SOME ASPECTS OF THE INSECT ECOLOGY OF CITRUS ORCHARDS

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C O N T E N T S

INTRODUCTION

During the summer of 1952-1953 and through the winter of 1953, an opportunity was offered of investigating certain aspects of the insect ecology of the citrus orchards of the Eastern Cape Province. Special attention was given to securing large collections of the insects during the normal fumigation programme carried out in the Sundays River Valley. From these, there has been obtained some information regarding the complexities of the insect communities of the orchards, which is supplementary to the work of the investigators who have been active in this field in the past.

It is becoming more apparent to the producers of agricultural products that a full knowledge of the conditions under which pest species live and thrive in nature is essential, if attempts at their control are to be made along intelligent lines. The general spirit of cooperation which has been found to exist in so many farmers of the Eastern Cape during this investigation, is a most heartening sign. As pointed out later in this work, the insect is so intimately bound up with its environment, that to understand the insect, it is essential to have a thorough knowledge of the environment, both biotic and non-biotic.

It was with the hope that a little might be added to our knowledge of the biotic environment of pest species that this work was undertaken.

SPECIES OF CITRUS INVESTIGATED

In the Eastern Cape Province, while most varieties of citrus may be grown, production of citrus fruits for commercial purposes is restricted to a few species only, the main object being the export of fine quality fruit to Europe. The species of citrus which are covered by that term in this work are:-

The Lemon	(*Citrus limonia*)
The Grapefruit	(*Citrus grandis*)
The Orange	(*Citrus sinensis*)

Two varieties of the last-named species are included, namely, the 'Valencia' and the 'Navel'.

CHAPTER I

MATERIAL COLLECTED IN THE SUNDAYS RIVER VALLEY

METHODS OF COLLECTING.

Insects were collected by a variety of methods, the choice of any one being dependent on the conditions at the time of collection and the use to which the material was to be put. The methods used included the following:-

1. Collection of insects killed during fumigation.

Much of the work described in the following pages is based upon collections made in the Sundays River Valley citrus orchards by this method. The Sundays River Citrus Cooperative Co. Ltd. carries out an annual programme of fumigation against red scale (*Aonidiella aurantii* Mask.) which, during 1953, fell between 3rd February and 10th March. Extensive use was made of these operations in collecting.

The method of fumigation is that used in most of the larger citrus-growing areas of the world, and was first used over seventy years ago. The tree is enclosed within a large octagonal tent of canvas, the size of which depends on the size of tree to be treated. The normal sheet sizes cover a large range, so that sheets are available for use with any sized trees. The tent is thrown over the tree with

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the aid of long bamboo poles and the edges are tucked in towards the centre of the tree to make the whole as gas-proof as possible. A quantity of hydrocyanic acid gas is then pumped in under the tent, the amount being determined by the volume enclosed. In practice, the distance over the top of the tree and its circumference at its widest part are measured. When these two are known, the dosage of fumigant to be applied is read off directly from charts. The circumference is measured by passing a graduated tape around the canvas-covered tree. The distance over the top of the tree is read off directly from markings on the canvas sheet, these markings being indications of the distance from the centre of sheet, which is shewn by a cross. It is ensured that this cross is at the top of the crown of the tree when the measurements are taken. The operations are invariably carried out at night, mainly to avoid phytocidal action by the fumigant.

Two forms of hydrocyanic acid fumigant are available. Anhydrous hydrocyanic acid may be pumped in under the tent in liquid form, when it rapidly volatilizes to give a gas; or, Calcium cyanide powder may be blown in. This powder is known commercially as "Cyanogas". Hydrocyanic acid gas is given off and a powdery residue is left. Each tree is treated for some thirty-five minutes, after which the canvas is removed and placed over an adjacent tree. In the field, enough canvases are used to fumigate a row or more of trees

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at a time, so that one team of workers moves along the rows throwing the tents from one row to the next, and is followed by a second team which takes the necessary measurements and applies the correct dosages of fumigant.

When collections of insects were to be made, plastic sheets, (of a material frequently used in the manufacture of raincoats) were placed under the trees to be fumigated prior to the fumigating tents being placed in position. Animals killed by the fumigant fell onto the sheets from which they can be removed with ease and shaken into containers. The containers may then be taken to the laboratory for the sorting of the contents from the debris, and for further study of the catch. This rapid transfer of specimens from the plastic sheets to the containers is possible owing to the smooth surface of the material, and is a great advantage as hand-picking of the insects from any other type of material would be impossible in the field at night. The plastic sheets can be brought into use immediately the canvas fumigating tent has been removed and the insects shaken into the containers. The sheets used were of various sizes, but were selected so that approximately the same area of ground was covered below each tree. This amounted to about a quarter of the area below the tree.

Owing to the powdery residue left by 'Cyanogas', it was only possible to make collections from trees fumigated with the anhydrous form of hydrocyanic acid.

-This...

This method of collecting is an excellent one, having many advantages, of which the most important are as follows:-

a) It is a comparatively easy method of collecting, although at times some degree of physical exertion is required under the rather unpleasant conditions created by clouds of dust and an hydrocyanic-acid-laden atmosphere. Faint traces of the gas, in a dust-free atmosphere do seem to have a slightly stimulating effect on men working in the orchards, which is rather surprising considering the great toxicity of the gas.

b) The method gives a sufficiently large number of insects in a short period of time to give a good indication of the species present and their relative abundance in individual trees and orchards.

c) The treatment of each tree is proportional to its size, so that insects from each tree are collected to the same degree of intensity. This is very difficult to achieve with any other collection method, which may vary in efficiency with the degree of fatigue of the collector, his varying powers of concentration and other such factors. In other words, the 'human factor' is reduced to the minimum by the st strictly standardized conditions and routine governing the activities of the fumigation teams. This method, on the whole, has proved an excellent one for giving a representative collection from any tree with insects in sufficiently large numbers so that comparisons between species are possible,

-and...

and between trees, orchards, and populations over a wide area.

At first sight, this method would appear to be a means of obtaining as complete a collection as possible, but it should be borne in mind that it has certain disadvantages. Any conclusions arrived at on the basis of such collections must be upheld by other evidence. The most important disadvantages are as follows:-

a) By the fumigation method, only the nocturnal populations of the trees can be obtained as all fumigation is carried out at night, when there is no dew, and the temperature is low enough to avoid damaging the trees by the 'scorching' effects of the fumigant. It is very difficult to obtain a method of daylight collecting which will give exactly comparable collections. No such comparisons, therefore, have been made in this work, although such comparisons would be of great interest. It is known that certain species of insects are more abundant at night, even when they may also be active during the daylight hours. Anoplolepis custodiens Smith, the most abundant ant, and the most frequently occurring in the Sundays River Valley, is essentially a diurnal worker, but specimens have been obtained by fumigation collections made quite late at night.

b) Many species may be on the wing at the time of collection, and so may not be in the trees at all. This is particularly the case with the moths and other nocturnal nectar-feeding species. During the months in which fumi-

-gation ...

gation is carried out (February to March) very few trees are in blossom. Due to this many of the nectar-feeders may well have been out of the trees feeding at the flowers of weeds, or crops, such as lucerne, adjacent to the orchards, though their other activities may be much more directly connected with the citrus trees themselves.

c) The fact that some species of insects and mites are resistant to the toxic action of hydrocyanic acid gas may result in their not falling from the trees, or to their doing so in reduced numbers, thus giving a false impression of their numbers. This has been found to be the case particularly with the mites, and with the beetles Asynonychus godmani Cr., Formicomus rubricollis, Laf., Formicomus coeruleus Thunb. and Pseudocolotes oneili.

d) The trees from which collections have been made by this method form a somewhat unnatural environment in that their insect population is modified by treatment with insecticides at regular intervals.

e) Representative collections cannot be made at definite time intervals from the same tree, as the populations are virtually destroyed at fumigation. Observations of natural population changes and species fluctuations with respect to individual trees cannot be made when the trees are fumigated.

f) It is not possible to estimate the number of specimens which are disturbed and escape when the tent is placed in position. That some do is highly probable.

Despite these many disadvantages, however, the method remains a most useful one, and much of the work done in the Sundays River Valley is based on this method of collection.

In an attempt to overcome some of the disadvantages mentioned, and to obtain living material for laboratory study, the following additional methods of collection were used:-

2. Hand Collection of Insects.

This method was used mainly in the search for predators affecting the insects attacking the trees, particularly the predators of the various species of Coccids. Coccinellidae other Coleoptera and Neuroptera were easily taken in this way, and this is the only satisfactory method of obtaining the larvae of Lepidoptera. Collecting insects from which parasites, if present, were to be bred was done by this method, as well as those insects affecting the weeds of the orchards. It is the best method for collecting those insects which occur on the more exposed parts of the trees, such as the stems, fruit, and leaves.

3. Sweeping with a Net.

When this method was employed, a miscellaneous collection was obtained. It was used when material was collected with a view to obtaining a general idea of the insect fauna of a tree. Once the insect was in the net there was, of course, no way of telling whether it came from the leaves,

-fruit ...

fruit, flowers or bark. The sweeping disturbed the insects into activity and flight, or caused them to lose their foothold and fall into the net, with the result that no idea of the insects' activity prior to collection could be obtained. This method gave a good collection of those species which were visiting the leaves for the purpose of taking the honeydew secreted by insects, and usually the more active species were taken.

4. Collection of Infested Fruit from the Trees.

This method was used to obtain material of the False Codling Moth (Argyroploce leucotreta Meyr.) and Trypetid flies. The infested fruit was picked and removed to the laboratory, usually in brown paper bags, for the breeding out of the insects concerned.

5. Collection of Infested Fruit from the Ground below the Trees.

This was the main method employed to obtain those insects associated with the fallen fruit. It was found necessary to supplement this by the use of a camel-hair brush, dipped in alcohol, as when the fruit had been lying on the ground for some time many of the more active beetles (members of the family Nitidulidae) were liable to escape and enter the soil crevices or holes which they themselves had dug.

-6. Beating ...

6. <u>Beating the Trees whilst a Sheet is placed beneath them</u>

When a large sheet was placed beneath the trees and the overhanging branches were beaten or shaken violently, a number of species which are not easily taken by other methods were obtained. They included the smaller, less active species, such as representatives of the Thysanoptera, Psocoptera, small beetles and the larvae of lacewings and lady-bird beetles. This method had similar disadvantages to collection by sweeping with a net, but like that method, it gave a good collection of living material.

7. <u>Hand Collection of Infested Leaves</u>.

As the trees from which collections were made by fumigation were infested with red-scale in varying degree, it was thought desirable to obtain an estimate of the degree of that infestation. This was done by taking one hundred leaves at random from each tree; the leaves were taken in groups of three, one from as high as could be reached, one from a medium height, and the third from a low branch, and leaves were taken from all sides of the tree. Usually this involved walking around the tree some three or four times. The leaves collected were placed in a paper bag. Any other insects from the same tree were placed in a container which was also placed in the bag, and removed to the laboratory for later counting. The number of scale present on these

- leaves ...

leaves was taken as a measure of the degree of infestation.

The eggs of Mantispids and Chrysopids were also obtained by collecting the leaves on which they had been deposited.

SAMPLING.

It is well known to citrus entomologists that the conditions within the orchards are very different from those in the outer rows of trees, and that a corresponding difference in the fauna is to be expected. The details of the differences of conditions and fauna have been very little studied. During collection by fumigation an attempt was made to obtain collections from trees in the outer rows and also from rows nearer the centre of the orchards. The trees were usually taken in groups of five, and whenever a group was taken in the outermost row, the next group was taken from a row nearer the centre, and so on. In this way collections from a large number of trees from slightly varying environments were obtained, and these may be considered to give a collection which is fairly representative of the orchard as a whole.

IDENTIFICATION OF INSECTS COLLECTED.

The insects collected were sorted into species and, for ease of reference, each species was designated by a number. This serial number consisted of two letters of the alphabet indicating the species within that order. Many species were identified by authorities in the several groups, this assistance is acknowledged in the appropriate section of the work. Others were identified by comparison with named specimens in the Albany Museum, Grahamstown, or in the collection of Mr. G.B. Whitehead.

The orders, (following Brues and Melander, 1st Edn., 1945) are listed below with their reference numbers so that when species which have not been identified are mentioned, they may be placed in their correct orders with ease.

Abbreviations used are:-

TH	Thysanoptera	HE	Hemiptera
CB	Collembola	OD	Odonata
OR	Orthoptera	EP	Plectoptera
PH	Phasmatodea	NE	Neuroptera
TP	Thysanoptera	LE	Lepidoptera
BL	Blattariae	DP	Diptera
MT	Mantodea	CO	Coleoptera
PS	Corrodentia	HY	Hymenoptera
HO	Homoptera		

LOCATION OF COLLECTING SITES.

Work has been done in the Sundays River Valley, and on several farms in the Grahamstown and Bathurst districts. A brief visit was also make to orchards near Fort Beaufort. In the Sundays River Valley the work consisted mainly of collecting large numbers of insects by the fumigation method, and of field observations on some of the species. In the Grahamstown and Bathurst districts the work consisted of field observations and the collection of living material for study in the laboratory, together with collections of fallen fruit from which living specimens were obtained. The data from the collections obtained by the fumigation method are those used in the study of the distrubution and populations of the various species.

Sundays River Valley

The orchards of this area fall under the Lake Mentz Irrigation Scheme. Collections were made from 83 trees. These comprised 4 varieties of citrus, from 6 orchards on 5 farms, located in 4 sections of the valley. For reference purposes each orchard has been designated by a letter and each tree in that orchard by a number. Thus, the orchards range from A to F, and the number of trees from which collections were made varied from orchard to orchard. As a rule trees 1-5 were in the outermost row of the orchard, trees

TABLE I

LOCALITIES AND TREES FROM WHICH COLLECTIONS WERE MADE

DATE	LOCALITY	VARIETY	ORCHARD	TREE NOS.	NO. OF TREES	TOTAL TREES PER ORCHARD
3/2/53	Sunland	Valencias	A	A1-A8	8	
4/2/53	Sunland	Valencias	A	A9-A12	4	12
5/2/53	Tregaron	Navels	B	B1-B5	5	21
6/2/53	Tregaron	Navels	B	B6-B21	16	
3/3/53	Summerville	Grapefruit	C	C1-C5	5	12
4/3/53	Summerville	Grapefruit	C	C6-C13	7	
5/3/53	Dunbrodie	Lemons	D	D1-D5	5	5
5/3/53	Dunbrodie	Grapefruit	E	E1-E8	8	
6/3/53	Dunbrodie	Grapefruit	E	E9-E13	5	23
8/3/53	Dunbrodie	Grapefruit	E	E14-E23	10	
9/3/53	Dunbrodie	Grapefruit	F	F1-F5	5	10
10/3/53	Dunbrodie	Grapefruit	F	F6-F10	5	

The collection from tree number C9 was placed in a container which later was broken in transit; this tree, therefore, was not considered further.

Conditions in the orchards.

As all fumigation is carried out at night and a collector is forced to work very rapidly owing to the speed and efficiency with which the fumigating teams work, it was not possible to collect information concerning conditions in the orchards at the time of collection. The following information is given in order to indicate the conditions in the orchards.

Orchard A.

This was a Valencia orchard of some 20 to 27 years standing. It had been treated with "Thiophos" towards the end of December 1952 and had been sprayed to counteract Zinc deficiency some two weeks before fumigation took place. Many of the trees shewed the yellow motling of the leaves characteristic of zinc deficiency. Ant control was not carried out in this orchard, but the trees were comparatively free of these insects. Windbreaks surrounded the orchard on all sides, and there were very few weeds between the trees.

Orchard B.

The age of this orchard, as in many of those in the Sundays River Valley, was not known with certainty. It was of medium sized navel orange trees, situated adjacent to natural bush which lay to the north, in an exposed position on a hillside. There was much weed growth around the bases of the trees and between the rows. Collections included some from the Southern end of the orchard, in which the

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heaviest infestations of red scale were found. Trees towards the centre of the orchard were markedly less affected.

Orchard C.

This was of medium sized grapefruit trees, carrying a fairly heavy crop. It was little protected from the wind and consisted of seven long rows of trees. Irrigation had been carried out shortly before collections were made and the ground below the trees had a thick covering of weeds.

Orchard D.

This was a small orchard of lemon trees of large size and great age. It was very well cleared of weeds and well protected from wind. One side was adjacent to natural bush, another to an orchard of valencia oranges, and a third to a small patch of maize. The trees were planted close together and their crowns were in contact in many cases.

Orchard E.

This orchard was a very large one, of grapefruit trees, in which the ground was fairly clear of weeds, but in which the lower branches of the trees were in contact with the ground. The trees were carrying a good crop, and they appeared to be in fine condition.

Orchard F.

This was a large orchard of large grapefruit trees bearing a heavy crop and having a profusion of weeds below the trees. A very heavy mulch had been applied just prior to fumigation. The orchard was well protected by wind-

- breaks ...

breaks. The surrounding orchards and a maize field on one side were all covered with weeds.

Grahamstown and Bathurst Districts.

In contrast with the Sundays River Valley, the farms from which material was obtained in these districts have no regular irrigation scheme in operation. One orchard from each of the following farms was used:-

"Rosslyn"	(Mr. R. Purdon)
"Heather Glen"	(Mr. T.W. Gleaves)
"Luembe"	(Mr. Tyson)
"Fairy Vale"	(Mr. McClean)

Most work was done on the first-mentioned farm. In the orchard chosen, the trees suffered acutely from the drought. No marketable crop was produced as a result of the dry weather, and the trees shewed every sign of water deficiency, being wilted for a long period.

Fort Beaufort.

On 6th August 1953 a brief visit was made to 3 orchards on the farm "Lorraine" (Mr. G.L. White) in the Kat River Valley. Small collections were made. The weather had been cold, with some frost, and the insect populations of the orchards were very meagre indeed. The trees were virtually clear of red scale, but a little Soft Scale was present on a few of the trees. Observations made here are included in various sections of the work.

ANNOTATED LIST OF SPECIES TAKEN BY FUMIGATION COLLECTION

The following is as complete a list as it has been found possible to compile of the insects collected by the fumigation method in the Sundays River Valley. It includes some species which are known to be present, but which did not fall on to the collecting sheets for one reason or another. These include the various species of Coccids, which do not fall when killed, and the Mites which do so in reduced numbers. The number of each species taken has been given where it has been possible to count this. In addition, notes are given on those species which are of any importance in the orchard ecology, or about which some interesting facts are known. In many cases our knowledge of the insects is very slight, and often we may only surmise the normal activity of the species under consideration.

Much of the discussion on the ecology of the orchards is based on the data given here, together with that obtained by field observation and laboratory experiment. These facts have either been observed in the laboratory or noted in the field, or there is good evidence that the information given is correct. Only much further observation and experiment will confirm or refute much that is written here, and future work will no doubt prove that much of our present opinion is based on erroneous assumptions.

The insects are dealt with in systematic order, the

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system of classification used being that of Brues and Melander (1945). Although this system admittedly leaves much to be desired, it is, nevertheless, a convenient one, and one with the aid of which rapid grouping of large numbers of insects may be carried out with some ease. A more satisfactory system of classification from the academic point of view is that of Omer-Cooper (1939)

In the list given below, the number by which the species has been designated is given, and where identification has been possible the name is also given. The right-hand figure gives the total number of specimens obtained for those species in which counts have been possible.

INSECTA

COLLEMBOLA

Entomobryidae

CB 1		2
CB 2		1

Only two species of this order were taken by fumigation. These were all taken from one tree. It is most unlikely that these insects were in any way connected with the trees, and it is more likely that they were associated with the soil below. These insects are known to be very susceptible to changes in the non-biotic components of the environment, particularly humidity changes, and it is likely that the soil of the orchards contains large numbers of specimens. In the Grahamstown area members of this order were found in large numbers about the bases of the trees in one orchard, but absent from the soil between the rows of trees. The soil was noticeably damper about the bases of the trees.

ORTHOPTERA

Tettigoniidae

OR 2	Phaneroptera sp.	3
OR 7	Eurycorypha sp.	3
OR 8	Homorocoryphus sp.	1

Identified by comparison with named specimens in the Albany Museum, 1953.

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These three species may be dealt with together. They are met with occasionally on the trees and are generally distributed through the orchards. Although sometimes causing damage, their numbers are usually so small as to make them of little importance economically. They appear to be general feeders and are just as likely to be seen eating any plant in the vicinity of the orchards as the trees themselves. They attack the leaves and the fruit, feeding here and there on a leaf, and eating out sections from the fruit. The two first-mentioned species were seen eating fruit and leaves, and the last-mentioned was seen eating leaves. At times when other foods are scarce it is possible that these insects may become pests, but in the normal course of events they are not sufficiently damaging to cause concern. They may, however, be considered as minor pests, in that they add their small share to the damage done.

Gryllidae

OR	3	*Gryllodes* sp.	9
OR	5	*Gryllodes* sp.	1

Identified by comparison with named specimens in the Albany Museum, 1953.

The density of the cricket population varies from orchard to orchard. They were most numerous in orchard F, where they were collected from 7 out of 10 trees. Their numbers per tree were also highest there, but on no occasion were they seen to attack the trees in any way. One was observed

- feeding ...

feeding on a fallen fruit. In addition to this, they have been seen eating a variety of vegetable matter, both fresh and decaying. Orchard F had been very heavily mulched just prior to fumigation, with a mixture of vegetable debris and manure, and in this crickets were very numerous. These insects are undoubtedly omnivorous in nature and are essentially soil dwellers, living on food that is to be found on the surface of the soil. They were observed on low-growing vegetation at times, but they are to be considered as part of the soil fauna. They do not appear to be attracted to citrus, at least when other food is plentiful, and seem to prefer decaying matter to fresh. They may be carnivorous on occasion, but no evidence of this was noted. Although they inhabit the region of the soil where many insects are liable to pupate, there is no direct evidence to indicate that they attack pupae.

