SOME ASPECTS OF THE MICRO-ARTHROPOD FAUNA IN THE SOILS OF PINEAPPLE FIELDS, IN THE BATHURST DIVISION, EASTERN CAPE PROVINCE.

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THESIS FOR DEGREE OF M. Sc.

1956

"You may seek it with thimbles,
you may seek it with care,
you may hunt it with forks and hope,
you may threaten it's life with a railway share,
you may charm it with smiles and soap."

Lewis Caroll.
"The Hunting of the Snark."

CONTENTS.

INTRODUCTION.

Although a considerable amount of work has been done on the fauna of the soil of temperate forests and pastures, very little is known about that of tropical and sub-tropical soils. Most of the work done on tropical soils concerns the fauna of the tropical forests. Only a few papers, such as Van Zwaluenberg (1931) on the fauna of Hawaiian sugar-cane fields, Strickland (1947) on grass-lands in Trinidad, and Salt (1952 and 1955) on cultivated land, pastures and elephant grass leys in East Africa, do not deal with forests.

In South Africa, Lawrence's (1953) study of the biology of the floor fauna of the relict forests is the only published work. Some unpublished studies also exist. Watts (1951) endeavoured to show the effect of the planting of pine trees and blue gums on the fauna of the relict forests. However, he took too few samples and did not distinguish between those plantations cleared from forest and those planted on grassland or heath. Farquhar (1947) carried out morphological studies on a few selected soil inhabiting arthropods. Carnegie (1954) carried out a very brief study of the fauna in the soil beneath different trees in a citrus orchard, but the methods he used are questionable, and this study may be disregarded.

Even in Europe comparatively little work has been done on the effect of cultivation on the fauna of the soil, though a fair amount has been done on grass leys and pastures. Tischler (1955 a & b) has studied the effects of annual cereal crops on the fauna of the soil in Germany; Strickland (1945) compared the soil faunas of cacao plantations and the natural tropical forests in Trinidad from which the plantations were originally cleared; Salt (1952) took a few samples from cultivated lands in his study of the soil fauna of grassland in East Africa and Van Zwaluwenberg (1931) has published an account of the soil fauna of sugar-cane in Hawaii.

The present investigation represents an attempt to discover the effect of an imported perennial tropical and sub-tropical plant, the Pineapple, on the soil fauna of a semi-arid region (rainfall 15-25 inches).

Three well-established "Queen" pineapple fields, each of over six years' growth, were sampled and their soil fauna compared, quantitatively and to a lesser extent qualitatively, with that of the soil under the natural vegetation from which they were originally cleared.

The three types of natural vegetation chosen were (classified according to Dyer, 1937) inland scrub or poor bush, low forest or tall bush and coastal grassland.

The first two of these are distinguished by the habit of the trees, rather than by the species, most of which are common to both. The canopy of the scrub is about 8 to 9 feet above the ground while that of the tall bush is about 12 to 18 feet high. The latter also contains a few plants more characteristic of the relict forests such as _Dracaena hookeriana_. The grassland was a typical coastal pasture growing on very sandy soil, and consisting largely of "Rooigras", _Themeda triandra_. This area was heavily grazed by cattle and was used as a pasture before part of it was planted with pineapple.

In all cases only the upper six inches of the soil was sampled. Thus this investigation deals only with the effect of the Queen variety of the pineapple on the upper six inches of the soil, but since this upper six inches is believed to contain about 70% of the total soil fauna unless deep ploughing is used, it seems to be adequate for comparative purposes, since in pineapple cultivation only shallow ploughing is generally used.

DESCRIPTION OF EXPERIMENTAL AREAS.

As has been stated in the Introduction, three areas were chosen for sampling. One of these was on Mr. A. W. Staples' farm "Unique" in the Blaauwkrantz valley near Langholm. The other two were on Mr. A. W. Legg's farm "Glenhope" at Hayes Siding about five miles from Bathurst. These two areas are about a mile and a half apart and 15 miles from "Unique". The Bathurst district lies at the extreme southern limit of the sub-tropical zone and is sometimes considered as warm temperate rather than sub-tropical.

