often caused heavy concentrations of hoppers along watercourses where the later green feed existed. In such positions and concentrations the hoppers were very vulnerable to destruction.

It is difficult to describe the concentration of hoppers that existed. One station-owner in the North East reported crossing thirty swarms of hoppers in a distance of twelve miles. A Departmental Officer reported driving through continuous hoppers for distances of from five to eight miles on several occasions. All were moving rapidly across the road in moderately sparse concentration (three to four per square yard).

Swarms varied in size from one square chain to one square mile but usually the larger swarms were several acres in size.

An accompanying map shows the extent of the hatchings in the State.

Rainfall Recorded at Jamestown during the Hatching PeriodSeptember - November 1955

<u>Date</u>	<u>September</u>	<u>October</u>	<u>November</u>
1	1	14	4
2	-	2	1
3	2	-	-
4	-	-	-
5	1	-	-
6	-	1	8
7	2	1	-
8	4	14	2
9	-	-	-
10	-	-	-
11	-	1	58
12	-	20	-
13	-	-	-
14	-	-	-
15	-	7	-
16	-	-	-
17	-	-	31
18	-	-	9
19	-	-	18
20	-	1	-
21	-	-	-
22	7	-	-
23	28	-	-
24	27	-	31
25	-	-	12
26	2	4	30
27	80	-	2
28	-	-	-
29	-	11	-
30	-	24	-
31	-	4	-
Total	15.4	104	206

Maximum Temperatures recorded at Yongala during the Hatching
Period - September - December 1955

<u>Date</u>	<u>September</u>	<u>October</u>	<u>November</u>	<u>December</u>
1	62 ^o F	64 ^o F	63 ^o F	73 ^o F
2	62	58	71	64
3	54	67	76	65
4	53	73	79	65
5	57	74	81	75
6	64	74	80	84
7	68	62	68	91
8	60	60	64	96
9	62	57	70	98
10	-	64	60	100
11	68	65	65	87
12	72	66	75	82
13	75	75	76	81
14	75	75	78	91
15	67	75	76	84
16	65	69	69	80
17	-	85	71	86
18	62	65	52	89
19	75	79	65	93
20	81	92	75	69
21	83	74	89	77
22	63	77	91	83
23	56	83	-	83
24	-	71	62	70
25	64	61	58	74
26	63	73	63	70
27	59	72	75	74
28	69	75	80	79
29	65	64	86	82
30	65	63	73	67
31	-	61	-	60

1. Observations recorded by Field Officers of Hatchings and behaviour of Locusts in the Hopper Stage

(1) Hatching

- (a) Hatching took place over a period of 6-8 weeks. Early reports were as follows:-

Nelshaby - Baroota area	19/9/55
Laura district	20/9/55
Narridy - Redhill -	
Crystal Brook - Georgetown -	
Wirrabara districts	26/9/55
Glenora Station	27/9/55
Monash district	28/9/55
North Eastern Pastoral	
Country - Mt. Bryan - to -	
Koomoloo & North to Lilydale	27/9/55 - 3/10/55.

- (b) Hatching took place for the first time in history on Yorke Peninsula and south of Balaklava.
- (c) The main hatchings in the North-East Pastoral country took place on the flood plains of the Manunda, Newikie and subsidiary creeks.
- (d) There were no reports of hatchings in the Black Oak - Blue Bush Association on the Stations Pine Valley, Lordwell, Cane-Grass, Parcoola and Morganvale.
- (e) Late Hatchings had less chance of survival. It was reported on 9/11/55 that young hoppers were dying on the Willochra Plain through lack of food and dry conditions. The same thing was noted in the Peterborough area on 7/11/55.

(2) Movement

- (a) Hoppers were very sensitive to temperature changes. On days of some cloud the hoppers would move freely while the sun was shining but would start to camp when cloud cut out sun's rays for more than 5-10 minutes.
- (b) Hoppers never appeared to travel in any definite direction. It was not uncommon to see a swarm travelling north and a few miles further on find a swarm travelling south.
- (c) Each band of hoppers appeared to hold a definite line of movement but this movement may be in any direction.