Acrididae

OR	Oedalius sp.	1
OR	Acrida sp.	1

Identified by comparison with named specimens in the Albany Museum, 1953.

Both of these species of grasshoppers are essentially grass-feeders, and are found in large numbers amongst the various grasses growing among the trees and along the edges of the orchards. The two specimens taken in the collection

were ...

were certainly in the trees by chance or were below the trees at the time of fumigation.

PHASMATODEA

Bacillidae

PH 1 Bacillus sp. 1

Identified by comparison with named specimens in the Albany Museum, 1953.

The same remarks apply to this species as to the Acridids. It is strictly a grass feeder, and appears to occur in very much smaller numbers than other grass feeders in the field.

THYSANOPTERA

TP 1		12
TP 2		13
TP 3	Elaphrothrips edouardi Jacot-Guillarmod	2

Determined by Dr. H.K. Hartwig, 1953.

TP 1 and TP 2 are representatives of a new genus and are being studied by Dr. J.C. Faure; they do not appear to attack citrus but probably occur on orchard weeds.

Elaphrothrips edouardi has been taken below bark on citrus at Fort Beaufort. Previous records have all been from citrus, either under bark of orange or on dead branches of lemon, except for one record from Duranta flowers. All previous records are from Pretoria. The males are brachy-

- pterous ...

pterous, and the females are brachypterous or macropterous. Jacot -Guillarmod states that there is little doubt that this species is viviparous.

BLATTARIAE.

BL 1 3
BL 2 4

The two species taken were both observed frequently feeding at the more tender shoots of a variety of weeds growing in the orchards, particularly in orchard F, in company with Tettigoniids. They were not seen attacking citrus and seemed to prefer other plants when presented with a choice in the laboratory. The specimens collected came from orchard A, C, and E, and although many were observed in orchard F, none were taken by fumigation. This supports the conclusion that they seldom frequent the trees, but prefer the weeds. They may feed on decaying matter as well as living tissue, as specimens were kept for some time in the laboratory feeding on both fresh shoots and those that had been picked for some time.

MANTODEA

Mantidae

MT 1 3

MT 2 <u>Callidomantis</u> sp. 2
Nymphs 10

The Mantids occur generally throughout the orchards. Two species were taken on the collecting sheets, and these appear to be the most common species in the area, as adults were seen on many occasions. Some nymphs were collected by fumigation, and some of these may belong to other species. From an ecological point of view, however, Mantids all play a similar part in the trees, namely, that of general predators. They are, in fact, very much the same as the spiders in this respect, and probably do enter into some competition with the latter for food, although Mantids in the later instars tend to attack prey that is rather too large for spiders. Little is known concerning the specificity, if any, of feeding habits in Mantids. The same is true of most prodaceous insects, but this specificity is undoubtedly a very important matter in orchard ecology.

One Mantid was seen in the field eating a Tettigoniid and another was kept for some time in the laboratory on a diet of flies, bees and wasps. There appeared to be little choice, except that Lepidoptera were not taken. So far as Mantids are concerned it is probably the size of prey which largely determines any specificity which might be apparent. The number of Mantids present was not large, but during their lifetimes they probably devour a great many insects, and so may have some effect on insect populations.

CORRODENTIA

Caeciliidae

PS 2	1
PS 4	91

Psocidae

PS 5	1

Of the Psocoptera, specimens of three species were taken from trees which were widely separated. Their normal feeding habits are such that they are found associated with lichens and fungi growing on trunks and branches. These insects also frequent leaves, where they may be feeding on the tissues. They are more frequent on older trees than on younger; presumably this selection is correlated with the greater growth of lichens and fungi on older trees. Hubbard (1885) makes mention of Psocoptera on orange trees in America, but does not attach any importance to their presence. The possibility of their being carriers of fungal spores cannot be overlooked, but it is not likely that any spores carried would be pathogenic. The Psocoptera are preyed upon by a large number of insects, and being fairly slow-moving they fall easy victims to such active predators as ants and spiders. Pearman (1932) has reported several species of coccophagous species of this order, and although the feeding habits of the species taken are not known with certainty, the occurrence of one species in large numbers on trees heavily infested with red scale is suggestive. This matter is discussed more fully later.

HOMOPTERA

Membracidae

HO	4	*Xiphistes pallidus* (Buckt.)	8
HO	5	*Congroneura fasciatus* Buckt.	16
HO	10	*Oxyrachis* sp. nr. *tuberculatus* (Walk.)	17
HO	21	*Oxyrachis* sp. nr. *bisenti* Dist.	1

Determined by A.L. Capener, 1953.

None of the species of this family taken are known to attack citrus, and the specimens collected were probably in the trees taking shelter, or preparing to pass the winter there, as suggested by Mr. A.L. Capener (*in litt.*, 1953). All the specimens were adults; no nymphs were seen at all in the orchards. In the case of *Oxyrachis* sp. nr. *bisenti* Dist., *O.* sp. nr. *tuberculatus* (Wlk.) and *Xiphistes pallidus* (Buckt.) the host plants are probably *Acacia* spp. and in *Congroneura fasciatus* Buckt. it is probably a species of *Solanum*. This genus of plants is represented in the orchards by more than one weed.

Cercopidae

HO 8 2

This species of Cercopid has been seen on a weed, probably *Chenopodium* sp., on several occasions in small numbers. It was never seen on the trees.

Gyronidae

HO 6	6

Jassidae

HO 12	3
HO 15	1
HO 18	91

Fulgoridae (sens. lat.)

HO 11	1
HO 13	1

Tropiduchidae

HO 2	27
HO 7	1
HO 14	1

Chermidae

HO 1	Trioza erytreae del G.	77
HO 16		1
HO 24		2

Determined by Dr. E. McC. Callan, 1953.

Of the three species of Chermid taken, only one is known to be associated with citrus, namely, Trioza erytreae. This is "citrus psylla", which is widely distributed in Africa. It ranges from Eritrea to the Cape, and only attacks citrus and related plants of the Rutaceae. This species attacks the tender leaves, causing the formation of small open galls, and in cases of badly infested trees the leaves curl and become yellowed. It

- was ...

was taken in every orchard investigated, but in none of them was any sign of great damage noticed.

Aphididae

HO 3 Toxoptera aurantii (Fonsc.) 151

Identified by Dr. E. McC. Callan, 1953, by comparison with specimens determined by Prof. E.O. Essig.

This was the only species of aphid seen on the trees. It is well known as the "black citrus aphid", is practically worldwide in distribution and occurs almost everywhere that citrus is grown. It occurred throughout the orchards of the Sundays River Valley and nearly all the trees appeared to be infested to some degree. It is unlikely that any were completely free of the pest. They were restricted to small colonies on the most tender shoots. Where the colonies attained any size, they were attended by ants, usually Anoplolepis custodiens. Several of the colonies were searched for individuals which might be parasitised, but from none were parasites obtained. The main enemies of these insects in the area investigated seemed to be the lady-bird beetles, both larvae and adults, and the larvae of Syrphid flies. These predators were frequently seen attacking aphid colonies.

In all, some 151 specimens were taken by fumigation methods, but this cannot be taken to give a true estimate of the numbers present, as comparatively few of the individuals fell from the trees when killed.

- Coccidae ...

Coccidae (sens. lat.)

Lepidosaphes beckii (Newm.)
Icerya purchasi Mask.
Aonidiella aurantii Mask.
Pseudococcus sp.
Coccus hesperidum Linn.

Lepidosaphes beckii.

This species, commonly known as mussel scale, is not the major scale pest of the Sundays River Valley, but does occur over a wide part of the Valley, being more common in the section near the town of Kirkwood than elsewhere. In the Addo area it is not very common, and alone, is not important. In the Grahamstown and Bathurst areas it is of major importance, and of general occurrence. Many specimens were collected and removed to the laboratory during the months of March, April and May, 1953, in order to breed out any parasites which might be present, but no parasites were found. These scales are attacked in their younger stages by the larvae of certain Coccinellid beetles and by the larvae of the members of the family Chrysopidae. The lady-bird beetle, Chilomenes flavipes, attacks the scale in the Grahamstown area.

It is not intended to treat this species of scale in great detail, as it is a much-studied insect, being of great economic importance in nearly all the citrus-growing areas of the world. It attacks the leaves, stems, fruit and older branches, sometimes causing the death of the tree.

- Icerya ...

Icerya purchasi

This well-known species, introduced from Australia, occurs in small numbers throughout the orchards, but is well controlled by natural enemies, where ants are under control.

Coccus hesperidum

This species, the soft scale, occurred in all the orchards investigated. Its occurrence is sporadic and is closely connected with that of ants. It is attacked by several parasites and these reduce its numbers considerably in the absence of ants. This scale species produces considerable quantities of honey-dew, and this is important in connection with the food supply of many of the insects inhabiting the orchards. Many species of insects take honey-dew, and it seems to play an important part in their diet, judging by the great increase of insect life to be found on trees with much honey-dew. The presence of the soft scale, therefore, is of importance in attracting insects from other environments into the orchards.

Pseudococcus sp.

This species occurred in small numbers but did not appear to reach a dangerous level of infestation at any point.

Aonidiella aurantii

The California red scale , probably indigenous to South

..East...

East Asia, is the major Coccid pest of the Sundays River Valley. It occurred in every orchard and on virtually every tree investigated. The least infested trees have but few scale present, while the worst-infested trees may be killed by the vast numbers of scale on leaves, stem, branches and fruit. This species has been well-studied by entomologists in several parts of the world and large sums of money are spent annually on means of combating it. It is highly desirable that some form of biological control be established, but the possibilities of this being achieved are small until a much greater knowledge of the ecology of the orchards is acquired. The relations between red scale and ant distribution and numbers is dealt with elsewhere, but one or two points concerning this insect may be made here. No attempt is made to cover ground already dealt with in other works.

There is, without doubt, a tendency for red scale to be abundant in the outer rows of the orchards, with greater intensity of infestation towards the more southerly sections. In addition, those trees adjacent to roads and other situations where dusty conditions prevail are more liable to heavy infestation than others. It is difficult to explain these facts. The outer rows may offer a microclimate more congenial to the species - work on the question of microclimate in the orchards is much needed - or the conditions there, where there is a greater likelihood of a dust-disturbing breeze, may be less congenial to parasites and predators of

- the ...

the scale. There is some indication that parasites are less liable to attack a dusty scale than a clean one. That the same is true of predators is not unlikely. That some differences in environmental conditions do affect the scale in the outer rows of trees cannot be disputed, but whether the differences are biotic, climatic or edaphic is not known with any degree of certainty. The suggestion is that they are biotic, consequent upon microclimatic conditions.

The species of scale occurring on the trees have been dealt with very briefly here, as they have been much studied and the results of the investigations have been published elsewhere.

In addition to the Homoptera mentioned, a small number of unidentified nymphs was obtained.

HEMIPTERA

PENTATOMIDAE.

HE	7	*Carbula litigatrix* Kirk.	3
HE	10	*Acrosternum heegeri* Fieb.	3
HE	13	*Dryadocoris apicalis* (H.-S.)	8
HE	14	*Afrius marmoratus* (Dall.)	1
HE	15	*Macrorhaphis acuta* Dall.	1
HE	16	*Nezara viridula* (L.)	5
HE	17	as HE 16.	2
HE	30	as HE 7.	1

Identified by Dr. E. McC. Callan by comparison with named specimens, 1953., and by Dr. D. Leston, 1953.

The members of this family all occurred in small numbers and with a general, scattered distribution. The feeding habits of only one species, *Nezara viridula*, have been

- observed ...

observed. This is known to attack citrus in Florida, U.S.A. and is very widely distributed, occurring in most of the warmer parts of the world. It pierces the leaves and shoots of citrus, as it does not occur in great numbers, it cannot be considered as a major pest, but probably adds its small share towards the total amount of damage done by the minor pests. It appears to be under natural control, and as the life-cycle of the species is probably fairly long, the annual fumigation possibly aids in its control. The feeding habits of the other species is not known, but they probably feed on various species of weed found in the orchards.

Coreidae

HE	3	*Cletus* sp.	1
HE	23	*Cletus* sp.	7
HE	21	*Homoeocerus* sp.	1
HE	34	*Serinetha* sp.	1

Identified by comparison with named species in the Albany Museum, 1953.

Lygaeidae

HE	4	*Lygaeus* sp.	1
HE	18	*Dieuches* sp.	3
HE	22		2
HE	28		1
HE	31		1

Identified by comparison with named specimens in the Albany Museum, 1953.

- Pyrrhocoridae ...

Pyrrhocoridae

HE 1 *Dysdercus* sp. ? 3
HE 36 1

Identified by comparison with named specimens in the Albany Museum, 1953.

The two species of this family occur in very small numbers, and have both been observed feeding on weeds; they do not appear to attack the citrus trees at all. The former species is common on a Malvaceous plant near Grahamstown, and the latter has been seen feeding at a roadside plant near Addo.

Tingididae

HE 25 1
HE 29 3

These specimens have been submitted to Professor C.J. Drake for determination. They appear to be associated with weeds of the orchards.

Reduviidae

HE 11 Probably *Coranus* sp. 3

The above species was taken in the Sundays River Valley and another in the Bathurst area. In both cases they are known to be general predators. *Coranus* sp. (?) has been observed feeding on a large parasitic Braconid (Hymenoptera) and an adult of the Bathurst species was maintained for some time in the laboratory on a diet of various Diptera. Some

-Selection ...

selection of food seemed to be made, as not all the flies offered were taken with equal readiness; in some cases the Reduviid inserted its proboscis into the prey, which, after it had become motionless, was discarded. Syrphid flies appeared to be the most acceptable food for this species, as these flies were always sucked out until a dry husk remained.

In the field an unidentified Reduviid nymph was seen attacking a small species of parasitic Hymenopteron. It would seem that Reduviid bugs are somewhat selective in their habits, but much more observation and experiment is needed before any definite statements on the matter may be made. It is likely that they consume large numbers of the less active soft-bodied insects, such as caterpillars and aphids, although no Reduviid has been seen attacking aphids in the orchards. The size of the prey will certainly be a factor in any selection of food which may take place, and it is possible that the food preferred may change according to the instar of the predator, thus involving a certain amount of "automatic selection". The family as a whole can be considered as general predators, and specificity in feeding among such insects as the Reduviids is an important matter in ecology, about which little is known.

<u>Ploiariidae</u>

HE 12 <u>Ploiaria</u> sp. 7

- One ...

One species only of this family occurs on the trees, and this was taken only in small numbers; their habits have not been observed, but they are presumably predators attacking the smaller insects found on the bark of the trees and other such situations.

Anthocoridae

HE 6	7
HE 8	3
HE 20	1
HE 26	1
HE 35	1

Five species were taken, and as the family as a whole is thought to be predaceous upon a variety of insects, it is likely that those taken were feeding upon such insects as thrips, aphids and upon mites. Only small numbers were obtained in the collections by fumigation, and none were taken in the collections from Bathurst and Grahamstown.

Miridae

HE 2	26
HE 5	13
HE 9	4

These have been submitted to Dr. J. Stehlik for determination. These three species occurred only in connection with a few trees, and all are known to be associated with orchard weeds, one of which is Chenopodium sp.

In addition, some 65 nymphs of Hemiptera were taken, which have not been identified.

- ODONATA ...

ODONATA

OD 1 2

These two specimens were obviously in the trees by chance and this order is of little importance in citrus ecology.

PLECTOPTERA (EPHEMEROPTERA)

Austrochloeon virgiliae Brnrd.
Austrochloeon africanum (E.P.)
Chloeon lacunosum Brnrd.
EP 4

Determined by Mr. R.S. Crass, 1953.

In all, some 36 specimens were taken of this order. As these are aquatic in their nymphal stages and as the adults do not feed, they are of little importance in orchard ecology, although they have been seen in great numbers in those orchards near the river. Here they may form an important part of the food of various crepuscular animals. These insects are widely distributed through the orchards during irrigation, and their occurrence there may therefore be somewhat sporadic.

NEUROPTERA

Hemerobiidae

NE 1 4

The one species of Hemerobiid was taken in small numbers.

- The ...

The larvae probably feed on aphids, and possibly the scale insects and mites. In other parts of the world these insects are considered to be important natural enemies of pest mites. The adults are known to take honey-dew.

Chrysopidae

NE 2 Chrysopa sp. (spp. ?) 28
NE 4 1

It is probable that the former species of this family mentioned above is actually divisible into several species. Specific determination in this family, particularly in the genus Chrysopa requires the attentions of a specialist before any definite determination can be made. This group in South Africa is badly in need of attention, owing to its great economic importance. The larvae feed on aphids, scale, mites and on other small soft-bodied insects, including the larvae and pupae of their own species. The feeding habits of the adults are stated to be the same as that of the larvae, but in the laboratory the adults could not be induced to take any food but sugar-water. Several insects were offered to the adults, such as red scale, mussel scale, thrips and aphids, but none were eaten. These adults did deposit solid faeces from time to time and the alimentary canal was gradually emptied of solid matter whilst in captivity. The habit of taking honey-dew in nature may be of some importance ecologically.

Large numbers of larvae occur on the trees, and are

- attacked ...

attacked very heavily by parasites (<u>Tetrastichus</u> sp.). One species of egg parasite, <u>Trichogramma</u> sp., has been reared from eggs taken in the field. From 19 eggs collected in one orchard near Bathurst in March and April, 1953, 3 parasite adults were obtained. No hymenopterous parasites have apparently been recorded from Chrysopids in Africa, although in other parts of the world they are well known.

<u>Sisyridae</u>

NE 8	1

One adult was taken. The larvae are believed to feed on fresh water sponges. The activities of the adults are not known. The specimen taken probably came from the river or irrigation canal.

<u>Mantispidae</u>

NE 5	3
NE 9	1
NE 10	1
NE 11	1

This family is fairly well represented in the orchards, and, although only six specimens were taken in the fumigation collections, the insects were met with frequently on the trees. The adults are predaceous and were noticeably more abundant on those trees with much honey-dew, their presence no doubt being due to the large numbers of insects there upon which they could prey. The larvae are known to be predaceous in

- the ...

the egg-sacs of spiders. It has not yet been possible to associate any of the species present with any particular spider host. The larvae of these insects exhibit the interesting phenomenon of hypermetamorphosis. Adult Mantispids are also quite common on various shrubs and herbbaceous plants when in flower, such as the shrub, Gymnosporia buxifolia, which is visited by many insects in search of nectar. The prey of adult Mantispids consists of small species of flies and small Hymenoptera so far as could be judged from laboratory fed animals. Sugar water was taken as well. Mantispids may be said to play much the same part in orchard ecology as do the Mantids, except that they prefer the smaller species as prey.

Coniopterygidae

NE 6 Coniopteryx turneri Kimm. 7

Identified by Mr. B. Stuckenberg, 1953.

Seven adults were taken of this species. In the larval stages, Coniopterygids are thought to attack mites, and possibly scale and aphids, and other Homoptera; the habits of the adults of the species taken are unknown.

Myrmeleontidae

NE 3 1

- Ascalaphidae ...

Ascalaphidae -

NE 3 1

The above two families, which occur in small numbers, are predaceous. The larvae live in pits in the sand (Myrmeleontidae) or in the open, with or without a dusty covering (Ascalaphidae). The larvae of the former family commonly occur in the sandy areas around the orchards and seem to feed primarily on ants, which they probably devour in large numbers, together with other small ground-dwelling insects.

Approximately 100 neuropterous larvae, mainly Chrysopids, were taken by fumigation collection.

LEPIDOPTERA

The specimens of moths and butterflies taken by fumigation have been submitted to Dr. A.J.T. Janse and Mr. L.Vari for determination.

125 specimens were collected and approximately 49 species are represented.

Although a large number of Lepidoptera were taken, no species was obtained in large numbers, and most of the species have no direct connection with the citrus trees, being in the orchards by chance or attracted to the honey-dew, on which they are thought to feed. The larval stages of many of them are probably passed on the grasses and weeds of the orchards.

- Little ...

Little of note has been observed in connection with this order, and their position and importance with regard to the ecology of the orchards is difficult to assess.

Papilio demodocus

This familiar insect is known as the 'Orange dog'. This species, both in the adult and larval stages, was found in every orchard investigated, but no adults were taken in the fumigation collections. It seems that the adults do not pass the night in the trees but seek shelter elsewhere. Where they go during the hours of darkness could not be ascertained, although a careful watch was kept on several occasions on fine days. The butterflies could be seen flitting about the trees until sundown, when they were no longer to be seen.

The larvae are either not killed by the hydrocyanic acid gas or they do not fall from the trees when killed. The former seems the more likely. Their presence was frequently made known by the scent which was emitted by them when they had been in an atmosphere of hydrocyanic acid gas. If such survival is possible they would gain some advantage from the fumigation, as their predators and parasites are probably killed by the gas. It is seldom, however, that the caterpillars are present in sufficiently large numbers to constitute a major pest on old trees, although young trees may be defoliated.

It is possible that the species referred to here, is, in

- fact ...

fact, divisible into more than one species.

Argyroploce leucotreta Meyr. (The False Codling Moth)

This species is the major Lepidopterous pest of citrus trees in the Eastern Cape Province, occurring throughout the citrus growing areas, and attacking a number of other cultivated and wild fruits. The question of which wild fruits are attacked and in which the insect can complete its development is one in need of definite answer. This species has been studied by Gunn (1921), Horne (1939) and Harris (1944). Remarks are here restricted to certain general questions concerning the insect as a pest. Other matters, such as control measures, are not dealt with in detail as they are covered adequately by the published literature.