Area I : Farm "Unique". This area lies on a fairly steep north-facing slope, draining down into the Blaauwkrantz river. The mean annual rainfall is about 20 inches, but must have been considerably below this in the year studied (1955), though no records are available. The soil is a light loam, very stony, and rather poor agriculturally.

The pinefield is eight years old, has reached the end of its economic life and is soon to be uprooted. The growth of pineapples is very patchy, being good in places and very bad in others, apparently at random.

The natural vegetation adjoins the lower borders of the field. It may be described as a high inland scrub or as a low bush. The canopy is about 8 to 10 feet above the ground. The whole association is very thorny and there is comparatively little herbaceous cover on the ground. The litter layer (absent in pinefields) is relatively thin. This bush has been much cut by firewood gatherers, which may account for its poor growth.

Area II : Farm "Glenhope". This area lies in a valley on a slight slope facing the sea, which is about four miles distant. The mean annual rainfall is over 25 inches, but was probably somewhat less in the year of sampling (1956). The soil is a clayey loam, and stones are almost absent. The pineapples are growing on almost flat ground. The field is about six years old and is an island of "Queens" in a much larger field of "Cayennes". The growth of the pineapples is almost uniformly good, with occasional dead or stunted plants. This field is referred to as Glenhope pinefield, 1.

The natural vegetation lies about 100 yards from the area of pinefield sampled. It may be described as tall bush or low forest. The plant species in the association are mainly the same as those in the bush at "Unique". Its general appearance is very different, however. The canopy is much higher, about 20 feet from the ground; thorny plants are much less in evidence; certain trees, absent at "Unique" and more characteristic of the relict forests, such as Dracaena hookeriana, are common. There is a considerable growth of herbs on the floor and the litter layer is fairly thick. In general aspect this bush resembles the low relict forests on the Zuurberg, rather more than it does the "Unique" bush.

Area III : Farm "Glenhope". This is situated about a mile and a half from the last, and about 100 yards from Hayes Siding. It is on top of a low ridge overlooking the sea. The rainfall is the same as in the last area. The soil is very sandy and stones are absent. The pinefield is about 6 to 7 years old and is now being uprooted. It is broken up into belts of about 40 yards width by rows of elephant grass (Pennisetum sp.) which are used as wind breaks. The area does not seem to be well suited to pineapples, being according to Mr. Legg, too sweet (alkaline) and subject to waterlogging. The growth of the pineapples is almost uniformly poor. Sampling was carried out as far as possible from the wind breaks. This field is referred to as Glenhope pinefield 2.

The field is almost entirely surrounded by the grassland from which it was originally cleared. This is a typical coastal pasture, in which the dominant grass is "Rooigras" (Themeda triandra). It is fairly heavily grazed and both old and fresh droppings are abundant. This grazing must have an effect on the fauna but since it was used as a pasture before being planted with pineapples, this need not be taken into consideration.

THE SOIL FAUNA : A BRIEF REVIEW OF THE GROUPS OF SOIL-INHABITING ARTHROPODS FOUND IN THE PRESENT INVESTIGATION.

1. Introduction. The soil fauna, or edaphic fauna as it is often called, has been recognised as an ecological entity for a considerable time, but it is only during the present century that it has been studied as such. In fact, it was the invention of the Berlese funnel that first made the study of this fauna a practical proposition.

The groups of arthropods that make up this fauna have been reviewed several times. The most important of these reviews are those of Jacot (1940), Strickland (1945) and Kuhnelt (1955 a and b), while Lawrence (1953) has published an important account of the biology of the floor fauna of forests.

The following is a brief account of the various groups of arthropods found in the present investigation. Tables 20 - 28 (appendix) show the groups of Arthropod captured at each station and the number of samples in which they occurred.

2. Myriapoda. The myriapods represent a very small proportion of the fauna of the soils studied. They never account for more than 4% of the fauna in the natural vegetation and were always below 2% in the pinefields.

This is in contrast to the findings of Van Zwaluwenberg in Hawaii, where the Myriapoda formed 25% of the arthropod fauna and were the second most important group.