- (d) There appeared a general tendency to move down slope.
- (e) Hoppers tended to move in defined paths from hills to plains along roads and through crops and scrub.
- (f) Movement up to 1 mile per day was quite common in the 5th and 4th instar stage.
- (g) In the Telowie Baroota area a strip 17 miles long by 2 miles wide was one big hatching ground. When the hoppers had eaten the area out they moved westward to unaffected agricultural land. A surprising number, well dispersed were left behind.
- (h) Hoppers moved at $\frac{1}{2}$ mile per day but would remain in areas of abundance of green material.
- (i) When ever large swarms marched over fallow they completely obliterated cultivation marks. This pounding occurred to a lesser extent on non-cultivated areas and together with the loss of cover paved the way to two dust storms on the Western side of the Flinders Range.

(3) Feeding habits and preferences

- (a) Food preferences appeared to be in the following order.
 1. Medics
 2. Danthonia spp.
 3. Stipa spp.
 4. Annual Weeds (Nicotiina and Milk Thistles)
 5. Annual Saltbush)
 6. Perennial Saltbush) Stems eaten below leaves
 7. Blue Bush (Tips of leaves chewed and sap sucked)
 8. Black Bush Tips (only eaten when forced to)
- (b) Hoppers preferred Wimmera Rye Grass and lucerne to wheat, barley and oat crops.
- (c) Evidence of Cannibalism was noted particularly when a swarm was crossed by a vehicle.

V Control in the Hopper Stage

The control campaign was designed to destroy as many locusts as possible between hatching and reaching the winged stage. The success or failure of the campaign rested

on the effectiveness of the work done during this period. If the efforts in the hopper phase had been one hundred per cent effective fliers would not have developed at all. There are obvious reasons why complete control of hoppers was impossible. Our vast pastoral holdings, presented a very great physical disability. A general lack of knowledge of the insect was responsible for belated reporting of the egg beds.

Lack of appreciation of the effectiveness of modern methods and insecticides caused an apathetic outlook towards the campaign.

1. Organisation

As outlined earlier, as much preparation as possible was made before hatching. An extension programme which aimed at making all landholders familiar with the habits of locusts, insecticides and the law in relation to locust control had been steadily progressing from June onwards. Following the extensive hatchings of late September and early October the extension programme was intensified. In order that closer contact could be made with District Councils and landholders the Departmental staff was increased to thirteen field personnel and at least one Officer fully engaged on campaign arrangements in Adelaide.

The field personnel were disposed as follows:-

Upper North and North East Pastoral Areas	8
Upper Murray and Northern Mallee Areas	1
Murray Flats	1
West Coast	3

The extension work of those in the field consisted in advising about techniques of control, equipment, and insecticides.

At this stage the Sayer Sprayer proved a valuable aid to extension. A cheap but effective piece of equipment when fitted to Departmental vehicles assisted greatly in demonstrating not only the Sprayer itself but technique and use of insecticides. Demonstrations were conducted over a wide area of the State. From Yunta in the North East and Hawker in the North through the Agricultural areas and over the whole of the affected areas of the West Coast. In addition Sprayers were loaned to District Councils and private landholders who fitted them to appropriate vehicles.

The efforts of departmental officers assisted by publicity from an appreciative and co-operative press and radio off-set greatly the disabilities and difficulties of the early days of the campaign.

The policy of concentrating all efforts on ground control in the hopper stage met with some opposition. Agitation by some landholders and landholder groups for

the use of planes on hoppers took place when the magnitude of the plague was realised.

Without interfering with the all-out effort to destroy as many hoppers as possible with ground equipment arrangements were made with Air Craft Companies to procure planes at short notice to destroy hoppers under certain conditions.

The conditions under which it was possible for landholders to secure planes for aerial control in the hopper stage are outlined in the following circular.

"Request for the Department of Agriculture to arrange
Aerial Spraying of Grasshoppers"

The following information is issued for the guidance of Departmental Officers concerned with requests by landholders for aerial spraying of grasshoppers.

1. Brief outline of distribution and size of swarms in relation to aerial spraying is required.
2. Location of swarms is the first essential to marking for aerial spraying.
3. On usual distribution and size of swarms, the Sayers Exhaust Sprayer will do the required job as soon as the swarms are located, without the need for marking and reporting for aerial spraying.
4. If very large continuous swarms covering at least 20-30 acres are encountered aerial spraying may possibly be a proposition.