As a pest, the False Codling Moth is unique in that only a very low population density is required for the outbreak to be of a serious nature. Seldom is more than one larva found in a fruit, but that one renders the fruit useless from the point of view of the grower. This means that the actual density of population of the species need not be at all high in comparison with most pest species for the results to be disastrous. The population density obviously varies a great deal over a comparatively small area, and from year to year. No explanations for these facts can be given which are wholly satisfactory, nor will they be possible until more is known concerning the ecology of the insect. The number of

-fruit ...

fruit affected rarely becomes greater than twelve per cent. This low percentage nevertheless involves large numbers of fruit in an area such as the Sundays River Valley.

The eggs of this insect are laid on the fruit, preferably in a crack or some other irregularity of the peel, and, in navel oranges, frequently in the 'navel'. The larva bores straight into the fruit on eclosion. It is thus well protected from the effects of chemicals with which the fruit may have been treated. The caterpillar, living as it does throughout its life within the fruit, is also protected in its later instars. The pupal case is woven under debris on the ground and incorporates some soil particles.

The eggs are parasitised by Trichogramma lutea and their contents are destroyed by this parasite. The eggs are also attacked by a species of mite which sucks out the contents. Harris (1944) reports egg-parasitism by T. lutea in the Grahamstown and Bathurst districts as varying from 20.3 to 75.4 per cent.

Even at a fairly low percentage of infestation, the fruit-fall due to False Codling Moth is an impressive sight when the usual 'orchard hygiene' has not been carried out. This is, perhaps, a reason for the exaggeration of the degree of infestation given so frequently.

This species constitutes a difficult problem for the economic entomologist. In a pest with a high population density, reduction to a sub-economic level is frequently

- practicable ...

practicable. In such pests, however, it ceases to be an economic proposition to apply measures designed to reduce the population density once a certain level has been attained. It is virtually impossible to destroy a species; the lower the population density the more difficult it becomes to achieve destruction of the remaining individuals. In the False Codling Moth we are faced with an already low population density, in addition to which the individuals that are present are extremely difficult to attack with present means owing to their habits. The use of insecticides is not economic owing to the difficulty of obtaining contact with the insect, and because of the expense of applying large quantities of insecticide against relatively few individuals. It is clear from the work of Harris (loc. cit.) that the egg parasites and predators are capable of maintaining a severe check on the pest, and that under natural conditions such a check is quite adequate to prevent the insect from endangering the host plant. If the present method of collecting and destroying fallen fruit becomes uneconomic, as it may do, then some means of biological control will have to be sought. At the present time, reduction of this species to lower levels of population density seems unlikely.

DIPTERA

Chironomidae

DP 45 1

DP 48	2
DP 57	5

These three species were all taken in small numbers. Their larvae live in water or in decaying vegetable matter, and they are not likely to be connected with the trees in any way.

Culicidae

DP 25	1
DP 47	4
DP 49	1
DP 51	1
DP 58	1

Many of the specimens of this family collected were males, and were probably attracted to plant secretions, or were present by chance when fumigation collection was carried out. The females which were taken were probably sheltering in the trees or attracted to the labourers in the orchards; they could frequently be heard on the wing.

Mycetophilidae

DP 2	218
DP 81	1

The species of which most specimens were taken was found mainly in orchards A and F, whilst the only specimen of the other species was obtained in orchard C. These insects live, in the larval stage, upon fungus or upon decaying vegetable matter, of which there was an abundance, particularly in orchard F. It is very remarkable that one of the species

- was ...

was present in such great abundance on the trees.

Cecidomyidae

DP 16	7
DP 56	4
DP 65	1

Most of the members of this family are gall forming insects, but those taken in the orchards are thought to be predaceous. Clausen (1940, p.353 *et seq.*) reports a number of species attacking mites, diaspine Coccids, Aphidids, Aleyrodids and Thysanoptera. The feeding habits of the species taken are not known, in either the larval or adult stages. Some larvae, however, were seen on leaves infested with mites and although they were not observed feeding, they were large and apparently nearing pupation. It is very likely that the mites occurring in such large numbers on some of the trees are attacked by Cecidomyid larvae, and these larvae may play an important part in reducing the numbers of harmful mites. In other parts of the world (California) the larvae are important in this respect, e.g. in the case of *Arthrocnodax occidentalis* Felt. (Clausen 1940).

Stratiomyidae

DP 76	*Ptecticus* sp.	1
Dp 93		2

The larva of the first-mentioned species develops in fallen fruit, and has been found in large numbers in those

- fruit ...

fruit which are in an advanced stage of decay. Numerous specimens of the second species have been seen in the vicinity of a large 'dump' of fallen fruit, but no Stratiomyid larvae were found in the fruit. Whether the larvae live on the substance of the fruit or whether they live on other dipterous larvae present is not known.

Tabanidae

DP 84	1

The single specimen of this family which was collected was probably sheltering in the trees when it was caught. Normally it is attracted to livestock.

Empididae

DP 5	13
DP 12	1
DP 68	8

Dolichopodidae

DP 3	4
DP 53	1
DP 55	1
DP 71	1

The two above families may be mentioned together, and comprise small predaceous flies. The larval habits of the species collected are not known, but the adults feed on a variety of small insects on the trees and in the weeds of of the orchards.

Phoridae

DP 32	1
DP 79	2

Pipunculidae

DP 9	4

As far as is known, the species of this family are parasites of Homoptera. The host of the Sundays River species is not known, but it is unlikely that it is an insect attacking the trees, as no Homopteron of sufficiently large size was taken from the trees. No members of this family were encountered in the Bathurst or Grahamstown areas.

The host is probably a weed-inhabiting insect.

Syrphidae

DP 28	Xanthogramma rotundicornis Loew.	1
DP 66	Eumerus triangularis Herv-Bos.	1
DP 80	Eumerus erythrocerus	1
DP 83	Eumerus obliquus Fabr.	7

Determined by B. Stuckenberg, 1953.

Xanthogramma rotundicornis is a species which, in the larval stages, is predaceous on aphids. The adults have been seen imbibing honey-dew from soft scale and aphids. The larvae are known to be capable of devouring large numbers of aphids in a comparatively short time, and the reduction in numbers of aphids on an infested plant previously free of Syrphid larvae is striking. In this respect the larvae rival the Coccinellids for speed and efficiency. They were

- frequently ...

frequently found attacking colonies of aphids on the field.

Eumerus spp. is a genus of Syrphid flies known to pass the larval stage in decaying vegetable matter of various types. The food of E. triangularis and E. erythrocerus are not known, but E. obliquus has been reared from fallen oranges in the Sundays River Valley. (private communication, B. Stuckenberg.)

Tachinidae

DP 95	1
DP 96	2
DP 98	5
DP 99	1
DP 106	1
DP 107	11

Doxiidae

DP 94	1
DP 102	1

The two families mentioned above are frequently placed together by authorities.

So far as known all the species are parasitic, but the hosts of the species collected are not known. Many species are not specific in their host preferences and thus are able to parasitise a wide range of hosts.

Sarcophagidae

DP 113	6
DP 104	3

- Calliphoridae ...

Calliphoridae

DP 100		7
DP 103		16
DP 105		1
DP 60	*Lucilia* sp.	3

Muscidae

DP 1	3
DP 13	1
DP 22	1
DP 67	1
DP 89	1
DP 92	2
DP 101	1
DP 108	1

Anthomyidae

DP 7	1
DP 8	8
DP 14	1
DP 17	1
DP 23	27
DP 24	13
DP 36	3
DP 38	7
DP 44	1
DP 59	1
DP 64	4
DP 90	4
DP 91	20

These four families include mostly species which pass their immature stages in decaying animal and vegetable matter. The adults occur wherever sweet substances are to be had, and on decaying matter. They will feed on practically any liquid substance found in nature.

- Ulidiidae ...

Ulidiidae

DP 27		5

Trypetidae

DP 78	*Euaresta bullans* (Wd.)	1
DP 86	*Ceratitis capitata* (Wd)	16
DP 88	*Dacus (Didacus) ciliatus* Lw.	3
DP 97	*Dacus (Didacus) ostiofaciens* Mnro.	5
	Pardalaspis melanaspis Bez.	1

Determined by Dr. H.K. Munro, 1953.

Of the five species taken only one (*Ceratitis capitata*), is directly connected with the citrus trees. The other four species are associated with weeds occurring in the orchards, as follows:-

Pardalaspis melanaspis - larvae in fruits of *Capparis* sp.

Dacus (Didacus) ciliatus - larvae in cucurbitaceous plants,

Dacus (Didacus) ostiofaciens - larvae in pods of Asclepiadaceae. This last species has not been previously recorded from the Cape Province.

Euaresta bullans.

Only one specimen of this species was taken, and the larvae have been recorded as living in the burrs of the weed *Xanthium spinosum*. It is a European species of fly, and has been introduced into Australia and South Africa and South America. This single specimen is the first record of this species in Africa. I am indebted to Dr. H.K. Munro for the above information.

The means by which this insect is distributed is probably within the burrs of the weeds, as larvae or pupae, attached to livestock, or in fodder.

Remarks on Ceratitis capitata are not made as it is a much-studied species and occurs in all the citrus growing areas of South Africa, and many other parts of the world.

A notable omission from the list of insects taken is Pterandrus rosae (Ksh.), the Natal Fruit Fly. This species has not been collected in the Sundays River Valley, although it is a serious pest in many parts of South Africa.

Tetanoceratidae

DP 72	1

Lauxaniidae

DP	20	3
DP	26	1
DP	37	1
DP	54	2
DP	75	11
DP	82	4
DP	85	1

These flies are believed to spend their larval existence in decaying matter, mainly of vegetable origin. This family has not been well-studied in South Africa and the species taken in the orchards are not thought to have any connection with the trees at all.

Ochthiphilidae ?

DP 77	1

- Odiniidae ...

Odiniidae ?

DP 63	13

Drosophilidae

DP 4	1213
DP 34	3
DP 15	34

Some discussion of the very abundant species DP 4, is given elsewhere. The other species occurred in much smaller numbers. All are thought to pass their larval stages in fallen and rotting fruit, where they form the prey of beetles (?) and possibly other Diptera.

Chloropidae

DP 6	5
DP 21	1
DP 43	5
DP 52	1
DP 62	3
DP 73	1

Of the six species taken, none are believed to be directly concerned with the citrus trees. The family is mainly phytophagous and the species collected are likely to be associated with weeds in the orchards.

Unidentified Diptera

DP 70	1
DP 69	1
DP 30	2
DP 50	1
DP 74	8

COLEOPTERA

Carabidae

CO	31	Callida silvicola Per.	4
CO	53	Geobaenus lateralis Dej.	1
CO	110	Lebia congrua	3
CO	111	Xenitenus sp.	1
CO	34		1

Determined by Dr. A.J. Hesse, 1953.

All the species of Carabidae taken are essentially ground-dwelling insects, living in the tufts of grass or in the soil, or about the weeds, where they prey upon other Arthropods and ground dwelling insects. Lebia congrua appears to be somewhat arboreal, as several specimens have been observed in the trees themselves, presumably seeking some of the insects on the branches and stems. The degree of specificity in feeding is not known, but related species are reported as being somewhat specific. If that is the case with L. congrua, then it is possible that it plays a more definite role in citrus ecology than that of a general predator.

Scydmaenidae

CO	41	4

Malachiidae

CO	4	Pseudocolotes oneili Pic.	693
CO	45	Hedybius plagiocephalus Er.	2

- CO 59 ...

CO	59	Ebaeus (Mixis) rufithorax Pic.	13
CO	68	Attalus sp.	1
CO	117	Hedybiocephalus fossulatus Pic.	1
		Ebaeus quadrinotatus Champ.	5

Determined by Dr. A.J. Hesse, 1953.

All the members of this family which were taken are considered to be predaceous, but although many specimens were observed on the trees, their object in being there was not clear. E. oneili occurs in such numbers that it is possible that it plays an important part in the insect ecology of the trees. It is most likely to be predaceous upon some bark-dwelling insect, as most of the specimens were seen on the branches rather than on the leaves. At this stage it is best to regard this family as one of general predators so far as those occurring on citrus is concerned.

Anthicidae

CO	2	Formicomus rubricollis Laf.	2192
CO	39	Formicomus coeruleus Thunb.	113
CO	55	Anthicus bisbipartus Pic.	5
CO	93	Anthicus brevicignatus Pic.	1
CO	85	Anthicus (Aulacoderus) sp.	3

Determined by Dr. J.C. von Hille, 1953.

The most frequently occurring insect collected during the fumigation collections was the Anthicid Formicomus rubricollis, the other species of this family were much less frequently seen.

Field observations of F. rubricollis lead to the suspicion that the adults are predaceous. They are active, and fast-moving, and can be seen about the orchards during the

- day ...

day and at night, running along the branches and on the ground. They also frequent the weeds. They are not confined to citrus orchards alone, and this species has been seen in many areas of the Eastern Cape, usually on some plant, but sometimes on the ground.

On one occasion an adult was seen feeding at the newly cut edge of a citrus leaf. The manner in which they move about the trees suggests that they are seeking prey of some sort, perhaps of some special type. They do not appear to have any interest in any species of scale insect, nor in the aphids, and they do not frequent the exudations of scale insects, although they do take sugar water in the laboratory. It is possible that they normally feed on the eggs of other insects, in which case, if they are at all specific, the species upon which they feed must be present in very great numbers if it is to supply the demand made by such a large population of beetles. The only animals occurring in such numbers in the orchards are the spiders and ants, but no connection appears to exist between these species, so far as could be seen. One adult was seen under loose bark of one tree, apparently feeding on a fungus growth in company with Psocoptera. Only much patient field observation of individual specimens will be likely to yield information with regard to the habits of these insects. Several specimens were, in fact, watched for some time, but little of striking interest was seen.

- Elateridae ...

Elateridae

CO 24	*Heteroderes* sp.	13
CO 7		2

In their larval stages these insects live in the soil and feed on the roots of plants. They probably feed on the weeds in the orchards, such as grasses.

Nitidulidae

CO 112	2

A number of species of this family are found in large numbers in fallen fruit in which decay has proceeded for some time. They are not seen in or about newly fallen fruit. They appear to be predaceous in both larval and adult stages, and feeding upon dipterous larvae seems to be the usual habit. Only one species was taken from the fumigation collection sheets, indicating that they seldom come up into the trees.

Colydiidae

CO 65	1

Monotomidae

CO 106	2

Mycetophagidae

CO 75	2

- Cryptophagidae ...

Cryptophagidae

CO	9	53
CO	22	14

Bostrychidae

CO	21	6
CO	64	3

These insects occur regularly in the orchards and are probably borers into the trees themselves. Their numbers, although small, are probably greater than the collections would indicate owing to their concealed habits.

Languriidae

CO	103	*Anadastus illaetabilis* Pasc.	1

Determined by Dr. A.J. Hesse, 1953.

Lathridiidae

CO	26	39

Coccinellidae

CO	3	*Rodolia iceryae* Jansen	8
CO	105	*Rodolia cardinalis* Muls.	3
CO	6	*Lotis nigritula* Crotch.	84
CO	10	*Cranophorus* sp.	15
CO	27	*Chilomenes propinqua* (Muls.)	7
CO	72	*Chilomenes lunata* (Fabr.)	2
CO	37	*Exochomus flavipes* (Thunb.)	10
CO	42	*Epilachna* sp.	1
CO	43	*Platynaspis capicola* Cr.	7
CO	50	*Rhizobius* sp.	44
CO	52	*Scymnus morelleti* (Muls.)	19
CO	54	*Scymnus (Pullus)* sp.	17
CO	92	*Thea variegata* F.	1
CO	11		1

- CO 40 ...

CO	40	1
CO	44	1
CO	48	4
CO	51	15
CO	69	1
CO	97	1
CO	108	5
Co	118	1

Determined by Dr. A.J. Hesse, 1953.

This family includes some of the most important insects to be found in the orchards, and 22 species were collected. With the exception of one phytophagous genus (Epilachna) they are all predaceous, feeding on scale, aphids, mealy bugs, Australian bug and other pests found on the trees. Some are specific in their food requirements and others appear to be more general in their feeding habits, but it is doubtful whether any of the species are completely indiscriminate in their selection of prey. They have been named, as far as possible, in the above list, and their food preferences, where these have been noticed, are given later in the list of species which prey on insects attacking the trees.

These insects, in both larval and adult stages, are responsible in large measure for reducing the numbers of such rapidly reproducing insects as scale and aphids, and their importance in this matter cannot be over-emphasised. They have been used in several of the most successful biological control projects against various pests in different parts of the world. Any attempt to control the main pests of citrus in the Eastern Province by biological means will almost certainly be based upon the activities of one or more

- of ...

of these insects.

Tenebrionidae

CO 75 1
CO 94 1
CO 119 1
CO 104 Himatismus sp. probably variegatus F.

Determined by Dr. A.J. Hesse, 1953.

Lagriidae

CO 89 Lagria villosa F. var. obscura F. 3
Chrysolagria fuscipennis Fohr.

Determined by Dr. A.J. Hesse, 1953.

These two species both occur in small numbers in the orchards, the adults are frequently seen on the flower heads of weeds, the larvae are believed to be phytophagous, living on some orchard weed. These species are not restricted to citrus orchards.

Criocerid ae

CO 23 Lema trilineata Olivier 40

This beetle attacks a weed common in the orchards, namely, Datura stramonium. It also attacks various other Solanaceous plants (Omer-Cooper and Miles, 1951).

Chrysomelidae

CO 30 2
CO 67 16
CO 90 1

- CO 13 ...

CO 13	Oncocephala promontorii Per.	1

Determined by Dr. A.J. Hesse, 1953

None of these species are normally attracted to citrus trees, they are all associated with weeds of the orchards.

Eumolpidae

CO 15		2
CO 102		1
CO 71	Monolepta vincta Gerst.	6

Determined by Dr. A.J. Hesse, 1953.

Above species are associated with weeds.

Halticidae

CO 114	Phyllotreta sp. ?	1
CO 115	Phyllotreta sp. ?	1

These insects are associated with Cruciferous (?) weeds.

Cassididae

CO 8	Cassida melanophthalma Boh.	20
CO 38	Cassida sp.)	
CO 38a	Cassida sp.)	3
CO 61	Hypocassida gibbipennis Boh.	1
CO 88	Aspidomorpha tecta Boh.	5
CO 60		1

All the species of this family are common on weeds, frequently Convolvulus spp.

Mylabridae

CO 70	Mylabra sp.	18
CO 86	Mylabra sp.	1

- These ...

These insects are known as "bean weevils" , the larvae of which occur in the pods of nearly all leguminous plants.

Curculionidae

CO	1	*Asynonychus godmani* Cr.	239
CO	12	*Baris* sp.	1
CO	47	*Baris*	4
CO	19	*Apion antiquum* Ghl.	9
CO	20	*Sibinia* sp. probably *luteoviridus* Ghl.	11
CO	33	*Sibinia* sp.	66
CO	58	*Sibinia* sp.	1
CO	28	*Neoclonus usnpio* Hrbst.	2
CO	46	*Tachyphloeus spathulatus* Boh.	1
CO	49	*Sciobius pullus* Sparm.	11
CO	62	*Lixus haerens* Boh.	1
CO	107	*Parpacus horridus* Boh.	1
CO	5		62
CO	32		6
CO	63		1
CO	66		5
CO	74		1
CO	83		1
CO	100		9

Determined by Dr. A.J. Hesse, 1953.

Of all the species of weevils taken, the host plants of only a few are known with certainty. As the family is mainly phytophagous it can be said that those which do not attack the trees must be associated with weeds. The species known to attack citrus is dealt with below, the others are named, where possible, in the above list.

One species of *Sciobius* has been found to attack citrus in South Africa, but whether *S. pullus* does so is not known. *Asynonychus godmani* is the species which attacks the citrus trees, the adults feeding on the leaves, especially those of the lower branches. The form of damage is very

- characteristic ...

characteristic, the leaves are eaten along the edges and so given an irregular outline. The damage done to old trees is seldom great enough to warrant special control measures being taken. The adults are nocturnal feeders, and lay their eggs on the bark of the tree. The larvae drop to the ground and feed on the roots of the trees, but it is very likely that they also attack the roots of a great many species of other plants as well. In fact, they appear to prefer the latter when available. Most damage is done to young trees, and the adult damage is similar to that of Papilio demodocus larvae. The adults are very resistant to the toxic action of hydrocyanic acid gas. From the work of Whitehead (1948) it can be seen that up to 60 per cent. or more of the beetles may survive fumigation. In the fumigation collections made in 1953, in the same area as that in which Whitehead worked, nearly every individual survived the fumigation. Many of them were initially immobilised and fell onto the collecting sheets, but these later recovered. There was no way of estimating the number of beetles remaining completely unaffected. It would seem that the resistance to fumigation is now greater than in 1948. Should this be so, the pest has a greater potentiality for doing damage now than formerly, and it is a very common species indeed.

- Unidentified ...

Unidentified Coleoptera.

CO	29	1
CO	16	52
CO	17	21
CO	25	115
CO	95	1
CO	101	2
CO	57	4
CO	109	1
CO	79	2

In addition to the above, 18 larvae of this order were taken, all of the family Coccinellidae, except one.

HYMENOPTERA.

Tenthredinidae

HY 101 Athalia flacca Konow. 1

Tentative determination by Dr. E. McC. Callan, 1953.