All four classes of myriapods were found in this investigation. The Chilopoda were virtually absent in the pinefields and none were obtained in the grassland. They were more numerous in the bush soils where the commonest species was a geophilid, Polygonarea oligopus Attems, but they were never common. Diplopods were taken at all stations, but were nowhere common. Both juliforms and polydesmids were collected. The majority of the specimens obtained were juveniles, many being in the hexapod stage.

The dominant myriapods in the pinefields and grassland were the pauropods. They are also common in the bush soils. Professor P. Remy of the University of Nancy has recently identified 3 species from material I sent him. One of these is a well-known European and Tropical African species, Allopauropus danicus (Hansen). The other two are previously undescribed species which he has named A. grahami and A. adjacens (in press). The Symphyla vie with the pauropods for the position of the dominant myriapods in the bush soils, but are very rare in the grassland and pinefields. Two species of these myriapods were found, representing two families. The commonest was a scutigerellid, Hanseniella sp. The other was very rare and found only in the bush at "Glenhope"; it is an unidentified scolopendrellid.

3. Crustacea. The only crustaceans found were isopods. These animals are very common on the surface of all soils studied. However, very few specimens were obtained in cores, possibly due to their activity, which enables them to escape. Two species, the oniscid Philoscia (Aphiloscia) vilis B-L, and the armadillidiid Bethalus nigrinus B-L were found on the surface, but only young specimens of Philoscia vilis were taken in the cores.

4. Insecta. Insects form about 50% of the arthropod population in the natural vegetation but only about 30-40% in the soil of pinefields.

The classification of insects used in this work, is not a natural classification, but rather one of convenience. It does not follow the classification of any author.

Three Sub-Classes of insects are recognised. The Collembola, Apterygota and Pterygota. The composition of these sub-classes is explained below.

The Collembola are by far the most numerous of the insects in all soils. They form about 80% of the insects found, and next to the mites are the most important arthropods in most soils. Delamare-Deboutteville (1950) considers them, of all the soil arthropods, to be the most important indicators of soil fertility.

For the purposes of the present investigation the arthropleonous Collembola have been classified into two groupings : the "Poduridae" which represent the Poduridae of Essig (1942) or the Poduromorpha of most modern authors, together with the Isotomidae, which are placed in the Entomobryomorpha by most authors. These represent the true soil Collembola. The second group consists of the Entomobryidae, sensu stricto, of all authors. These are mainly surface dwelling forms rather than true soil forms. A few Sminthuridae have been collected at all stations and a very few Neelidae, mainly from the bush at "Glenhope".

The Apterygota (the Apterygota of Imms (1948) minus the Collembola) form only a very small proportion of the fauna especially in the pinefields and grasslands. A species of Japyx was found at all stations, and was fairly common in the bush soils. It was conspicuous, if not common in pinefield 2 at "Glenhope". A second much larger species was taken a few times in the bush soils.

A species of Campodea is not uncommon in bush soils, but only one was collected in a pinefield and none were taken in the grassland.

The Protura are the dominant Apterygota in the soil. They are common in all the soils studied, especially so in the bush. There appears to be only a single species, Eosentomon sp. nov.

The Pterygota form about 30% of the insect fauna in the grassland, and only about 20% in the bush soils and pinefields. Although a relatively small component of the fauna, this group is, in regard to variety and number of species, by far the most diversified of all the soil insects if not all soil arthropods. Twelve orders have been obtained in the course of this investigation. The ants are the dominant insects in the pinefields and grassland, but in the bush they are exceeded in numbers by the psocids. With the exception of the ants by far the greater part of the Pterygota obtained were juvenile or larval forms and most of the adult insects found appear to be only accidental inhabitants of the soil.

Some soil-dwelling insect larvae, such as wireworms and white grubs, are important pests, especially of grasslands. In this connection it is interesting to note that a white grub, the larva of the beetle Macrophylla maritima Burm. (Scarabaeidae), a well-known pest of turf at Port Alfred, has recently caused serious damage to newly established pineapples on a farm in the Bathurst district. These larvae were common in the grassland sampled, but scarce in the other soils.