In such cases the procedure will be as follows, if the landholder(s) seek our assistance in arranging aerial spraying:-

- (a) Any landholder or group of neighbouring landholders concerned with concentrated egg beds of such area that spraying with ground equipment is impracticable should clearly mark the limits of the area with flags or conspicuous stakes.
- (b) Having clearly marked the boundary of the area on the ground, request should be made to the nearest Agricultural or Horticultural Adviser for aerial spraying to be arranged by the Department of Agriculture on behalf of the landholder or group of landholders concerned. Complete the attached form.
- (c) The district Adviser will inspect the defined area, and if of the opinion that spraying with ground equipment is impracticable, will recommend

that a contractor be instructed to carry out aerial spraying.

- (d) Accounts for the spraying cost will be rendered to the appropriate landholders in such form as to indicate costs of insecticide material separately from operational costs.
- (e) Landholders may be reimbursed by the Government of material costs on presentation of the contractors receipted account.
- (f) If aerial spraying has been decided upon, the landholder will be required to indicate the area to be sprayed by placing sheets in 6 ft. squares flat on the ground around the boundary for identification by the Air Craft pilot.

Two 44 gallon empty drums with one end removed will be required for mixing spray mixture. Firefighting pump units will be required for filling aircraft tanks. Landholders will arrange for the operation of loading and mixing equipment.

- (g) A supply of application forms will be forwarded to all District Advisers."

(Copy of Application Form for Aerial Spraying of Hoppers)

Request for Aerial Spraying to be arranged

On behalf of
(All landholders concerned)

Address

Hundred and Section No.

Estimated Area to be sprayed

Sketch showing area to be sprayed. (Indicate adjacent landmarks)

.....
.....
Signatures of Landholders

Recommendation of District Adviser:-
Signature

Although the framework organisation for the use of planes on hoppers was effected Landholders did not avail themselves of it.

The request for its use in the first place resulted from a realisation of the magnitude of the plague and a feeling of hopelessness on the matter of control. The campaign proved that ground equipment and modern insecticides were quite capable of controlling hoppers providing the necessary will to do the job existed.

2. Equipment

Any equipment capable of spraying liquid proved useful in killing hoppers. The type of equipment varied with the size of property and extent of infestation. All of the following appliances proved effective under appropriate circumstances.

(1) Knapsack Sprays

Knapsacks were used effectively on small swarms and in inaccessible country. Their greatest disadvantage was the limited area that could be covered.

(2) Firefighting Units

Good use was made of the firefighting equipment existant in the properties. They were used with long hoses as for firefighting or adapted to booms fitted to the rear of vehicles. They proved ideal in rough inaccessible country and along creek banks when used with hoses. When connected to a boom carried at the rear of a vehicle sufficient elevation could be secured to enable treatment in country covered by small bush growth.

(3) Sayer Spray Units

Vehicles fitted with Sayer Sprayers proved excellent units in rough country along creek banks, road sides and etc. When fitted to a jeep as was the case with the Army vehicles a mobile unit was formed which could traverse large areas of rough country, spraying the bands of hoppers as they were found. The combination of a Sayer equipped Jeep or Landrover and a medium sized boom spray proved ideal. The Sayers could be used for small swarms and in the more difficult areas and the boom on bigger swarms on cleared or open country. Sayers Sprayers had the advantage of using only 2 gallons of water per acre and for this reason were ideally suited to pastoral areas.

There is some evidence however that Sayers Units place undue stress on the motor vehicle, causing excessive running expenses. All vehicles were not suited to their use but when fitted to Jeeps, Landrovers or high revving utilities they functioned quite well. The Sayer Sprayer provided an economical and effective piece of equipment which played its part in the success of the campaign.

(4) Boom Sprays

Boom Spray outfits were available in considerable numbers throughout the agricultural areas. They proved the best machine for treating large concentrations in level country. A variety of sizes and modifications of the boom unit did effective work during the hopper stage. The medium sized weed spraying booms were most common. Some 50 ft adjustable for height, machines carrying 220 gallons of water were capable of treating one acre per minute.