The host plant of this species is not known, but it is highly probable that it is a member of the Cruciferae.

Gasteruptionidae

HY 30 Gasteruption sp. 1

This species is a parasite of a species of solitary wasp or bee.

Ichneumonidae

HY	1	46
HY	2	6
HY	3	12
HY	6	1
HY	8	1

- HY 11 ...

HY	11	1
HY	26	1
HY	27	5
HY	36	4
HY	37	1
HY	38	1
HY	40	3
HY	41	10
HY	43	1
HY	44	6
HY	45	1
HY	50	1
HY	53	1
HY	51	3
HY	55	1
HY	56	1
HY	60	9
HY	61	2
HY	63	2
HY	65	1
HY	70	1
HY	72	4
HY	75	1
HY	76	1
HY	77	3
HY	81	1
HY	82	1
HY	84	1
HY	90	2
HY	91	1
HY	92	1
HY	93	1
HY	94	1

<u>Braconidae</u>

HY	13	5
HY	17	3
HY	18	1
HY	22	1
HY	32	1
HY	39	1
HY	42	3
HY	47	1
HY	62	1
HY	64	2
HY	67	1
HY	68	2
HY	69	1

- HY 73 ...

HY	73	1
HY	74	2
HY	78	1
HY	79	1
HY	80	2
HY	83	1
HY	109	1

<u>Callimomidae</u>

HY	16	2

<u>Eurytomidae</u>

HY	12	3
HY	15	6
HY	89	1
HY	95	1

<u>Encyrtidae</u>

HY	19	2
HY	20	1
HY	21	1
HY	71	4
HY	87	10
HY	100	3
HY	102	1
HY	103	1
HY	108	63
HY	110	16
HY	111	52
HY	113	2

<u>Pteromalidae</u>

HY	29	1
HY	48	1
HY	86	1
HY	88	4
HY	96	1
HY	98	1
HY	112	1

- <u>Eulophidae</u> ...

Eulophidae

HY	5	4

Chalcididae

HY	4	8
HY	7	22
HY	9	1
HY	10	17
HY	14	1
HY	23	2
HY	24	2
HY	52	7
HY	54	3
HY	24	2

In addition to the above, approximately 150 unidentified Chalcidoidea were taken.

Ecologically, the above families of the Ichneumonoidea and Chalcidoidea are amongst the most important families of insects in the orchards. As can be seen from the lists, a great number of species and individuals were collected from the trees, but it has been, unfortunately, impossible to identify them, or to associate them with definite host insects, except in very few cases. Many of them, of course, are not connected with the insects of the trees at all, but have been attracted into the orchards by the plant and animal secretions which are to be found there, and of which they are very fond. The question of hosts of the common parasites is one in urgent need of investigation.

Pelecinidae ?

HY	97	1

- Figitidae ...

Figitidae

HY 85 3

Many of the species of this family are parasitic on Dipterous larvae, their hosts living in decaying organic matter. The host of the species taken is not known.

Dryinidae

HE 34 Mesodryinus sp. n. 10

Identified by Dr. E. McC. Callan, 1953.

This one species of Dryinid was collected only in orchard C. These insects are parasitic on Homoptera. The host of this species is not known but is probably a species of Flatid. This genus is known from Europe, India, Seychelles, Trinidad, North and Central America. This is apparently the first record of the genus from Africa.

Tiphiidae

HY 104 Meria sp. 1

Identified by Dr. E. McC. Callan, 1953.

This insect is probably parasitic on Scarabaeid grubs in the soil. It is usual for only the last larval instar to be attacked by the insects of this family. The life-history of the species taken is not known.

Formicidae

HY 28 Anoplolepis custodiens Smith 407

HY	31	_Tapinoma danitschi_ For. var _bevisi_ For.	44
HY	33	_Crematogaster liengmei_ For. race _weitzaeckeri_ Em.	301
HY	46	_Polyrachis (Myrma) spinicola_ For.	5
HY	49	_Pheidole megacephala_ race _punctatula_ For.	344
HY	59	_Camponotus maculatus_ F. var _lactipennis_ Sm.	5
HY	106	_Cataulacus_ sp.	2
HY	58	_Sima (Tetraponeura) clypeata_ Em. var. _durbanensis_ For.	8
		Technomyrmex albipes Sm. race _foreli_ Em.	27

Determined by Dr. G. Arnold, 1953.

Some of the members of this family which occur in the orchards are of great importance in citrus ecology. Some of the species occurred extremely commonly and were collected in large numbers. They are mainly predators, but as their activities lead to their disturbing and destroying the parasites and predators of many citrus pests, their general effect upon the ecology is great. They assist pests, in some cases, that would otherwise be controlled by natural agencies, to attain great abundance. The main offenders in this respect are _P. megacephala_, _C. liengmei_, and _A. custodiens_. The other species are less important, and they are less frequently met with in the orchards. The effects of _P. megacephala_ are mentioned elsewhere, and _C. liengmei_ is a general predator attending honey-dew producers. _A. custodiens_ is by far the most commonly occurring ant and also the most important ecologically in the Sundays River Valley. In the Grahamstown and Bathurst areas _P. megacephala_ is of great importance. _A. custodiens_ has has been more closely studied during field observations than the other species and its relationship with other insects

- is ...

is discussed elsewhere. A few notes on the habits of the species, however, are given below.

Activity of Anoplolepis custodiens during daylight hours.

When it was intended to make relative estimates of ant activity on various trees in connection with red scale infestation, it became clear that any fluctuation in ant activity would affect the results obtained if observations were carried out at different times of day. A preliminary investigation, therefore, was made into the relative degree of activity of the ants over a period from 8.45 a.m. until 8.00 p.m. This was done (on the 20th January, 1953) by counting the number of ants ascending the trunk of one tree during each quarter hour period. It was found impossible, unfortunately, to count those descending the tree at the same time. A comparison of these two would have been of great interest.

The tree chosen for the count was a Valencia orange tree, about 10 feet in height, the ground below being covered by grass and weeds, but without the branches of the trees in contact with this undergrowth. This left only one route of ascent for the ants. It was found that they all travelled more or less along a distinct path on the north-west-facing side of the tree. The object of the ants' visit was to obtain honey-dew from the numerous aphid colonies present on the tender shoots of the tree. These observations were made on a day of fine weather and the counts of ants which

- were ...

were subsequently made in connection with red scale infestation were made on similar days. The following figure (Fig. 1.) gives the numbers of ants ascending the trunk of the tree every quarter hour. The data on which the figure is based are given in Table A of the Appendix, which includes the hourly temperatures registered by a nearby thermograph.

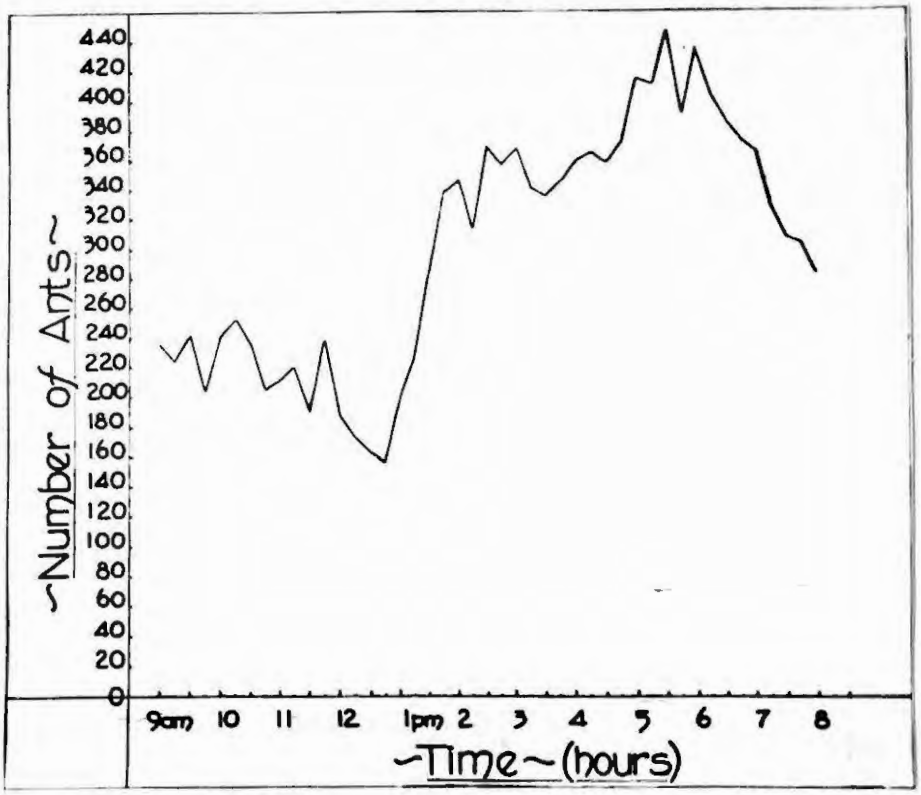

Figure 1.
Activity of *Anoplolepis custodiens* during each quarter hour period of day.

After considering the above figure, it was decided that the most convenient time for making ant counts would be between 2 and 4.30 p.m.

It would appear that ant activity during the morning hours is more or less constant, until just before noon, when a fairly clear drop in activity is indicated. From 1 p.m. onwards a more or less steady increase in activity is noticeable until the peak is reached between 5 and 6 p.m. After that a steady and rapid decline follows until dark. This, of course, can only be said to give an indication of the state of affairs on that day at the times given; changes in conditions and the time of year will alter the activity, but the above data gave an indication of the conditions and state of ant activity at about the time the counts were made in relation to red scale infestation. It enabled a time to be set for these counts. They are interesting in themselves, however, in that they give an idea of the general level of ant activity in connection ~~of~~ with the collection of honey-dew form aphids. An estimate of the amount of honey-dew produced at various times of day would prove an interesting experiment.

Vespidae

HY	25	Polistes sp.	15
HY	35	Polistes sp.	41

Two species of Polistes were taken in the orchards, they frequently make their nests in the trees, and feed their larvae on such insects as caterpillars and other soft-bodied

- forms ...

forms. Adults appear to feed mainly on plant and animal secretions.

Psammocharidae

HY 66 1

This wasp was very common and active about the bases of the trees and amongst the weeds of the orchards. It preys on spiders, which were abundant in the habitats in which the wasp was seen.

OTHER ARTHROPODA

ARACHNIDA

Chelonethida 1

These animals occur on the trunks of trees in small numbers, where they seem to feed on such insects as Psocoptera.

Araneida 1147

The spiders occur in every situation in the orchards in large numbers. They prey mainly on insects, and their importance in the ecology of the orchards is discussed elsewhere. They are all general predators.

Acarina

Ixodidae 1
Other Acarina 184

The tick is probably from the grasses, where it was

- awaiting ...

awaiting the arrival of a host. The other Acarina (mites) were from the trees. They include predaceous and phytophagous species, and are of some importance in orchard ecology. Their importance is difficult to estimate owing to the small numbers which were taken in relation to the numbers present.

CHILOPODA

Only one specimen of this group was taken, it was probably on the tree by chance, or perhaps crawled on to the collecting sheet during the fumigation.

NUMERICAL DATA OBTAINED FROM COLLECTIONS MADE IN THE SUNDAYS RIVER VALLEY

A summary of the numerical data obtained from the fumigation collections is given below in Table II.

TABLE II

ORDER	NO. OF SPECIMENS	NO. OF SPECIES	NO. OF TREES	NO. OF ORCHARDS	PERCENTAGE OF TREES
Coleoptera	4440	102	83	6	100.0
Araneida	1236	many	83	6	100.0
Diptera	1891	94	82	6	98.4
Hymenoptera	1497	110	80	6	96.0
Homoptera	502	18	67	6	80.0
Lepidoptera	125	49	65	6	78.0
Neuroptera	180	11	63	6	75.6
Hemiptera	178	31	58	6	69.6
Orthoptera	71	7	29	6	34.8
Plectoptera	36	4	17	5	20.4
Mantodea	15	2	13	6	15.6
Acarina	185	2	9	3	10.8
Corrodentia	83	3	9	5	10.8
Thysanoptera	27	3	9	4	10.8
Blattariae	7	2	6	3	7.2
Odonata	2	1	2	2	2.4
Collembola	3	2	1	1	1.2
Phasmatodea	1	1	1	1	1.2
Chelonethida	1	1	1	1	1.2
Chilopoda	1	1	1	1	1.2
	10,481	444 + Spiders			

The percentages of trees from which the various groups were obtained in each orchard are given in Table B of the Appendix.

From Table II it can be seen that the most highly specialised orders, namely, the Hymenoptera, Diptera, and Coleoptera are the most frequently occurring insects, and also the most numerous in species. In most of the orders, the numbers of trees on which they occur is in keeping with the number of specimens and the number of species obtained. Two exceptions present themselves, however, in the Lepidoptera and Araneida.

From the number of Lepidoptera taken a slightly smaller percentage of the trees might be expected to be involved, particularly as the number of trees carrying out of season blossom was very small. The fact that this group is mainly nocturnal may mean that they were away from their resting places on the trees at the time of fumigation and so not caught in great numbers. It is clear, however, that the order is generally distributed in the orchards.

The Araneida are fewer in numbers than the main insect groups but have been taken on every tree. This is to be expected in a group which is carnivorous, in fact, they occur wherever there are insects upon which they can feed.

The Orthoptera are generally distributed through the orchards in small numbers. Their distribution is that of a group of general vegetable feeders.

Collembola are known to be severely controlled by non-biotic environmental factors and their numbers probably fluctuate greatly.

The orchards were not found to be heavily infested with Thysanoptera, although the possibility of these insects increasing in number is always present. Other citrus areas of South Africa and Rhodesia are heavily infested and thrips constitute important pests.

The Neuroptera, particularly the larval stages, occurred on a high percentage of trees. They are known to include predators of various species of Homoptera and the general distribution and large populations of the latter would account for the large numbers of Neuroptera present.

The occurrence of the mites is low, according to the collection figures, but it has been pointed out already that the resistance of these insects to the action of hydrocyanic acid gas is such that no reliance may be placed on these figures. A study of mites, in whatever habitat, requires special methods which cannot conveniently be carried out simultaneously with normal entomological methods. For that reason, the mites are somewhat neglected in this work, but their importance is recognised.

The numbers of specimens obtained may now be discussed, and the main sources of possible error pointed out.

The method of collecting used allowed a coverage of approximately one quarter of the ground below the trees, so that the figures given represent about one quarter of the insects which would have been taken had complete coverage been possible. Certain other factors may also affect the actual numbers obtained, such as the following:-

1. Some insects, although killed, may not fall from the trees. This may be so with the lepidopterous larvae. Several species were known to be present, but none were found on the collecting sheets. They may or may not be killed by the dosages of fumigant normally applied. It is possible that some insects may lodge in the trees in such a position that they are prevented from falling on to the sheets, but the frequency with which this is likely to happen is not great, as the procedure of covering and uncovering the trees is a violent one and the trees were shaken vigorously before the sheets were taken up.

2. The previously mentioned resistance to hydrocyanic acid gas may be a source of error in the estimation of number of specimens present on the tree. This is true for several species of insects, and not only for the mites. In the case of Asynonychus godmani nearly all of the specimens revived after being taken up. Resistance in spiders is practically nil, they are probably the most susceptible of all the species found in the orchards.

3. The loss due to insects escaping before the sheets are in place and due to their feeding at plants not in the orchards will affect the figures obtained for some species, particularly adult Lepidoptera.

- The ...

The Numbers of Insects in the Trees.

In all, 10,481 specimens were collected by fumigation, an average of approximately 126 per tree. As it is thought that only one quarter of the specimens present were taken, with full coverage approximately 42,000 insects could be expected. This gives an average of about 500 insects per tree. To this must be added the insects lost through the causes enumerated above, together with those which are normally hidden and not killed by the fumigant, such as the wood-borers. Such species as the Coccids, Aphidids and Mites live on the trees in tremendous numbers. If these are excluded, an estimate of the number of insects per tree probably falls in the region of 600 to 700 specimens per tree.

Actually, the number of specimens obtained from the trees investigated varied from 33 to 269. This indicates the very great fluctuation which may occur in insect populations in essentially similar environments. The trees, of course, varied greatly in size from one orchard to another and this will account for much of the variation, but the trees of each orchard are all within a certain narrow range of size. The fluctuation in each orchard far exceeds the expectations if size of tree is the only factor to be considered. Table C of the Appendix gives the detailed figures for the trees investigated.

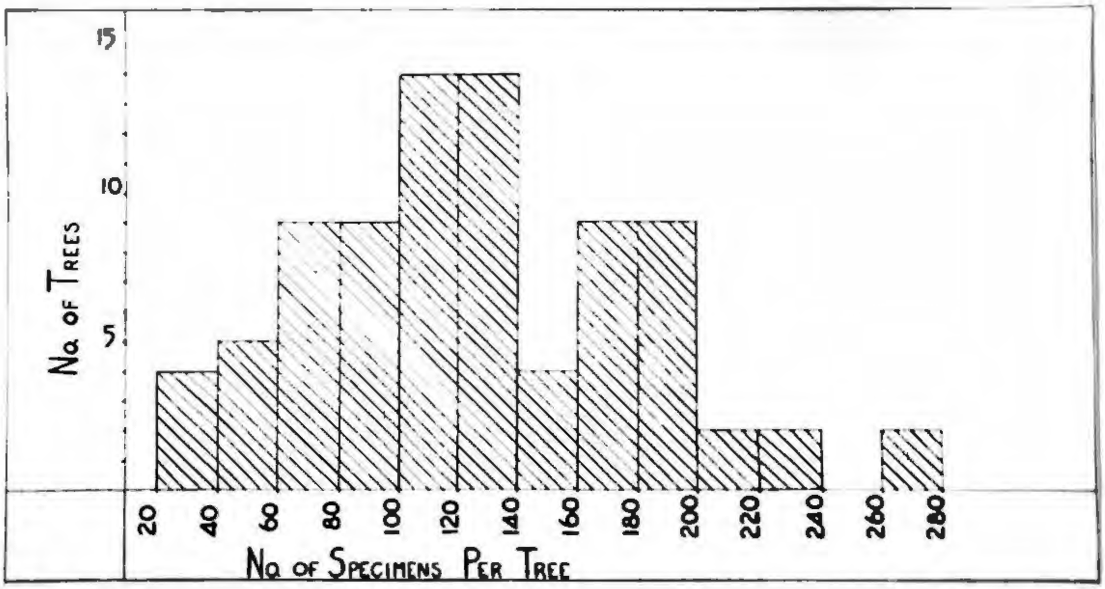

Figure 2.

Numbers of Insects obtained from the Trees.

In the foregoing figure the trees have been grouped according to the number of insects obtained from them, the number of trees falling in each group being indicated. The data on which this figure is based will be found in Table D of the Appendix.

It is evident that most trees yielded between 60 and 200 specimens, those yielding either more or less being less frequent. More trees yielded between 100 and 140 specimens than any other equivalent range.

RELATIVE ABUNDANCE OF SPECIES COLLECTED BY FUMIGATION

TABLE III

NUMBERS OF SPECIES REPRESENTED BY VARIOUS NUMBERS OF SPECIMENS.

No. of Specimens.	No. of Species thus represented	Percentage of total No. of Species thus represented.
1	199	45.45
2	49	11.43
3	41	9.33
4	24	5.56
5	18	4.11
6	11	2.59
7	13	2.69
8	10	2.40
9	8	1.93
10	5	1.16
11	4	.92
12	2	.46
13	5	1.16
14	1	.23
15	3	.69
16	4	.91
17	4	.91
18	2	.46
19	1	.23
20	2	.46
21	1	.23
22	1	.23
26	1	.23
27	2	.46
34	1	.23
38	1	.23
39	1	.23
40	1	.23
41	1	.23

- Table III cont'd. ...

Table III continued.

No. of Specimens	No. of Species	Percentage of total No. of species thus represented.
44	2	.46
46	1	.23
52	2	.46
53	1	.23
62	1	.23
63	1	.23
66	1	.23
77	1	.23
84	1	.23
91	1	.23
113	1	.23
115	1	.23
151	1	.23
218	1	.23
239	1	.23
328	1	.23
693	1	.23
1213	1	.23
2192	1	.23

(The figures in the percentage column are approximate only)

As the Araneida were not identified into species they are not included; their number was large, but the number of species was relatively small.

When the numbers of the species collected come to be considered, it is at once apparent that by far the greatest number of species occur only in small numbers.

It can be seen that the number of specimens varies from 1 (in 199 species) to 2192 (in Formicomus rubricollis). Those species of which a large or fairly large number of specimens was obtained are probably connected with the

- orchards ...

orchards in some way. There is no doubt, when the normal insect fauna connected directly or indirectly with the trees is considered, that there are some species which prove to be abundant and others which prove to be rare, but it is difficult to conceive of 46 percent of them being so. When collections are made over a relatively short period, it is inevitable that only a few specimens of the rarer species will be taken. Confining our attention to those species represented by only one or two specimens it seems necessary to come to some conclusion regarding the reason for their presence. They can be divided into several categories:-

1. Rare species directly connected with the trees, including those attracted to secretions of the coccids and aphids. This will account for some of the species, particularly many of the Hymenoptera and Diptera which occur but seldom in search of the secretions of honey-dew to be found on the leaves and stems of the trees. This category will account for some of the rarer predators and for parasites of the rarer species, also for the rarer parasites of the more frequently occurring species.

2. Species normally inhabiting plants in or near the orchards but seldom leaving them. This covers those species of Diptera and Coleoptera and other orders normally associated with the weeds of the orchards, and which may be on the trees by chance.

- 3. Species ...

3. Species normally inhabiting parts of the trees where they are protected from collection, such as borers or those insects associated normally with the roots of the trees. This includes those species which will only be taken by the collecting method used when they are out of their normal habitats. This is noticeably the case with the several species of Coleoptera found in fallen fruit. Only one species (2 specimens) was taken during fumigation collections, whereas several species and many specimens were taken by searching the fallen fruit themselves. This applies also to the Syrphid genus Eumerus, although these flies do appear to be less abundant than the species of beetles in fallen fruit It seems then, that species living in such protected places seldom leave them for other parts of the trees, leading to the belief that the degree of movement of species from one part of the trees to another is comparatively small. In fact, the tree might almost be considered as a set of distinct environments, the faunae of which are very little intermingled even in the limited space occupied by the citrus tree.

4. Species normally living in the soil below the trees and not connected with them in any way. The species of this group can be considered along the same lines as those of the previous category.

5. Species which have come into the orchard by chance,

- from ...

from other environments, near or far. This group contains the true, accidental visitors to the orchards, whose normal habitat is well out of them. We may include here, such insects as the Ephemeroptera and Odonata.

6. Species which are present due to their affinity for some objects which are present in the orchards only at certain periods, such as mulch, manure which has been placed beneath the trees, or labourers working in the orchards. These insects are only sporadically found in the orchards, and are there for a while for some purpose of a temporary nature; these are exemplified by the Sarcophagidae and other Diptera which are associated with decaying organic matter in the orchards, and the blood-sucking Diptera.

As the orchard is not an isolated environment, we are dealing with a combination of two different populations, one normally inhabiting the orchards and connected with the trees, and the other consisting of a miscellaneous collection of species usually occurring in small numbers, whose presence is explainable on other grounds. It is this second population which gives the great increase in the number of 'rare' species in a non-isolated environment. It would seem reasonable to suppose that, if this population could be accurately determined, (a thing difficult as far as an orange orchard is concerned) and so eliminated from consideration where the true population of the orchards is concerned, then

- we ...

we would find a rather different picture of the relative abundance of species. It would be a picture in which the number of truly rare species would appear rather smaller, species being represented by one specimen only would no longer be encountered, and one in which a larger number of species would appear with numbers closer to the mean number of specimens per species.

CHAPTER II

INSECT ACTIVITIES IN THE ORCHARDS.

In the lists which follow, the insects have been grouped according to our knowledge of their activities. Some species naturally fall into more than one group, whilst others are difficult to place. In matters such as these, further study will undoubtedly alter our ideas concerning many of the species.

The insects have been grouped as follows:-

1. Insects attacking the trees directly.
2. Parasites of insects attacking the trees.
3. Predators of insects attacking the trees
4. Insects associated with plant and animal secretions.
5. Insects associated with fallen fruit.
6. Insects associated with decaying matter.
7. Insects associated with weeds in the orchards.
8. Parasites and Predators of insects not attacking the trees.
9. General Predators.
10. Insects known not to be normally associated with the orchards.
11. Insects of unknown role.

1. INSECTS ATTACKING THE TREES DIRECTLY.

Tettigoniidae	
Phanoptera sp.	Leaves and fruit.
Eurycorypha sp.	Leaves and fruit.
Homorocoryphus sp.	Leaves.
Chermidae	
Trioza erytreae Del G.	Leaves.
Aphididae	
Toxoptera aurantii (Fonsc.)	Young shoots and leaves.
Coccidae (sens. lat.)	
Lepidosaphes beckii (Newm.)	Leaves, stem and fruit
Icerya purchasi Mask.	Stems, young shoots.
Aonidiella aurantii (Mask.)	Stem, leaves and fruit.
Pseudococcus sp.	Leaves and fruit.
Coccus hesperidum L.	Leaves and stems
Pentatomidae	
Nezara viridula (L.)	Leaves and shoots
Lepidoptera	
Papilio demodocus	Larvae on leaves.
Argyroploce leucotreta Meyr.	Larvae in fruit.
Trypetidae	
Ceratitis capitata (Wied)	Larvae in fruit
Drosophilidae	
DP 4	Larvae in fruit.
DP 34	Larvae in fruit.
DP 14	Larvae in fruit.
Bostrichidae	
CO 21	Larvae and adults stem borers?
CO 64	Larvae and adults stem borers?
Curculionidae	
Asynonychus godmani Cr.	Leaves (adults), roots (larvae)
Mites	Fruit and leaves.

2. PARASITES OF INSECTS ATTACKING THE TREES

Comocera californica How	Soft scale.
Scutellista cyanea Motch.	Soft scale.
Aphytis chrysomphali Mercet	Red scale.

Of these three species, the last mentioned has been identified with some certainty. Specimens of the other two species have been obtained, but identification has not been definitely confirmed.

No parasites were obtained from the many collections of mussel scale which were made.

3. PREDATORS ATTACKING INSECTS THAT ATTACK THE TREES.

Anthocoridae

HE 6	Feed on various insects?
HE 8	do.
HE 20	do.
HE 26	do.
HE 35	do.

Hemerobiidae

NE 1	Larvae, adults (?) on aphids

Chrysopidae

NE 2 *Chrysopa* sp.	Larvae on scale, mites, aphids
NE 4	do.

Coniopterygidae

Conipteryx turneri Kimm	Larvae on mites ?

Myrmeleontidae

NE 7	Larvae on ants.

Cecidomyidae

DP 86	Larvae attack mites.
DP 56	do.
DP 65	do.

Syrphidae

Xanthogramma rotundicornis Loew.	Larvae on aphids.

Coccinellidae

Rodolia iceryae Jansen	on *Icerya purchasi*
Lotis nigritula Cr.	Red scale
Cranophorus sp	?
Chilomenes propinqua (Muls.)	aphids.
Exochomus flavipes (Thunb.)	Mussel scale, aphids.
Platynaspis capicola Cr	Red scale.
Rhizobius sp.	Red scale, aphids.
Scymnus sp.	Mites ?
Scymnus sp.	Mites ?
Scymnus morelleti (Muls.)	Mites ?

- Chilomenes ...

Chilomenes lunata (Fabr.)	Aphids.
Thea variegata F.	Aphids.
Rodolia cardinalis Muls.	_Icerya purchasi_.
CO 11	
CO 40	
CO 44	
CO 48	
CO 51	
CO 69	
CO 97	
CO 108	
CO 118	
Acarina	on mites.
Mites	on eggs of _Argyroploce leucotreta_.

4. INSECTS ASSOCIATED WITH PLANT AND ANIMAL SECRETIONS

Hemerobiidae

NE 1	Adults.

Chrysopidae

NE 2 Chrysopa sp	Adults
NE 4	do.

Mantispidae

NE 5	Adults
NE 9	do.
NE 10	do.
NE 11	do.
	do.

Lepidoptera

Adults of many species	Adults.

Syrphidae

Xanthogramma rotundicornis Loew.	Adults
Eumerus triangularis Herv. Boz.	do.
E. erythrocerus Loew.	do.
E. obliquus Fabr.	do.

Dexiidae and Tachinidae	) Many species
Sarcophagidae, Calliphoridae, Muscidae,	)
Anthomyidae, Ulidiidae, Trypetidae,	) in
Tetanoceratidae, Lauxaniidae, Drosophilidae	)
and Chloropidae	) adult stage.

Ichneumonidae

Many species, in the adult stage.

Chalcididae

Many species, in the adult stage.

Formicidae

Anoplolepis custodiens Smith	Adults.
Crematogaster liengmei For.	do.
Technomyrmex albipes Sm.	do.
Pheidole megacephala For.	do.

The above 4 species are the main ones attracted to honey-dew

5. INSECTS ASSOCIATED WITH FALLEN FRUIT

Stratiomyidae

DP 76	Larvae - Predaceous ?
DP 93	do.

Syrphidae

Eumerus obliquus Fabr.	Adults bred from fallen fruit

Drosophilidae

DP 4	Larvae
DP 34	do.
DP 14	do.

Lepidoptera

Argyroploce leucotreta Meyr.	Larvae, causing fall, later leaving fruit.

Nitidulidae

CO 112	Larvae predaceous on dipterous larvae
CO 103	
CO 104a	do.
CO 105a	do.
CO 106a	do.

6. INSECTS ASSOCIATED WITH DECAYING MATTER

Gryllidae	
Gryllodes sp.	
Gryllodes sp.	
Blattariae	
BL 1	
BL 2	
Mycetophilidae	
DP 2	Probably on fungus growth.
DP 81	do.
Calliophoridae Muscidae Anthomyidae	Larvae in decaying matter and in animal faeces.
Sapromyzidae (Lauxaniidae)	Larvae in decaying vegetable matter.

7. INSECTS ASSOCIATED WITH THE WEEDS OF THE ORCHARDS

Acrididae	
Aedalius sp.	Grasses
Acrida sp.	do.
Gryllidae	
Gryllodes sp.	Tender shoots of various weeds.
Gryllodes sp.	
Phasmatodea	
Bacillus sp.	Grasses
Tettigoniidae	
Eurycorypha sp.	Various weeds.
Phaneroptera sp.	do.
Homorocoryphus sp.	do.
Thysanoptera	
TP 1	
TP 2	
Blattariae	
BL 1	Tender shoots of many weeds.
BL 2	
Psocoptera	
PS 3	Fungi and lichens on bark of trees.
PS 4	
PS 5	do.
Membracidae	
Xiphistes pallidus (Buckt.)	*Acacia* sp.
Gongroneura fasciatus Buckt.	*Solanum* sp.
Oxyrachis sp. *tuberculatus* (Walk) ?	*Acacia* sp.
O. sp. nr. *bisenti* Dist.	*Acacia* sp.
HO 19	Host plant unknown.
Pyrrhocoridae	
Dysdercus sp ?	Malvaceous plant
HE 36	

- Lepidoptera ...

Lepidoptera

Many species on a variety of weeds.

Trypetidae

Pardalaspis melanaspis Bez.	Capparis sp.
Dacus (Didacus) ciliatus Lw	Cucurbitaceae
D. (D) ostiofaciens Mnro.	Asclepiad pods
Euaresta bullans (Wd.)	Xanthium spinosum

Chloropidae

DP 6
DP 21
DP 43
DP 52
DP 62
DP 73

Coccinellidae

Epilachna sp.	Solanum auriculata

Lagriidae

Lagria villosa F. var. obscura F.
Chrysolagria fuscipennis Fohr.

Crioceridae

Lema trilineata Olivier	Datura stramonium

Chrysomelidae

Oncocephala promontorii Per.
CO 30
CO 67
CO 90

Eumolpidae

Monolepta vincta Gerst.
CO 15
CO 102

Halticidae

Phyllotreta ?	Cruciferae
Phyllotreta ?	do.

- Cassididae ...

<u>Cassididae</u>

<u>Cassida melanophthalma</u> Boh.	Convolvulaceae
<u>Cassida</u> spp.	
<u>Hypocassida gibbipennis</u> Boh.	
<u>Aspidomorpha tecta</u> Boh.	
CO 66	

<u>Mylabridae</u>

<u>Bruchus</u> spp.	Leguminous pods

<u>Curculionidae</u>

<u>Baris</u> spp.
<u>Apion antiquum</u> Ghl.
<u>Sibinia</u> sp. (prob. <u>luteoviridis</u> Ghl.)
<u>Sibinia</u> spp.
<u>Neocleonus sannio</u> Hrbst.
<u>Tachyphloeus spathulatus</u> Boh.
<u>Sciobius pullus</u> Sparm.
<u>Lixus haerens</u> Boh.
<u>Porpacus horridus</u> Boh.
CO 5
CO 32
CO 63
CO 66
CO 74
CO 83
CO 100

8. PARASITES AND PREDATORS OF INSECTS NOT ATTACKING THE TREES

Thysanoptera

Elaphrothrips edouardi Jacot-Guillarmod — Psocoptera ?

Mantispidae

NE 5	Paras. on spiders'
NE 9	egg cases.
NE 10	do.
NE 11	do.

Pipunculidae

DP 9 — Paras. on Homoptera

Gasteruptionidae

Gasteruption sp. — Paras. on solitary wasps or bees.

Ichneumonidae

Many species from unknown hosts.

Chalcidoidea

Trichogramma sp. — Chrysopid eggs.
Tetrastichus sp. — do larvae.
Many other species from unknown hosts.

Figitidae

HY 85 — Paras. on dipterous larvae.

Dryinidae

Mesodryinus sp. n. — Paras. on unknown homopteron.

Tiphiidae

Meria sp. — Paras. on scarabaeid larvae.

Psammocharidae

HY 66 — Spiders

9. GENERAL PREDATORS.

Mantidae

MT 1
MT 2

Reduviidae

Coranus sp.
HE 32

Ploiariidae

Ploiaria sp.

Odonata

2 spp.

Mantispidae

NE 5
NE 9
NE 10
NE 11

Myrmeleontidae and Ascalaphidae

NE 7
NE 3

Larvae living mainly on ants.

Dolichopodidae

DP 3
DP 53
DP 55
DP 71

Empididae

DP 5
DP 12
DP 68

- Carabidae ...

Carabidae

Callida silvicola Per.
Geobaenus lateralis Dej.
Lebia congrua Per.
Xenitenus sp.
CO 34

Malachiidae

Pseudocolotes oneili Pic.
Hedybius plagiocephala Er.
Ebaeus (Mixis) rufithorax Pic.
Ebaeus quadrimaculatus Champ.
Attalus sp.
Hedybiocephalus fasculatus Pic.

Anthicidae

Formicomus rubricollis Laf.
Formicomus coeruleus Thunb.
Anthicus bisbipartus Pic.
Anthicus brevicignatus Pic.
Anthicus (Aulacoderus) sp.

Formicidae

Anoplolepis custodiens Smith
Tapinoma danitschi For var bevisi For.
Crematogaster liengmei For. race weitzaeckeri Em.
Polyrachis (Myrma) spinicola For.
Pheidole megacephala F. race punctatula For.
Camponotus maculatus F. var lactipennis Em.
Cataulacus sp.
Sima (Tetraponeura) clypeata Em. var durbanensis For.
Technomyrmex albipes Sm. race foreli Em.

Vespidae

Polistes spp.

10. INSECTS KNOWN NOT TO BE NORMALLY ASSOCIATED WITH ORCHARDS

Collembola

2 species

Odonata

2 species

Ephemeroptera (Plectoptera)

Austrocloeon virgiliae Brnrd.
Austrocloeon africanum (E.P.)
Cloeon lacunosum Brnrd.

Sisyridae
NE 8

Chironomidae

DP 45
DP 48
DP 57

Culicidae

DP 25
DP 47
DP 49
DP 51
DP 58

Tabanidae

DP 84

Calliphoridae

Lucilia sp.

Tetanoceratidae

DP 72

11. INSECTS OF UNKNOWN ROLE

Cercopidae

HO 8

Gyponidae

HO 6

Jassidae

HO 12
HO 15
HO 18

Fulgoridae

HO 11
HO 13

Tropiduchidae

HO 2
HO 7
HO 14

Chermidae

HO 16
HO 24

Pentatomidae

HE 7 Carbula litigatrix
HE 10 Acrosternum heegeri
HE 13 Dryadocoris apicalis
HE 14 Afrius marmoratus
HE 15 Macrorhaphis acuta
~~HE 17~~
HE 30 as HE 7.

Coreidae

Cletus spp.
Homoeocerus sp.
Serinetha sp.

- Lygaeidae ...

Lygaeidae

Lygaeus sp.
Dieuches sp.
HE 22
HE 28
HE 31

Tingididae

HE 25
HE 29

Miridae

HE 2
HE 5
HE 9

Phoridae

DP 32
DP 79

Tachinidae

DP 95
DP 96
DP 98
DP 99
DP 106
DP 107

Dexiidae

DP 94
DP 102

Sarcophagidae

DP 113
DP 104

Ulidiidae

DP 27

Unidentified Diptera

5 species

- Scydmaenidae

Scydmaenidae

CO 44

Colydiidae

CO 65

Monotomidae

CO 106

Cryptophagidae

CO 9
CO 22

Mycetophagidae

CO 76

Languriidae

Anadastus illaetabilis Pasc.

Lathridiidae

CO 26

Elateridae

Heteroderes sp.
CO 7

Tenebrionidae

Himatismus sp. probably variegatus
CO 75
CO 94
CO 119

Unidentified Coleoptera

6 species.

CHAPTER III

DISCUSSION OF FIVE TREES OF STRIKING FAUNAL DIFFERENCES FROM THE OTHER TREES INVESTIGATED

Upon considering the data obtained from trees from which collections were made, a group of five trees was noticed in which certain faunal differences were very evident. The trees concerned were Nos. B1-B5, navel orange trees at Tregaron. These trees were in the same row, and adjacent to one another. They were situated alongside a dusty road, and were themselves fairly well covered with a layer of dust at the time of collection. They are the five trees on which the highest red scale populations were recorded in all the 83 trees investigated.

Formicomus rubricollis was present in large numbers on these trees, the lady-bird Rhizobius sp. occurred on them and on only two other trees, both of which were in the same orchard. The Corrodentia were well represented on three of the trees, the only trees in the orchard on which they did occur. The Drosophilid fly, DP 4, which had occurred in varying numbers on a very high percentage of the trees investigated, was virtually absent from these five trees, only one specimen being taken from them. In general, the Diptera were poorly represented here. Amongst the Hymenoptera

- there ...

there appears to be significance in the presence of the ant *Pheidole megacephala*, which was active on two of the trees and which occurred on four others in the same orchard, three of which were close to those under consideration. This may mean that the ant was active on all five of them at one time or another. Neither the larvae nor adults of Chrysopids were taken on these trees; it may be pointed out that most of the Chrysopids taken were in the larval stage. The density of red scale on these trees ranged from 132 to 576 per 100 leaves.

The more or less striking differences in the insect fauna of these trees is apparent from the following table, in which the numbers of specimens of the species mentioned above is given for each of the trees investigated.

TABLE IV

NUMBERS OF SOME SPECIES TAKEN

Tree No.	Scale per 100 leaves	*Formicomus rubricollis*	*Rhizobius* sp.	DP 4	Corrodentia	Total Diptera	*Pheidole megacephala*	Neuroptera
A 1	1			11		120		4
A 2	1	8			2	10		3
A 3		4		18		25		1
A 4		7		14		20		6
A 5	4	5		24		56		5
A 6		7		11	1	17		3
A 7		2		5		6		4
A 8	8	4		18		88		2
A 9	1	2		3		3		
A10	7			2		7		2
A11		3						2
A12	1	11		1		4		1
*B 1	576	70	7	1	23	2		
*B 2	132	43	5		21	3		
*B 3	149	45	7		13	1	27	
*B 4	342	69	11			2		
*B 5	291	100	10			3	12	
B 6	3	32		13		22	29	7
B 7		16		8		10	20	4
B 8	7	36		24		28	48	5
B 9	11	42	1			5		1
B10	27	10		8		18		
B11	4	40		4		10		
B12	6	79		18		20		
B13	3	31		5		9	45	1
B14	5	11		13		15		2
B15	18	45		10		17		1
B16	16	1		8		10		2
B17	12	2		6		13		1
B18	3	79	3	32		35		1
B19		10		2		3		4
B20	17	23		61		14		1
B21		38		23		24		1
C 1	27	44		1		8		1
C 2	32	14		2		16		
C3	4	29		4	2	22		4
C 4	9	45		2		8		
C 5	3	15		1		6		
C 6	16	64		8		12		3
C 7	7	3		1		12		1
C 8	1	32				10		4
C10	2	45		8		17		2
C11	2	31		8		15		5
C12	3	43		8		13		1
C13	8	40		2		11		2
D 1	8	4		51		55		10
D 2	10	2		23		28		
D 3	7	10		32		33		3
D 4		18		35		39		1
D 5	3	18		10	9	11		1
E 1	71	7		18	10	27		
E 2	73	47		15		23		
E 3	28	45		42		47		4
E 4	46	26		23		29		6
E 5	53	10		34		37		4
E 6	98	12		23		31		1
E 7	33	7		57		63		1
E 8	60	24		24		26		1
E 9	4	94		41		49		
E10	7	45		8		11		7
E11	12	15		9		12		1
E12	8	11		9		14		
E13	15	7		3		8		2
E14	28	10		125		131		6
E15	18	15		19		20		3
E16	17	13		22		27		1
E17	23	16		4		9		2
E18	14	20		17		18		
E19	9	65		14		18		
E20	7	16		87		74		11
E21	7	11		8		12		1

We have in the trees B1-B5 a group on which there are, apparently, certain factors differing from the other trees, even those of the same orchard. They were situated at the southern end of the orchard, and were in an outside row of trees, both of which factors are known to cause a tendency for an increase of red scale infestation to take place. That the trees are favourably situated for a heavy scale infestation is clear, for the other faunal peculiarities possible explanations are more difficult to find, but an attempt to do so may clarify certain conceptions concerning the interrelations of species in the orchards.

Our almost complete ignorance of the habits of F. rubricollis renders any suggestion as to reasons for its peak occurrence on these trees purely guesswork, but it is tempting to speculate that there is some correlation. Further careful work on this species is needed.