Improvised booms were constructed in some instances. 12 ft. booms made of $\frac{1}{2}$ " or $\frac{3}{4}$ " pipe, fitted to a vehicle carrying a fire-fighting unit and 200 gallon tank provided a machine capable of effective work. A variety of nozzles including hacksaw cuts at 12" intervals, spray jets from a garden bar spray, and low volume weed spraying jets were used successfully.

(5) Air Blast Machines

When using either liquid or dust Air Blast Machines were very successful. Mounted on Jeep or Landrover these machines were capable of treating hoppers under a wide range of conditions.

They were capable of treating large acreages very quickly and had the advantage of needing only two men to operate them. When used as a dust machine sufficient material could be carried to treat large areas. The use of dust eliminated the need of water supplies.

(6) Sand Blast Units

These Units consisted of three ton trucks equipped with 400 gallon tank, pressurised hopper (100 galls) and an air compressor, capable of 100 lbs. per square inch pressure. They also carried small pumps for filling

tank from dams etc. The operator held a fine nozzled hose at an angle of 45° and using a lateral swinging action. As much use as possible was made of the wind. On days which were windy a larger nozzle was used and the vehicle speed increased from 12 to 15-20 m.p.h. The Machines were capable of giving a good coverage at up to 40 acres per hour.

Sand Blast Machines like the air blast Machines were especially suited to rough country inaccessible to a Boom Spray Unit. Each tank of 400 gallons of Spray was sufficient for 40 acres (10 galls. per acre). This amount of water per acre is high and presented a barrier to the use of the Machine in the drier areas. However in the better rainfall areas where water supplies are situated closer together these Machines were quite effective.

(7) Cultivation of Egg Beds

Ploughs and cultivators were used by some landholders during the winter months to rip up egg beds. This exposed the eggs to weather and birds and whilst it caused a reduction of numbers it was never completely effective.

(8) Burning

At least one instance occurred in which organised burning was employed to destroy hoppers. Six hundred acres of dry grass into which hoppers had congregated was burnt by a body of landholders organised by the District Council. The kill of hoppers was 100%.

3. Technique

Early in the season when the first reports of hatchings were coming to hand advice was given to await congregation before spraying. In practice this policy proved sound particularly in the more closely settled agricultural areas where anxious landholders were likely to spray too soon. Instances did occur when because of progressive hatchings repeated treatments were necessary. At least some of this could have been avoided and the cost of control reduced if the spraying had been delayed in the early stages until congregation had taken place. However under the circumstances of a lack of knowledge as to the extent of the plague and a lack of understanding on the part of landholders that congregation would occur, it was only natural that some would

become over anxious in their efforts to co-operate. On the other hand at that stage the co-operation of as many landholders as possible was being sort and all efforts were appreciated. Also the nature of some hatchings warranted immediate attention. For example where whole paddocks sometimes as large as sixty acres became a moving mass of tiny hoppers following a simultaneous hatching.

Hopper swarms did not appear to have any preference for direction of movement and "spotting" swarms in pastoral country was quite a task. It often meant traversing large areas and either marking swarms for follow up equipment to handle or spraying them and then proceeding.

The technique of control treatment varied somewhat with the equipment being used and temperature at the time of treatment. Knapsacks for example when used on small swarms could be used to treat the swarm from any direction when temperatures were low. On the other hand in the middle of a warm day the front of the movement would have to be treated first in order to prevent a breaking up of the swarm. In general this applied to all equipment, except the Boom Sprays, Air Blast and Sandblast Machines which were capable of covering large areas quickly.

As the season progressed the characteristic congregation of hoppers was less in evidence. Movement during sunny days was more pronounced and the habit pattern of the insect was more difficult to follow.

Towards the end of the hopper stage feed seemed to determine the congregation to a greater extent. The main concentrations were then found in the watercourse country which remained green later than the plains. Treatment of hoppers which had concentrated into such watercourse country often resulted in cleaning up all the hoppers in large tracts of land. However, in reaching these later feed areas the hoppers consumed large quantities of feed on the way.