The sudden appearance of Rhizobius sp. collected from these trees can be put down to the abundance of scale present, for Rhizobius sp. is known to occur on trees with heavy infestations of scale. This species feeds on a variety of scale including red scale and its limitation in distribution in an orchard generally infested with scale is hard to explain. The possibility that this occurrence may be connected with the absence of Chrysopid larvae cannot be dismissed, but the reason for the absence of the latter remains difficult to find. The ant, Pheidole megacephala,

- may...

may be a factor of some importance here. This ant is known to be very pugnacious and its presence in the vicinity of the five trees (although not collected from all of them) may mean that they are all subject to its attentions at some time, and is probably an important factor in the reduction of the predators of the scale, including the important Chrysopid larvae. This makes the presence of *Rhizobius* sp. difficult to explain unless this species is more able to withstand the attacks of the ant, or unless it is normally kept in reduced numbers by the Chrysopid larvae rather than by the ants. Looking at the picture as a whole, it can be said that in this orchard the population of *Rhizobius* sp. is usually at a minimum whilst the Chrysopids are more or less generally distributed - as shown by fumigation collections - except where *P. megacephala* enters the complex, and here the *Rhizobius* sp. increase markedly and the Chrysopids disappear.

Bearing in mind our very limited knowledge concerning the relative specificity in preying habits of the species concerned (a subject which has been investigated in only a few species within the last few years) any explanation of the state of affairs in this orchard must be along these lines:-

In the trees where *P. megacephala* does not occur there is an antagonism between the larvae of *Rhizobius* sp. and the larvae of the Chrysopids. (The adults of the Chrysopids

-would ...

would be supposed not to enter into this struggle, as most authorities do not believe that the adults feed - but see below). This antagonism is expressed in the competition for food, and in direct attack upon each other. The latter is the fiercer form of antagonism. The Chrysopid larvae appear to have very general feeding habits, having been observed to eat the eggs, larvae and pupae of their own species as well as red scale, mussel scale etc.

The presence of _P. megacephala_ would appear to upset this system somewhat, and in some manner the _Rhizobius_ sp. is given an opportunity to increase. It seems that the larvae of this species do not increase appreciably, but figures from fumigation collections are not reliable here, as Coccinellid larvae seem to retain their hold on the tree after death. The result is that the increase in the species is mainly seen as an increase of adult beetles. The increase may be due to attacks by _P. megacephala_ on the Chrysopid larvae, eggs or pupae. How it is that _Rhizobius_ sp. manages to survive in spite of the presence of the ant, even if its main predators are removed is not known. It may be that the beetle has some ability to resist the attack of the ants.

There is a second possible explanation for the reduction in number of Chrysopid larvae on these trees, involving the adults of the species. Most authorities agree that the adult lacewings do not feed, or at any rate, are not

- predators ...

predators, but specimens have been found in the laboratory to imbibe large quantities of water, especially when sugar is added. In the field it has been noticed that there are more adult lacewings on the trees where there are large quantities of honey-dew. The Chrysopids are undoubtedly attracted to these trees by this substance, and it is likely that it is on these trees that most eggs will be laid, and hence more larvae will appear. When searching for larvae, adults or eggs, in the Grahamstown district, it was found more profitable to search the trees on which honey-dew was to be found in large quantities since these trees appeared to yield more specimens than those without it. The former always had a much greater insect fauna than the latter, which fact was easily demonstrated by simply beating the trees. The insects flying out of the trees with honey-dew far exceeded in number those flying from the trees without it.

In the five trees under consideration, there was no honey-dew, or if there was, it was well-covered with a layer of dust, and this would probably prevent many insects from taking it. The dust on the leaves may have made them less attractive to the Chrysopid adults, with the result that fewer eggs were laid on them, this leading to a reduced population of larvae. This may, in fact, be the reason for the increase of scale on these trees, and on other dust-covered trees.

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From the figures obtained this second explanation appears to be the more satisfactory, or at least, would appear to be a part of the explanation, as it has been shown that (on trees B6, B7 and B8) the presence of _P. megacephala_ does not necessarily imply a decrease in Chrysopid larvae.

It is clear that we are dealing here with a very complex and interesting set of factors. A knowledge of many subjects is required, of which we are, unfortunately, at present largely ignorant, such as (1) the true nature of the antagonism between the two scale predators, (2) the preferred food of the ant, (3) the biology of adult Chrysopids, particularly their egg distribution and feeding habits and (4) the ability of _Rhizobius_ sp. to withstand the attacks of the ant, _P. megacephala_, and other predators.

The possibility that _Rhizobius_ sp. is attacked by a parasite which cannot operate under conditions of dust, or in the presence of the ant, cannot be ruled out. Unfortunately we know little about this, as the trees were fumigated, and hence this interesting ecological community broken, so that it was not possible to investigate these trees further. We are left, therefore, with an interesting set of data, from which certain details, which might have been obtained by experiments and observation, are missing.

The reason for the total number of Diptera being so low on these trees is undoubtedly the lack of honey -dew.

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This marked absence supports the view that most of the Diptera present on the trees are attracted to this substance and not to the trees themselves. The drop in the numbers of the Drosophilid fly, DP 4, however, is more difficult to explain, as it occurs on 73 out of the 83 trees investigated. Many of these trees were without appreciable quantities of honey-dew and the occurrence of this fly does not seem to be correlated with this substance. As the habits of the fly do not indicate an interest in any part of the tree except old fruit, the reduction of numbers here is a little puzzling.

The sudden appearance of the Corrodentia in large numbers on these trees cannot be explained unless they, too, have predators which are driven away by the ants, or unless they are capable of resisting the attacks of the ants themselves. This seems improbable. They are more likely to be associated with fungal or lichenous growth on the trees. Pearman (1932) has reported several species of this order as being coccophagous. The possibility of the species under consideration being so must not be forgotten but it was not possible to substantiate this. Finally, Badonnel (1943) records as the predators of these insects, the Pseudoscorpions, spiders, _Crabro_, ants and the Neuroptera Planipennia ... "Les fourmis font certainement la chase aux Psoques, et il est probable que les Planipennes s'en nourissent egalement."

CHAPTER IV

DISCUSSION OF INSECT RELATIONSHIPS IN CITRUS ORCHARDS

During the studies so far described, a picture has been obtained of the insect population and conditions under which it exists in the orchards; certain aspects of this over-all picture may now be considered.

THE ORCHARD AS AN ENVIRONMENT

The orchard, as an environment, can be seen to present two outstanding features, which greatly affect our conceptions of the ecology.

1. The orchard is by no means an isolated environment. On the contrary, it invites invasion by elements from surrounding habitats. In one case, the faunal invasion follows the floral, in the other case, the invading elements enter separately and independantly of one another. For example, illustrative of the first case, the fly, _Euaresta bullans_, followed its host plant, the weed _Xanthium spinosum_, into the complex of the orchards, apparently very recently in South Africa. To illustrate the second case, we may consider any example of a weed which enters the orchard from the surrounding country, and any insect which is attracted to the trees for shelter or for secretions of one sort or

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another. They are all essentially invading elements, coming into the ecological complex of the orchards from other environments - more or less distant. The important thing is that many species have come in in small numbers. They may later become established in some degree, but they are never likely to assume the numbers of those specise which are successfully associated with the trees themselves. The orchard, by its connections with other environments, contains a large number of species of which only small numbers occur. This matter has already been discussed.

2. The orchard is essentially a man-made environment, with which man is constantly interfering in ways which cause sudden changes in microclimate, fauna and flora.

The removal of weeds leads to the sudden removal of many insects, and the loss of food to a great many species which attack them. It is surprising how few species thus deprived of sustenance turn to the trees. The trees are probably protected to a large extent by the natural oils which are peculiar to the Rutaceae. A greater number of phytophagous species might be expected to attack the trees on the removal of their more palatable normal foods. In fact, it is likely that a general movement of insects from the orchard occurs when cultivation is carried out.

Manure and compost when introduced into the orchards in large quantities creates a satisfactory habitat for a

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large number of species, such as flies, beetles, and crickets - and they in turn serve as prey for the numerous carnivorous species which are present or which follow them in and increase at their expense.

Irrigation is carried out on a large scale in the Sundays River Valley, and the sudden flooding of large areas of land must have great effects on the insect fauna. It does so mainly in three ways:-

1. Certain insects are introduced with the water and form additional prey for those insects already present. Certain vertebrates, such as frogs, also make their appearance with the water. These are mainly insectivorous and so have their share in affecting the insect fauna of the orchards.

2. The sudden influx of large quantities of water must affect the microclimate of the orchards, making them more suitable for some species and less so for others. The effects of this may be great, but little is known of the microclimatic conditions of the orchards normally, and even less is known of the changes which take place on flooding. The only assumption which can be made with some degree of safety is that the humidities will rise and the temperatures drop. The sensitivity of insects to such changes and the effects which they have on the fauna is not known at present.

During the brief visit to Fort Beaufort an opportunity arose of investigating two orchards adjacent to one another, one of which had just been irrigated, the other not. Collecting in both by means of a sweep-net produced very little results, except on low patches of weed in the orchard which had been irrigated. There was a most noticeable congregation of small flies and small Homoptera on such patches. The orchards were, in general, both well cleared of weeds, but in the areas of ground from which trees had been removed and in which replants were to be made, a thick growth of weeds had been allowed to develop. There were such patches in both orchards and both were swept, but only those in the damp, irrigated orchard yielded insects in any number. Activity of soil-dwelling insects was markedly greater in the irrigated orchard. It is possible therefore, that irrigation of an area such as an orchard, in an otherwise dry district, may in itself be sufficient to cause a congregation of insects there, particularly in patches of herbage. It is possible that both migration into and emergence from hiding within the area both play a part in increasing the insect fauna of a damp orchard. There is, without doubt, an increase in certain forms of insect life in an irrigated orchard.

3. Perhaps the most important effect which irrigation has on the fauna results from the destruction of certain insects which may take place, particularly in the ground-

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dwelling species. It was very clear from observations made near Addo that ant activity was curtailled for several days following the flooding. It is conceivable that such a cessation of activity may be long enough for parasites and predators to destroy large numbers of aphids and scale insects. When ant activity was resumed, it appeared to consist mainly of building operations and ground foraging for some time. Many species besides ants must be affected by the sudden flooding, and if this be prolonged, destruction of pupae may result. Flightless species are likely to be most affected by irrigation water.

If the above-mentioned destruction of insects is considered in conjunction with what has been said of observations at Fort Beaufort, it will be seen that it is most likely that considerable changes in the faunal complex of the orchards, particularly of the soil and weeds, are effected by irrigation.

Fumigation and insecticide treatment is essential in most orchards if a marketable crop is to be produced. At the present time the cost of treatment is extremely high, making the need for more economical control methods more urgent than ever.

The recent tendencies towards the opinion that chemical treatment programmes must be arranged with greater regard for the insect community as a whole are striking. It is becoming increasingly evident that methods which destroy

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the insect populations of the plant completely tend to favour the pest species, rather than their natural enemies. Natural enemies of most plant pests of citrus are coleopterous, neuropterous or hymenopterous insects and these species seem, in general, to be very susceptible to the fumigants used. Assuming that the pest species has not developed a resistant strain, it can be said that the population of a tree is virtually destroyed when the tree is fumigated. Repopulation of a tree by invasion from sources not destroyed then takes place, and by the very nature of the relationship between prey and predator, a sequence of events takes place which involves a recolonisation of the trees by the species attacking them directly, followed by a reappearance of the predators and parasites sometime later. These latter species cannot maintain themselves until a certain density of population has been attained by the prey, and after that a considerable time must elapse before the predators and parasites can bring the pest species down in numbers and restore the 'normal' state of affairs. The word "equilibrium" has not been used as, in nature no set of populations in an ecological community has ever been found to be in equilibrium with its environment - all is in a constant state of flux. It is this continuous change which is one factor in making the mathematical treatment of population problems so difficult.

The effects produced by total destruction of the insect population are far-reaching, and it is frequently an

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advantage, in the long run, to the species at which it is aimed. This forces repetition of the treatments. Chemical treatments thus become essentially temporary measures and the cost of these is gradually increasing so as to become uneconomic in some cases.

Fumigation may well be replaced by the application of the newer insecticides, but these, too, seem to have the effect of destroying the entire insect population. Their effects have not yet been fully investigated. It is not proposed to enter into a detailed discussion of the effects of insecticides on insects, as this is fully dealt with in the literature of applied entomology, and is not in keeping with the nature of the present investigation.

THE TRUE FAUNA OF CITRUS TREES

The remarks so far made in this discussion have applied to the total insect population of the orchards. It has been pointed out that this consists, in reality, of two populations, only one of which can be said to be associated with the trees permanently. We shall now consider this section of the fauna alone; it may be thought of as the true fauna of the citrus trees, as opposed to the general fauna of the orchards as a whole.

The tree itself presents several distinct and very different attractions to insects. The roots, stems, leaves, flowers and fruit are found attractive by various insects, and in most cases a given insect will only be attracted to one or a few parts of the tree. In addition, certain plants and animal secretions, nectar and honey-dew, are attractive to a wide variety of insects, from the trees and elsewhere. In fact, the secretions form a meeting point for the two elements of the orchard fauna.

From collections and field studies it seems that there is no essential difference between the faunae of orange trees (navel or valencia), grapefruit trees or lemon trees; the term "citrus" may be used to cover all types of tree when general matters are discussed, as at present.

A list of species known to attack the trees directly has been given, as well as lists of those associated with

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other aspects of the trees. It is those insects which are closely connected with the trees that are now to be considered.

It is apparent that we have a complete insect community in association with the trees. All parts of the tree are attacked and advantage taken of its product, nectar, from flowers and leaf bases. These citrus insects are attacked by predators and parasites - so far as is known, there is nothing in the community of which no use is made, and no species is without some form of control upon its reproduction potential. This control may be biological or climatic, and it is the nature of these controls which forms a large part of the more important section of the ecological studies of the trees.

It is essential, for the sake of simplicity, to consider these interrelations in general terms, otherwise the maze of detail leads to confusion with resultant lack of understanding of the roles played by the insects.

We shall consider, first, the Coccids, which are the main pests of the trees. The quantities of sap taken up by these insects is enormous, as the quantity of honey-dew secreted by some species shews. Their effect, if not checked in some way, is the death of the tree, due, apparently, to a combination of the effects of the loss of sap and those of the toxic substances introduced into the plant tissue. All parts of the tree may be attacked by one or other of the

- species ...

species. Their main predators are Coccinellids, adults and larvae, hymenopterous parasites, and neuropterous larvae. It is these insects which constitute, collectively, the main check on the numbers of scale, and it is therefore the interrelations of these species, and their relations with other species, which become of importance.

RELATIONS BETWEEN RED SCALE AND THE CUSTODIAN ANT

The relationship between the red scale (Aonidiella aurantii Mask.) and the ant (Anoplolepis custodiens Smith) has been studied in some detail during field work in the Sundays River Valley. In this area both species are found widely distributed but the ant is known to have no direct biological relationship with the scale, because the latter does not produce honey-dew. The ant, however, does attend other species of scale and aphids which secrete honey-dew and occur on many of the trees, but less abundantly than red scale. During their activity on the trees the ants appear to hinder and attack the predators and parasites of red scale with the result that even this species derives a measure of benefit from the presence of the ants. It was decided to investigate this matter in the field from two points of view, the first being an attempt to find whether there is a definite relation between the occurrence of the two species, and the second being an attempt to find if any numerical relation existed between the numbers of scale and the degree of ant activity. This work is largely confirmatory of work of others elsewhere, but, so far as is known, no data on this subject are available for the Sundays River Valley.

In order to obtain data it was decided to make estimates of scale numbers on several trees, and to estimate the degree

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of ant activity on those same trees. Scale populations were estimated by taking 100 leaves at random from each of the trees to be investigated and counting the red scale present on them. This number was used as an index of the abundance of the scale. The method used to ascertain the degree of ant activity on the trees involved counting the number of ants ascending the tree in unit time. The unit of time chosen was a quarter hour, and the number of ants ascending the trees in that time was taken as an index of the degree of ant activity. These counts were all made between the hours of 2 and 4.30 p.m. These times were decided upon after the activity of the ant species over the daylight period had been studied. As there are so many factors likely to affect such a count in the field, it was decided that any refinement of counting and estimation technique would be of little value in obtaining more accurate results.

The counts of red scale and ants were made on 82 trees, from 4 orchards in three districts of the valley and involved all of the main types of citrus grown.

The figures obtained in the counts are set out in Table V.

TABLE V

ANT ACTIVITY AND RED SCALE INFESTATION ON 82 TREES

Orchard	Tree No.	Scale	Ants
I	1	6	2
	2	10	-
	3	6	-
	4	-	-
	5	7	-
	6	-	-
	7	1	-
	8	2	-
	9	2	-
	10	1	-
II	1	56	-
	2	8	-
	3	17	-
	4	-	-
	5	-	-
	6	-	-
	7	2	-
	8	1	-
	9	-	-
	10	-	-
	11	231	-
	12	301	-
	13	271	-
	14	141	-
	15	7	-
	16	14	-
	17	22	-
	18	-	-
	19	-	-
	20	3	-
III	1	-	-
	2	-	-
	3	-	-
	4	-	-
	5	-	4
	6	-	-

- Table cont'd ...

Table continued.

III	7	9	330
	8	7	166
	9	3	213
	10	7	173
IV	1	9	4
	2	18	137
	3	32	-
	4	7	120
	5	3	9
	6	26	51
	7	5	43
	8	10	20
	9	1	-
	10	-	-
	11	8	-
	12	7	-
	13	13	-
	14	21	32
	15	-	165
	16	-	25
	17	5	-
	18	27	-
	19	3	12
	20	6	-
	21	33	90
	22	-	4
	23	8	31
	24	4	-
	25	9	12
	26	8	195
	27	7	148
	28	22	143
	29	1	3
	30	2	15
	31	14	57
	32	11	234
	33	20	374
	34	-	-
	35	35	277
	36	56	-
	37	-	-
	38	68	46
	39	34	207
	40	72	56
	41	11	405
	42	36	440

From the above table it can be seen that:-

1. There are 31 trees with both ants and scale present (37.8%)
2. There are 30 trees with only scale present (36.58%)
3. There are are 4 trees with only ants present (4.87%)
4. There are 17 trees with neither ants nor scale present (20.73%)

This would seem to indicate that red scale infestation may be fairly widespread in the absence of ants, and that, therefore, the control of ant activity is not likely to reduce red scale infestation generally, although it may do so under special circumstances, as has been shown in practice in the Sundays River Valley. Wherever the ants are active on the trees there appears to be a greater liklihood of red scale occurring, in only 4.87% of the trees do ants occur without a scale population of some size developing. The effect of ant activity, in general, would be to encourage and lead to the increase of red scale populations, but such activity is by no means essential for their development. It may well be that in certain cases only the presence of the ants prevents control of red scale by predators and parasites, but, in general, this cannot be taken to be the case.

Where ants are absent and red scale present there must be other factors involved which prevent such control, such as dust on both the trees and the scale, a factor which is thought to affect the willingness of parasites to oviposit, and such factors as small variations in microclimatic

- conditions..

conditions.

If we consider all the trees on which ants occur, it is seen that in only 4 out of 35 (11.4%) do they occur alone. If we consider the cases in which red scale occur, we see that in 30 out of 61 (49.1%) do they occur alone. These two facts confirm the previously-mentioned conclusion that where ants occur there is a tendency for red scale populations to develop, but the converse is not necessarily true.

A brief consideration of the orchards involved may be of value.

Orchard I. The figures obtained here confirm the conclusion that ants are not necessary for the establishment of red scale populations.

Orchard II This orchard shews that red scale infestation in the absence of ants may be quite heavy. Trees No. 11-14 were particularly heavily infested and it is significant that they were situated at the edge of the orchard adjacent to a very dusty road which resulted in the leaves being well covered with a fine layer of dust.

Orchard III. In this orchard we see an indication of the manner in which ants may be the main influence in the establishment of red scale colonies. The orchard is virtually scale-free on those trees on which there is no ant activity. Where ants are active (in association with aphids in this case) a relatively light infestation of red scale occurs. It will

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be noted that high degrees of ant activity are here accompanied by low red scale populations. It is in such cases as this, where there is a sharply defined relationship between red scale occurrence and ant activity, that ant control may be expected to lead to the greatest degree of scale control by natural enemies.

Orchard IV. A consideration of this orchard adds nothing to our knowledge of the relationship between the occurrence of the two species in question. As 42 trees were investigated in this orchard, it does, however, yield data upon which some consideration of the numerical relations between the two species might be made. This is done below. In this connection the other orchards are of little value, being either too small or not sufficiently infested with ants for useful figures to be obtained.

Numerical relation between red scale and custodian ant where both occur.

We turn now to the second aspect of the relationship between the ants and red scale. The fact that the presence of ants on the trees tends to assist the scale population to maintain establishment on any given tree raises the question of whether or not there is any numerical relation between the two species. A consideration of the data obtained in Orchard IV of the previous section may shed some light on this matter.

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In this orchard, which was a fairly large one, there was a wide range of red scale infestation, from practically clean trees to trees with an infestation of 72 scale per 100 leaves. The range of ant activity was also great, being from trees without ants to those in which 440 ants passed up the trunk in the period of a quarter hour. If we consider the trees on which both species occurred, the data obtained may be expressed as in Figure 3. The data is presented in full in Table E of the Appendix.

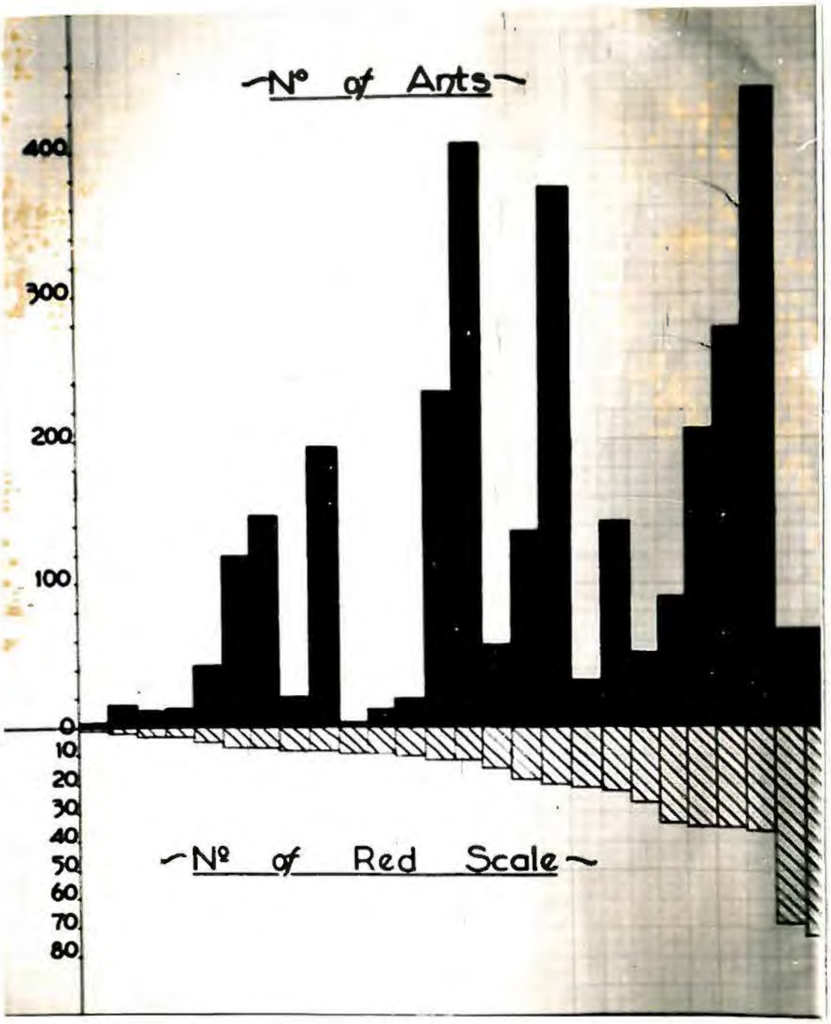

Figure 3.

Relation between red scale infestation and activity of custodian ant.

When considering this figure several points should be remembered. Firstly, the data on which it is based have been taken in a state of nature over a period of time, and during that time variations of activity are bound to occur, so that when considering a tree with high scale infestation it is possible that a period happened to be chosen for the ant count when ant activity was low, within the normal variation of activity which might be expected over a small period. Secondly, we do not know whether the ants vary their choice of trees from day to day. If they do, then it is possible that trees happened to be chosen at a time when ants were not particularly attracted to them, their attentions being elsewhere, but that those trees may on other occasions be more attended by ants. Thirdly, it was not possible to make all the counts on one day, and this will no doubt give some counts which may be considered above or below the "normal" degree of activity for the species.

Bearing in mind these three points, it can be seen that the higher peaks of ant activity are in some degree associated with the greater numbers of scale. With so many factors affecting the trees, and the possible sources of error mentioned above, it is not to be expected that any exact relations would be shewn . It is, therefore, perhaps all the more significant that the figure should show the general tendency to a parallel increase in ants and red scale. The degree of infestation in this orchard does not, unfortunately,

- vary ...

vary as much as in many others. Any sign of relationship would be expected to be shewn at the higher and lower extremities of the figure, and such is fairly clearly the case. It would seem, then, that where red scale and ants occur together, there is some slight indication of a numerical relationship between the two, but there are so many complicating factors that this is vague.

Another method of expressing the data obtained in Orchard IV may be used. This consists of calculating the ant activity/scale ratio for each tree and of grouping these ratios; these ratio groups are then plotted against the frequency with which they are found to occur. This is shewn in Figure 4, the full data for which may be found in Table F of the Appendix.

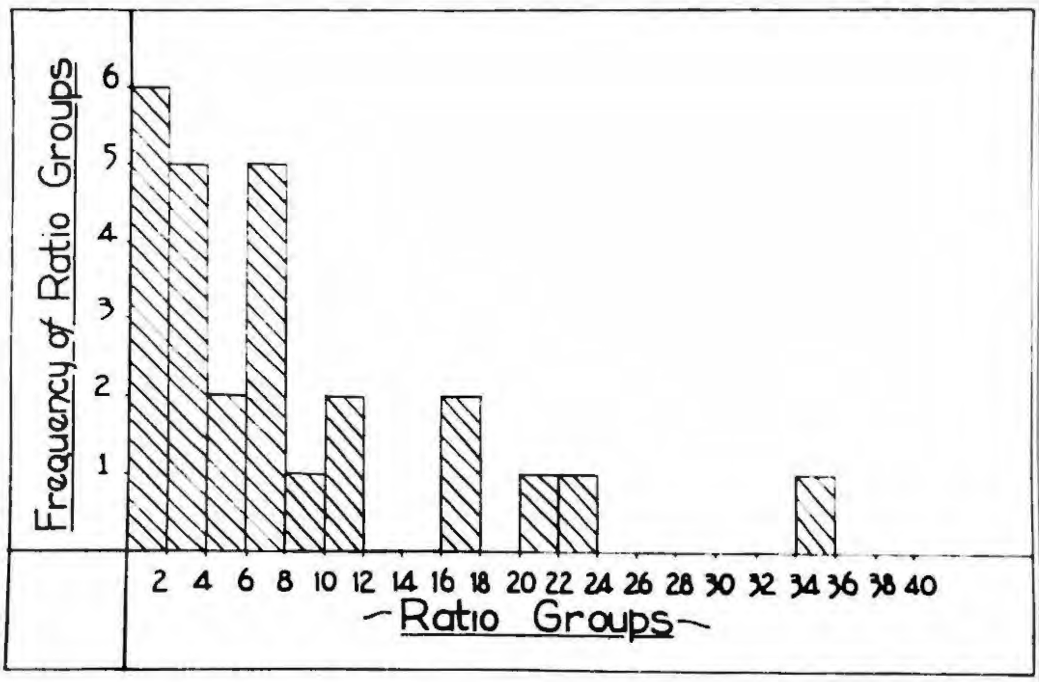

Figure 4.

Frequency of ant-activity/scale-infestation ratio groups.

This figure shows clearly that cases where the ant-activity/scale-infestation ratio is lower are of greater frequency than those in which it is higher. The lower ratios are given by cases where the levels of ant activity and red scale populations are both low or high. These cases are the most frequently found and hence it can be said that where ant activity is low, scale population may be expected to be low, and vice versa. Whether the one species has a direct effect on the other, or whether this parallel abundance is due to common response to some external factor, cannot be stated with complete certainty. From the evidence already presented, which indicates that red scale occurrence does depend to some extent on ant occurrence, it would appear likely that the cause of the parallel abundance is to some extent the ant activity.

It is to be expected that such factors as the distance of the exit hole of the ant nest from the trees is of some importance. The trees in orchard IV were arranged as indicated in the following diagram. In the diagram:-

1. Each square represents one tree.
2. The upper figure within the square gives the number of ants ascending the tree in a quarter hour.
3. The lower figure gives the number of scale per 100 leaves.
4. "A" indicates presence of aphid colonies.
5. "X" indicates presence of soft scale.
6. "H" indicates presence of an exit hole within one foot of the trunk of the tree.

- 56	3 1 A	4 - A	164 - A N	20 10 A	4 9 A
	15 2 A	31 8 A	25 -	- 1	137 18 A
46 68 A	57 14 A	- 4 A	- 5	- - A	- 32 A
207 34 A	234 11 A N	12 9 A	- 27	- 8	120 7 A
56 72 A	374 20 A X N	195 8 A N	12 3 A	- 7	9 3 A
405 11 A N		148 7 A	- 6 A	- 13 A	51 3 A
440 36 A N	277 35 A	143 22 A	90 33 A	32 21 A	43 5 A

Diagram I

Diagram of ant and scale distribution in Orchard IV

It will be noted from this diagram that the presence of an exit hole at the bottom of the tree leads to a greater attendance of ants on the tree, even though adjacent trees may carry aphids as well. In general, trees with an exceptionally high ant activity are those which have an exit hole near the base. It is on these trees that we should expect to find the greater scale populations, and, taken by and large, this is the case.

There appears to be a preference on the part of the ants for making their nests at the edges of the orchards. Whether this is due to some microclimatic preference, or to soil conditions, or due to the fact that the outer areas of the orchards are less cultivated and therefore the nests less disturbed, is not known. This last seems an important factor. A combination of the above factors may be the cause of the distribution of the ant nests in this fashion.

RELATIONSHIPS BETWEEN RED SCALE AND SPECIES OTHER THAN ANTS

From the large fumigation collections made in the Sundays River Valley, and the counts of red scale, data are available concerning the relative numbers of a large assortment of insect species, and an indication is given of the type of insect community which is to be found on the trees. Here we are concerned with the 'normal' populations, i.e. with the type of population found to be of most general occurrence. It has been found that of all the species taken, only one, Formicomus rubricollis Laf., may possibly bear any relation to red scale. The population of this beetle has been found to show a suggestion of correlation with red scale populations, as where the latter reaches its greatest density, the numbers of the beetle have also been found to reach a peak. As little is known of the biology of this beetle, it is impossible to say whether or not there is any significance in this fact. There appears to be little of interest with regard to the relative numbers of any of the other species taken.

DISCUSSION OF INTERRELATIONSHIPS OF INSECTS ON CITRUS TREES

The ants are the most important predators attacking the natural enemies of citrus insects. It is possible that spiders play a big part in reducing parasite and predator attack as well, as they are very numerous on the trees. The large numbers of Mantispids which are found indicate a high mortality among young spiders, but, even so, the number of adults remains large. The natural checks on spiders in the adult stages must be sought elsewhere. The effect of spiders depends, to some extent, on what proportions of their food consists of insects engaged in attacking pest species. As they are very general predators, it is likely that the proportion will be as the proportion of pest predators and parasites to the total number of insects present. As the vast majority of insects present have no connection with the immediate faunal complex of the trees, it is likely that these will form the bulk of the spiders' diet. The effects of spiders on the pest-destroying species would then be rather less than might be expected, but it must be remembered that they may cause considerable disturbance of the latter, and in that way hamper their activity.

The ants, spiders and other general predators are seen to stand at the end of a 'food chain'. The factors controlling these species are many and complex, (in the case of the ants the complex question of foraging territory is involved

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in addition to the other usual factors). Parasites, food supply and the attacks of larger insects and vertebrates and each other are important factors, together with such little understood matters as prey specificity, and ability to seek out prey.

The general picture of the state of affairs in connection with scale species is given below, diagrammatically, in a simplified form:-

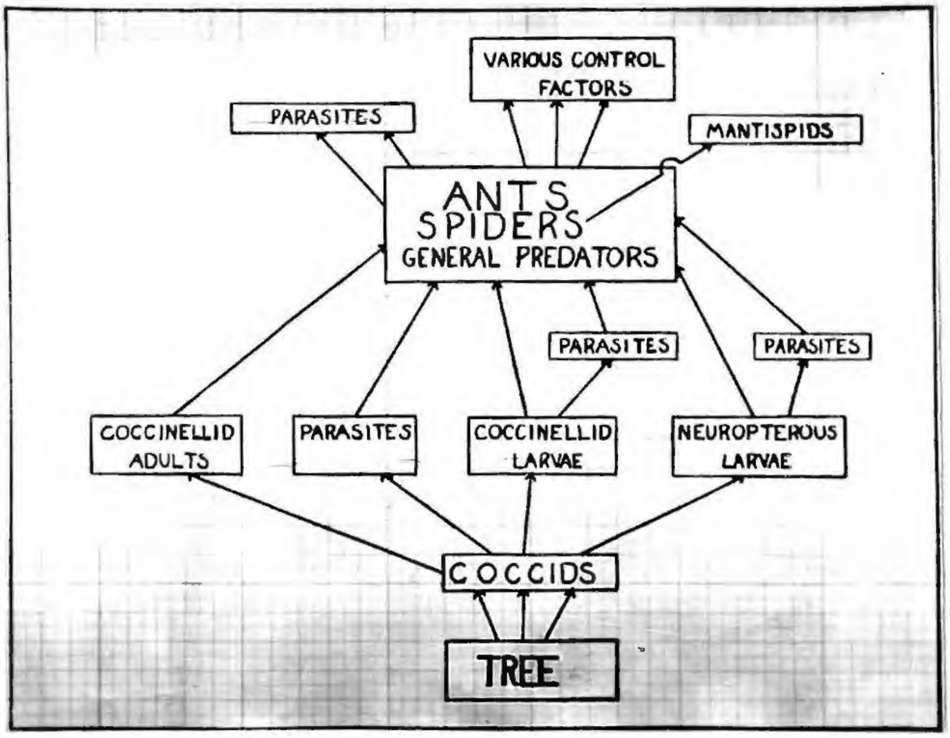

Diagram II

Food chain based on Coccids

The adult Coccinellids are attacked by a variety of general predators, and ants, in particular, disturb their activity, if not actually attacking them. The parasites of Coccids are attacked by ants and other general predators and by hyperparasites. The relative importance of these various factors in reducing parasite populations is not completely known, nor easily assessed. Many established species of parasites are able to maintain a high percentage of parasitism provided they are not disturbed too much, e.g. parasites of soft scale are able to maintain a percentage of some 25 per cent. in spite of the presence of ants in some areas.

Coccinellid larvae and neuropterous larvae attacking Coccids may be considered together as they are faced with similar resistant factors in the environment, and there is a direct antagonism between them. They are both attacked very heavily by parasites and this has an important effect on their ability to destroy scale. The larger the larvae the larger the scale they are able to attack. This limitation with regard to size of prey has been observed in the laboratory. Individuals weakened by parasites are probably less able to attack the larger scale, with the result that the few healthy larvae are left to deal with the large, breeding scale. They do not, in most cases, appear to be able to reduce the scale population when faced with the hardship of interference from ants. <u>P. megacephala</u> has

- been ...

been observed attacking Coccinellid larvae in the field.

One aspect of scale relationship remains to be mentioned, namely, that existing between the various species of scale themselves.

Firstly, the honey-dew producing species (and aphids) reduce the environmental resistance for all other species of scale, attracting and introducing into the complex of the tree the protecting ants. This subject has already been dealt with in some detail in regard to red scale and the custodian ant.

Secondly, it has been noticed that the colonies of scale are seldom mixed. In colonies of scale in which two or more species occur the individuals of the two species are seldom found mingling together. If two species occur on the same tree, it is more usual for them to occur in more or less distinct pockets. This cannot be due to limited movement on the part of the crawlers as crawlers of most species are known to be capable of long-distance movement. Can it be, then, that the scale introduce into the plant certain toxins which act as deterrents to other species of plant-sucking insects, such as other species of scale?

Considering the aphids, it may be said that their relationships are much the same as those of the Coccids. In addition, they have specific predators, the Syrphids, which

-in ...

in the absence of ants, control the aphid numbers in a most spectacular manner. The Syrphid larvae are attacked by parasites and ants, and being less pugnacious than the Coccinellid and neuropterous larvae, are at a disadvantage. Nevertheless, they constitute a most important element in aphid control. The presence of aphids has the same effect as the presence of other honey-dew producers, in that it decreases the environmental resistance for several species, by introducing into the complex, the ants.

Citrus trees are attacked by comparatively few defoliating insects, and those which do occur do most damage to young trees, and the most tender shoots of the older trees. The main species concerned are Papilio demodocus in the larval stage, Asynonychus godmani in the adult stage, and the few species of Tettigoniids.

Papilio demodocus is distasteful to vertebrates as the larvae possess osmeteria from which a very characteristic odour is given off. The eggs of these butterflies are laid on the surface of the leaf, singly, and are probably eaten by various insects and attacked by parasites. The larvae are attacked by predaceous insects and possibly birds. Ants are great enemies of the caterpillars.

The Tettigoniids are really only casual visitors, as they are just as likely to be found feeding on weeds etc., as on the trees. They are naturally controlled by birds, mantids and other insectivorous animals.

- Asynonychus ...

Asynonychus godmani is an interesting species on account of its great tolerance to hydrocyanic acid gas in the adult stage; there is some evidence that this tolerance has increased to some extent in the last few years. The adult is wingless and attacks mainly the lower leaves. The main controlling factors seem to operate against the larvae, which attacks the roots of a variety of plants. They seem to prefer plants other than citrus. It is noteworthy that these insects are more common in those orchards in which there is much weed growth. The availability of food is an important factor and the need for searching for food no doubt leads the larvae to be more easily overcome by predators.

The mites affecting the trees have not been closely studied. There is a distinct complex of species, based on the phytophagous mites, comprising the predaceous mites, the Coniopterygids, and certain Cecidomyid species. In addition to this, mites are known to attack the eggs of the False Codling Moth.

The fauna associated with the stems and bark of citrus is perhaps the most neglected of all the groups concerned with the trees. It includes such species as *Icerya purchasi*, which prefers as a feeding place some small crack or break in the bark. There are two species of Bostrichid which are thought to attack the stems. A small, interesting group of species occurs below the bark of those trees on which the stem

- has ...

has been cut and the bark dried out and peeled off to some extent. In the crevices so formed, a wingless Psocid is found, presumably feeding on the fungus which grows on the wood. This insect is apparently attacked by a predaceous thrips, which in turn, forms the major part of the diet of a spider which also lives beneath the bark. In the loose web which the spider spins, the remains of thrips have been found sometimes together with parts of small flies and beetles. It is likely that this small complex of species would not be confined to citrus trees, but search of neighbouring trees which appeared to offer very similar conditions failed to yield any of the species found below the bark of the citrus trees.

The uniqueness of the False Codling Moth as a pest has been mentioned, but even though present in small numbers this species has certain ecological effects. The presence of the larva within the fruit causes premature colouring and this is believed to induce oviposition by the Trypetids. The larva also causes the fruit to fall from the tree, and thus the food of those species attacking fallen fruit is increased, or, at least, is made available a little earlier. This means that the Drosophilids are supplied with decaying fruit and the food supply of the Nitidulids is also increased.

A list of the species associated with fallen fruit has already been given, and it is intended here to enter into a little more detail on this subject. The larvae of certain

- Drosophilid ...

Drosophilid flies, the Nitidulids (Carpophilus spp.) and the larva of the False Codling Moth live on the substance of the fruit. The last-mentioned species prefers fresh fruit but its activity paves the way for the attack of fungi on the fruit, and this leads to the state of decay preferred by the flies and beetles. The habits of the Stratiomyids and Syrphids living in fallen fruit are not known with certainty, but they appear to live on the substance of the fruit. The former species may be predaceous. Both of these last mentioned families are less frequently encountered than the Drosophilids. Fallen fruit was collected and 40 fruit were opened and their faunae collected. When large numbers of adult Nitidulids were present, it was not always possible to collect all the specimens, for as soon as the fruit was disturbed the beetles would make off at great speed. It seems that the adult beetles spend some time in the soil below the fruit as there are usually well-made burrows into which they disappear when disturbed. The larvae pupate in the soil. The majority of the beetles, however, were captured, and those which escaped were from fruit containing large numbers of specimens. Not every fruit contained insects, even some of those well-decayed were not inhabited. Of the 40 fruit, only 29 were found to contain specimens.

Figures 5, 6, and 7, indicate the numbers of insects taken. The data on which these figures are based are to be found in Table G of the Appendix.

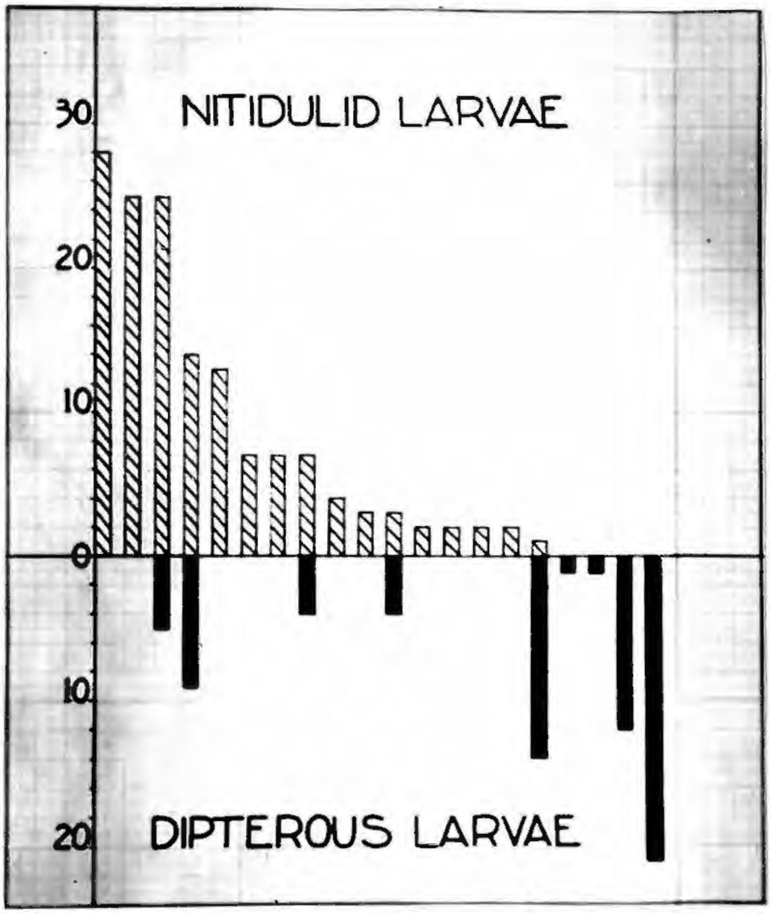

Figure 5.