4. Insecticides

Because of availability, the two insecticides most generally used during the campaign against hoppers were B.H.C. and Dieldrin. B.H.C. emulsions and dispersible powders were used as liquid sprays and applied by all types of ground operated equipment. B.H.C. dust was applied with the Air Blast Dusting Machine. Lindane was used to a limited extent in Market Garden areas. Dieldrin was used always in the liquid form and applied through all types of ground equipment.

Some small quantities of Aldrin were used against hoppers early in the Campaign. This insecticide was not generally used because of the supply position.

(a) Rates of Application

The following rates of application per acre for the various forms of insecticides was recommended throughout the hopper phase.

B.H.C. 2½ pts. 7% emulsion
 3 lbs. 50% dispersible powder
 2 lbs. 15% dust

Dieldrin 2/3 pt 15% emulsion

Aldrin ½ pt. 40% emulsion

(b) Effects of Insecticides

B.H.C. based materials were much quicker acting than Dieldrin. Within 20 minutes the results of spraying could be seen when using B.H.C. This had some obvious advantages. Landholders were impressed with quick results. Particularly early in the campaign it often encouraged greater activity and co-operation when results could be seen quickly after treatment.

B.H.C. Compounds were known to be relatively safe to handle by operators. This, too, assisted to some extent in gaining confidence and co-operation.

It was noticeable that B.H.C. had a greater repellent effect than Dieldrin but the residual effect was not so good. In the case of B.H.C. residual kills were noted up to 21 days after spraying but Dieldrin was effective for at least 6 weeks under certain conditions.

5. Government Assistance during the Hopper Stage(1) Insecticides

As mentioned previously in this report Government announced early in August that insecticide would be supplied free for the control of locusts.

This announcement assisted greatly in securing co-operation from landholders. The main organisation for distribution of insecticides was set up through the District Councils. The basis of this arrangement was that the Councils purchased and distributed to landholders and later claimed reimbursement for the cost of insecticide from the Department of Agriculture. In practice this arrangement worked very well. There were some slight disabilities which were rectified locally. The amounts of money involved caused slight embarrassment to some Councils, availability of insecticide caused some concern early in the Campaign, and distance of travel to District Council's Offices for supplies of insecticide was overcome by Councillors for outlying wards undertaking the responsibility of distribution.

Under the circumstances of the emergency no better or more reliable method of distribution could be suggested.

To better distribution for pastoral areas, depots were set up at Yunta, Burra, and Quorn. At these centres commercial agents held reasonable supplies and Departmental Officers were responsible for certification of the distribution.

(2) Army Jeeps

Towards mid-October it was arranged to make Army Jeeps and personnel available to pastoralists. The Jeeps were fitted with Sayer Sprayers and used both B.H.C. and Dieldrin.

The first of these vehicles commenced operations at Koomooloo Station on 17/10/55. It was unfortunate that at the out-set it was planned for the landholder to bear the cost of operating the Army vehicle and accommodating the personnel. On this basis pastoralists showed little interest and after placing the first few Jeeps there was no demand for them. When the conditions were altered so that the landholder had only to accommodate personnel and all other costs were met by the Government the demand for Jeeps increased. The Jeeps operated mainly in the pastoral country of the North and the North East but were used also on the West Coast. Murray Flats and Murray Mallee. Map No. 1 accompanying this report shows the localities in which Jeeps operated. There is no doubt that Sayer equipped Jeeps and Army personnel played their part in controlling the plague. The personnel operating the Jeeps did very good work under difficult conditions as one District Council reports: "The men operating Jeeps were most obliging in their efforts to co-operate with landholders and Officers of the Council."

The Jeeps were operating from 17/10/55 to 12/11/55 and although numbers varied somewhat there were over 20 in the field for most of that time. It is impossible to estimate the acreage of hoppers treated by these machines but there is no doubt that really good work was done. It is a pity that many more of them were not in the field at an earlier date.

(3) Booms and Air Blast Machines

When it became certain that the areas north of Pt. Pirie and west of the Flinders Range were beyond the capacity of the landholders Booms Sprays and Air Blast Machines were hired to operate in the area under the direction of a Departmental Officer. In this way a very heavily infested area of difficult country was cleaned up to the extent that only one small swarm of fliers escaped from the area. This was an important move, as it later relieved the aerial attack on fliers, of a front.