Larvae of Drosophilids and Nitidulids from fallen fruit.

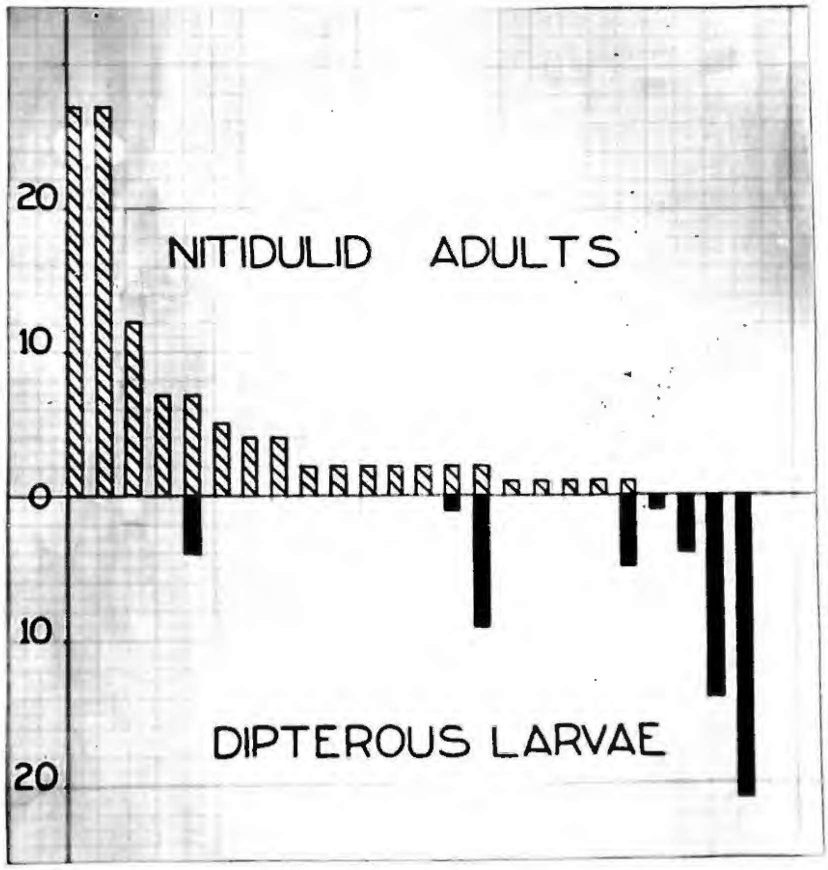

Figure 6.

Adult Nitidulids and Drosophilid larvae from fallen fruit.

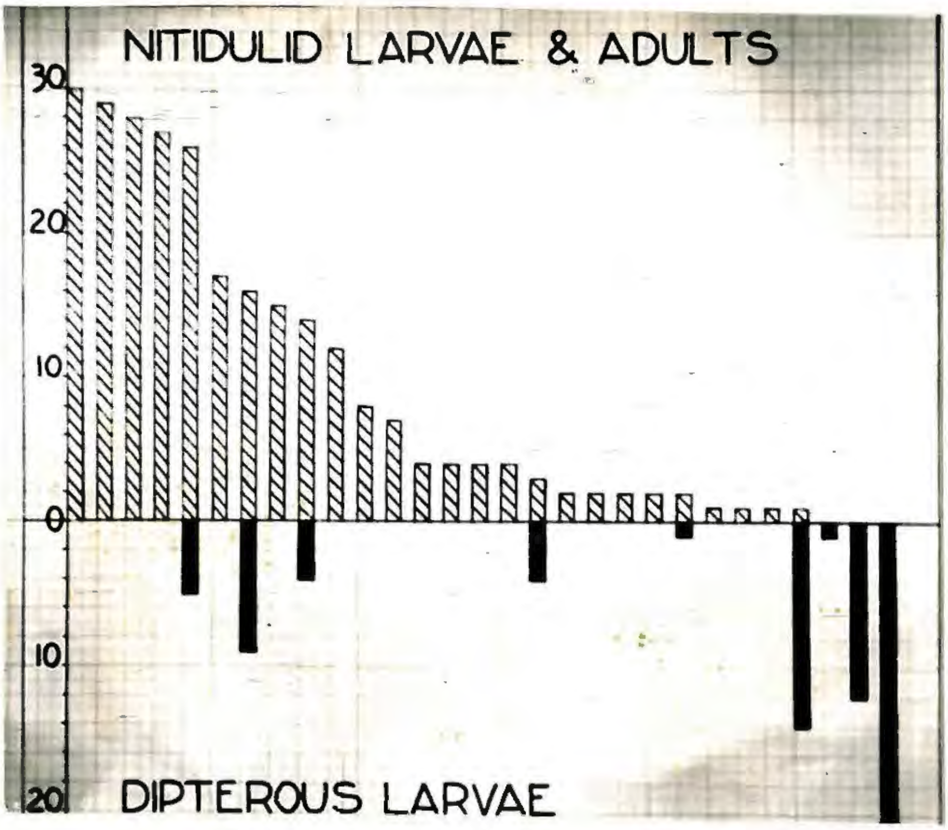

Figure 7.

Nitidulid larvae and adults and Drosophilid larvae from fallen fruit.

The foregoing figures indicate that larval and adult Nitidulids tend, for some reason, to be less abundant in the fallen fruit in which Drosophilid larvae occur. In general, there are fewer Drosophilid larvae where there are more Nitidulids, either larvae or adults (Fig. 7). The same may be said of the relative numbers of Nitidulid adults and Drosophilid larvae (Fig. 6) and Nitidulid larvae and the larvae of Drosophilids (Fig. 5). The reason for this apparent antagonism between the Nitidulids and the Drosophilid larvae is not known. It is probable that each species is able to develop only when the fruit is in a certain stage of decay, and that when a fruit is suitable for the beetles it is not so for the flies and vice versa. The interrelations of the insects of fallen fruit is in need of experimental investigation.

An interesting point is the degree of movement shown by the insects of fallen fruit. Only the adult beetles are known to move from one fruit to another in the field. The larvae apparently remain in the fruit as long as conditions there are satisfactory, and a food supply is available. This means that each fruit is an almost 'closed' environment so far as the larvae are concerned. If a large number of fruit are placed in contact with one another a certain amount of migration of beetle larvae takes place between them, and this gives them a greater source of food with the result that the distinct indication of the relation-

- ships ...

ships between the species breaks down.

HONEY-DEW AND NECTAR.

The pollination of citrus flowers has not, as yet, been studied in the Eastern Cape.

A very important factor in the insect ecology of the trees is the honey-dew produced by certain Coccids and the aphids. A list of species associated with this substance has already been given. During the field work it was most noticeable that the presence of honey-dew at any point was the cause of a congregation of large numbers of insects, some normally found in the orchards, but a great many of which were strangers, and seen only in connection with the honey-dew. From the point of view of the ecology of the orchards we must remember that honey-dew is produced by pest species, and we may deal with the two types of insects visiting it separately.

1. We deal here with the normal inhabitants of the orchards which visit the trees with honey-dew. It is seen that they do so for two main reasons - either they are attracted by the substance itself, or they are attracted to the large number of insects which congregate there and on which they might feed. The honey-dewed leaves, therefore,

- become ...

become a feeding centre for a large number of insects of all types, and as such constitute an important factor in the ecology and interrelationships of the species concerned. Many species may meet their mates on such trees. The fact that insects gather at honey-dew means that there is a tendency for insects which normally lay eggs on citrus trees to do so there in greater numbers than elsewhere. In the case of predators of pest species this is no doubt an important factor in the distribution of the species within the orchards in the larval stages. The tendency for hymenopterous parasites to be attracted is also of importance in this respect. Such species as the Mantispids, in which the adults are carnivorous, are attracted, with the result that more egg-masses are deposited in the vicinity of honey-dew. It is here, too, that spiders, on the egg-masses of which the larval Mantispids live, are most numerous. In fact, the trees with honey-dew are centres of more intense insect activity than other trees.

2. The many insects attracted from outside the orchards are also important. If there are species which have merely come for the honey-dew, then they form additional prey for the predators already present; if they are predaceous themselves they will increase the number of possible predators of pest species. There is little doubt that many specimens of such species as the lacewings, Hemerobiids, Syrphids and some parasitic Hymenoptera are

- attracted ...

attracted into the orchards primarily for the honey-dew, and having arrived there, feed also on the scale, aphids and other pests. In the final analysis, it is difficult to assess the importance of honey-dew from an economic point of view, but from an ecological point of view, its function is clear - without doubt it is a great influence in increasing the number of species and specimens to be found in the orchards, and it forms the meeting-point of species from within and without the orchards. Obviously the whole tempo of insect life is increased on the trees with much honey-dew.

GENERAL PREDATORS

The orchards are full of insects which prey upon a wide variety of insects, and to these the term "general predators" has been applied. These species are difficult to consider from an ecological point of view. There are large numbers of species - the Reduviids, Mantispid adults, Carabids, Malachiids, Formicids, and perhaps the Anthicids - which fall under this heading. The effects of the ants we have met with constantly; they undoubtedly destroy large numbers of insects which feed on pest species. It appears likely that general predators are beneficial in citrus orchards as far as larger species are concerned, but are somewhat detrimental with regard to small species. This is a very general statement and requires confirmation or refutation. We face here our almost complete ignorance of the specificity of preying habits once more. Our conceptions of the roles which the majority of species play will be altered when more extensive tests and observations have been carried out. We can only consider the general predators as a whole, and their effects collectively, including the spiders. As has been pointed out elsewhere, if their diet consists mainly of those insects which normally live on pest species, then they cannot be considered as beneficial from the economic point of view. As, however, they would

- seem ...

seem to prey more on species not directly involved in the community complexes of the trees, it appears that they are not of great importance economically. Ecologically, they would have a general "levelling effect" on a wide variety of species, reducing their numbers somewhat, in a rather indiscriminate manner.

INSECT MOVEMENT

The movements of insects in the orchards and trees are not of a spectacular nature under normal conditions, but on considering the habits of some of the species to be found there, and the effects which their movement may have on the community as a whole, it is seen that movement is of great importance. There are two distinct aspects of this to be considered.

1. <u>The movement of insects from one part of the tree to another</u>. It is clear that the tree may be looked upon as several distinct sub-habitats, that is, it consists of several distinct environments, in each of which certain species find more or less optimum conditions for activity and development. There is surprisingly little movement of insects from one to the other, considering the proximity of the sub-habitats to one another. In certain cases such movement does take place, with greater or lesser effects on the ecology of the trees. A good example is the False Codling Moth which during its life history occupies no less than three distinct sub-habitats. In its early stages, it is essentially an insect of the fruit on the trees. It causes fruit-fall, thereby becoming a member of the normal community of fallen fruit. Pupation takes place just below the soil surface, and the insect is then a part of the soil fauna. In each of these sub-habitats it remains for a

- certain ...

certain length of time, and during that time enters into the community of each as a proper and true participant in the ecology of that community. The Drosophilids are are essentially inhabitants of the fallen fruit in the larval stages, but the adults frequent the trees for protection and for the sweet secretions to be found there. The weevil, Asynonychus godmani, is an interesting example of a species which moves from one sub-habitat to another. The larvae, in their feeding activities may, in fact, move completely out of the community of the tree, and enter the weed communities.

The striking distribution and relationships of the Nitidulids have already been mentioned and the effects of movement of the adults pointed out. Even with great movement on their part very few specimens were taken from the trees. Here, as in most cases, movement is very strictly controlled and is connected with a very definite part in the life activities of the species. It is by no means aimless.

The ants operate in almost every sub-habitat of the trees and have profound effects in each, even when they are merely passing through on their way to other parts of the trees. This is the case with their influences on the insects of the bark of the trees.

2. Insect movement from one part of the orchard to another. There is a definite movement of adult

- Lepidoptera ...

Lepidoptera from the orchards to food sources; the adult _Papilio demodocus_ feeds mainly out of the orchards, only coming in to oviposit. Perhaps the greatest movements are those which take place to and from the trees with large quantities of honey-dew. Here there is a definite directed movement of large numbers of insects for a definite purpose. There is thus a concentrating movement of individuals coming to the trees and a dispersing movement from them. Movement into a tree with honey-dew means, for the individual, movement into an area in which insect life is at a much increased concentration.

The movement of small insects under the influence of air currents is a subject which has received attention these last few years. In the orchards this leads, apparently, to a general drift of insects of small size, and a somewhat characteristic distribution of such insects as scale crawlers (Quayle, 1916). When air currents reach a certain velocity most insect activity ceases, and the insects take refuge in the trees or in low herbage.

The importance of the movements in the orchards, however carried out, and for whatever purpose it may be undertaken, lies in the effects which it has on bringing together elements of the faunae of the different sub-habitats, and of different parts of the orchards and their surrounding habitats. The total insect fauna of the orchards is thus bound into one community by the movements of the species

- present ...

present; these movements are the foundation of the 'community' as a whole - without them the tendency would be towards a greater number of more distinct communities of smaller size.

While bearing the various conceptions of insect activity in the orchards in mind, we may, perhaps, attempt a simplified picture of the community complex of the orchards as a whole, and that of the trees in particular.

CHAPTER V

CONCLUSION

We have, in citrus orchards, a series of small, more or less distinctly separated, communities of insects, in each of which there is a complex of species based on the phytophagous types, and proceeding up through a series of more or less specific predators to the general predators, most of which are not confined to any one community, but are common to many. In the particular community of most interest to the citrus entomologist, namely, that associated directly and immediately with the citrus trees themselves, we find a series of sub-habitats, with their smaller sub-communities, such as that of the leaves, the stems, the fruit, and the fallen fruit. In each of these there is essentially the same community structure, and this is the same as that of the community as a whole. Binding these separate ecological units into a more or less unified whole, are those species which are common to all. These are, in fact;

(1) The general predators.

(2) Those species which move from one community to another for some reason.

(3) Those species attracted from one community to an-

- other ...

other due to the requirements of their developmental processes and habits.

From this, it is seen that the ecology of the trees themselves is inseparable from that of the rest of the orchard, such as the weeds and the soil. Any study of an insect species on the trees must ultimately take full consideration of the total community structure of the orchard, as each species is so intimately bound up with its environment as to be almost one with it.

SUMMARY

After a brief introduction, the species of Citrus on which the investigations were carried out are mentioned. This is followed by an account of the methods of collection used, and a discussion of their relative merits. The main method used was that in which the trees were fumigated with hydrocyanic acid gas, and the insects falling from the trees were taken up on sheets. The location of the areas where collections were made are then given.

An annotated list of the species taken by the fumigation method follows, and the numerical data obtained at the same time regarding the species present is given in an abbreviated form and discussed. A more detailed discussion of the relative abundance of the species is then undertaken.

The discussion of the ecology of the insects commences with the insects listed according to their activities, so far as known, and an account of five trees of striking faunal differences is given. A broader discussion of citrus ecology is then given, based on the data previously presented; this ends with a short reminder of the inherent "oneness" of the insect with its environment.

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APPENDIX

Table A

No. of *Anoplolepis custodiens* ascending tree, with Temperatures

Time Period	Ants/¼ hour	Temp. (C.)
8.45- 9.00 a.m.	236	24
9.00- 9.15	225	
9.15- 9.30	242	
9.30- 9.45	204	
9.45-10.00	241	26
10.00-10.15	252	
10.15-10.30	236	
10.30-10.45	205	
10.45-11.00	211	28
11.00-11.15	220	
11.15-11.30	190	
11.30-11.45	237	
11.45-12.00 noon	188	30
12.00-12.15 p.m.	174	
12.15-12.30	163	
12.30-12.45	156	
12.45- 1.00	198	32
1.00- 1.15	216	
1.15- 1.30	285	
1.30- 1.45	338	
1.45- 2.00	346	33
2.00- 2.15	314	
2.15- 2.30	368	
2.30- 2.45	357	
2.45- 3.00	367	35
3.00- 3.15	341	
3.15- 3.30	336	
3.30- 3.45	346	
3.45- 4.00	358	36
4.00- 4.15	365	
4.15- 4.30	358	
4.30- 4.45	372	
4.45- 5.00	414	34
5.00- 5.15	411	
5.15- 5.30	446	
5.30- 5.45	392	
5.45- 6.00	435	32
6.00- 6.15	404	
6.15- 6.30	386	
6.30- 6.45	374	
6.45- 7.00	366	30
7.00- 7.15	331	
7.15- 7.30	309	
7.30- 7.45	304	
7.45- 8.00	282	28

Table B

Percentage of Trees in each Orchard on which each Group of Arthropoda was taken.

Group	A	B	C	D	E	F	% of Total
Collembola						10	1.2
Orthoptera	8.3	49.5	33.2	40	21.7	70	34.8
Phasmatodea				20			1.2
Thysanoptera	41.5	4.95	16.6	20			10.8
Blattariae	16.6		16.6		8.68		7.2
Mantodea	8.3	4.95	24.9	20	21.7	20	15.6
Corrodentia	16.6	14.85	16.6	20	4.34		10.8
Neuroptera	91.3	64.35	74.7	20	69.44	100	75.6
Homoptera	83.0	65.25	83.0	80	91.14	70	80.4
Hemiptera	66.4	89.1	83.0	100	60.76	30	69.6
Odonata			8.3		4.34		2.4
Plectoptera		4.95	16.6	20	39.0	40	20.4
Lepidoptera	66.4	95.05	74.7	40	81.46	80	78.0
Diptera	91.3	100.0	100.0	100	100.0	100	98.4
Coleoptera	100.0	100.0	100.0	100	100.0	100	100.0
Hymenoptera	100.0	95.05	100.0	80	100.0	100	96.0
Chelonethida				20			1.2
Acarina	25.0		8.3	100			10.8
Araneida	100.0	100.0	100.0	100	100.0	100	100.0
Chilopoda				20			1.2

Table C

Numbers of Specimens Obtained from Trees from which Fumigation Collections were Made

Tree No.	ORCHARD					
	A	B	C	D	E	F
1	181	173	124	160	116	128
2	218	125	157	74	174	175
3	118	135	217	157	139	91
4	106	133	231	182	125	130
5	120	186	127	135	86	277
6	154	149	269		80	164
7	106	107	54		111	109
8	179	186	107		84	72
9	38	102	-		195	171
10	52	70	89		105	195
11	37	79	166		84	
12	55	229	99		67	
13		160	113		51	
14		61			185	
15		109			127	
16		33			79	
17		35			125	
18		197			72	
19		54			123	
20		135			196	
21		110			81	
22					78	
23					81	
Totals	1376	2568	1753	708	2564	1512
Highest	218	229	269	182	196	277
Lowest	37	33	54	74	51	72
Range	181	196	215	108	145	205
Average	114.6	122.3	146	141.6	111.4	151.2

Table D

Trees grouped According to Number of Specimens Obtained.

No. of Specimens per Tree	No. of Trees
Trees giving between 20 and 40 specimens	4
" " " 41 " 60 "	5
" " " 61 " 80 "	9
" " " 81 " 100 "	9
" " " 101 " 120 "	14
" " " 121 " 140 "	14
" " " 141 " 160 "	4
" " " 161 " 180 "	9
" " " 181 " 200 "	9
" " " 201 " 220 "	2
" " " 221 " 240 "	2
" " " 241 " 260 "	-
" " " 261 " 280 "	2
	83

Table E.

Ant Activity and Red Scale Infestation in Orchard IV

For convenience the trees have been arranged in the order of ascending intensity of scale infestation.

Tree No.	No. of Scale	No. of Ants
29	1	3
30	2	15
5	3	9
19	3	12
7	5	43
4	7	120
27	7	148
23	8	21
26	8	195
1	9	4
25	9	12
8	10	20
32	11	234
41	11	405
31	14	57
2	18	137
33	20	374
14	21	32
28	22	143
6	26	51
21	33	90
39	34	207
35	35	277
42	36	440
38	68	68
40	72	68

Table F

Ant Activity/Scale Infestation

Tree No.	Ants	Scale	Ant/Scale
1	4	9	.44
2	137	18	7.61
4	120	7	17.14
5	9	3	3.00
6	51	26	1.96
7	43	5	8.60
8	20	10	2.00
14	32	21	1.52
19	12	3	4.00
21	90	33	2.72
23	31	8	3.87
25	12	9	1.33
26	195	8	24.37
27	148	7	21.14
28	143	22	6.45
29	3	1	3.00
30	15	2	7.50
31	57	14	4.07
32	234	11	11.27
33	374	20	18.70
35	277	35	7.91
38	46	68	.67
39	207	34	6.08
40	56	72	.77
41	405	11	36.81
42	440	36	12.22

Table G

Insects Taken from Fallen Fruit

Fruit	Nitidulid Larvae	Nitidulid Adults	Total Nitidulids	Drosophilid Larvae
1	28	-	28	-
2	-	1	1	-
3	7	-	12	-
4	4	-	4	-
5	2	-	2	-
6	25	1	26	5
7	2	27	29	-
8	-	2	2	-
9	2	2	4	-
10	7	1	8	-
11	-	2	2	-
12	-	1	1	-
13	2	2	4	-
14	-	-	-	21
15	-	-	-	1
16	1	-	1	14
17	3	-	3	4
18	-	4	4	-
19	3	12	15	-
20	-	2	2	-
21	-	-	-	12
22	-	7	7	-
23	-	27	27	-
24	25	5	30	-
25	14	2	16	9
26	13	4	17	-
27	-	2	2	1
28	-	1	1	-
29	7	7	14	4