5. Arachnida. The Arachnida are the dominant arthropods in the pineapple soils, forming nearly 60% of the total population. In the natural vegetation, they form about 50% and are about equal to the insects in numbers. In the course of this investigation five orders of arachnids have been obtained.

Only two specimens of Palpigradi were obtained, one in the grassland and the other in the pinefield at "Unique", although they are fairly common in a patch of waste land in Grahamstown.

Three specimens of Harvest Spiders (Phalangida) were obtained, two in the "Glenhope" bush and one in the grassland.

Pseudoscorpions (Chelonethida) were fairly common in the bush soils, rare in the grassland and almost absent in the pinefields, where only two specimens were taken (both in the same sample, at "Glenhope" pinefield 1).

Spiders (Araneida) were found in all soils, but much more commonly in the bush than elsewhere. Relatively few of these active animals were caught. They are mainly surface and litter dwellers rather than true soil animals.

The Mites (Acarina) are the dominant arachnids and indeed the dominant arthropods in all the soils studied. They account for more than 90% of the arachnids in all soils and about 99% of the arachnids in pinefields. In the pinefields they constitute over 50% of the total arthropod population and about 40% of it in the natural vegetation.

Four super-families of mites were found in all soils sampled. The Parasitoidea comprised about 10% of the mites in bush and pinefield soils. In the grassland, they were relatively more numerous, making up about 20% of the mite population. This was due to large concentrations of these mites in two samples, which contained cow dung. Collembola were also concentrated in these samples, so the mites were probably attracted by an abundance of prey. Although relatively few in number, these mites are probably the most important predators of micro-arthropods and other small animals in the soil. Eight families of parasitoids have been found in the collections, six in the bush soils, comprising eight genera and five in the pinefield comprising five genera.

The Acaroidea occur in such small numbers that for quantitative purposes they have been lumped with the Tromboidea. Only one species of acaroid, Winterschmidtia sp. A, (Winterschmidtiidae) has been found, in both the pinefield and bush at "Unique". Nine families of

Tromboids comprising 15 genera have been found in the bush, 2 families and 3 genera in the grassland while 4 families and 5 genera were found in the Pineapple fields. These two super-families are believed to be predaceous, but there is little on their habits in the literature.

The Oribatoidea are the most abundant mites in the soil. Since they are phytophagous or saprophagous they are probably the most important indicator species, but they are extremely difficult to identify.

Three families of oribatoides[1] have been found in all soils studied. By far the most numerous of these is the Oribatidae, which form over 80% of all oribatoids obtained. The Pthiracaridae are fairly common in bush soils, scarce in pinefields and almost absent in grassland. They are essentially forest forms. The Pelopidae are scarce in all soils. They are relatively more abundant in pinefields than in natural vegetation. A large species of the genus Galumna is conspicuous in all soils.

1. In most recent works these three families are each split into several smaller families, but for the present purpose the older division into three clearly recognisable families seems adequate. The three families used are those given in Brues et al (1954).

TECHNIQUES FOR SAMPLING AND EXTRACTING THE SOIL FAUNA WITH SPECIAL REFERENCE TO THOSE USED IN THE PRESENT INVESTIGATION.

Introduction.

Owing to the importance of using the best method available, a considerable amount of time was spent in the investigation of the technique of sampling in the field and the subsequent extraction of the animals from the soil, since the results obtained depend to a very great extent on these.

In any investigation of the technique of sampling and extracting of the soil fauna two important facts must be remembered :

(1) As pointed out by Kuhnelt (1955 c.) no single method of sampling or extraction is suitable for all the animals to be found in the soil, and the methods must be varied according to the group being studied, or combined if all groups are to be studied.

In the present investigation only those methods especially suitable for arthropods are considered.

(2) The second point is extremely important and concerns sampling for all groups. The fauna of the soil is not randomly distributed either vertically or horizontally but shows a decided irregularity of distribution. This applies as much to the total fauna as to the individual groups and species, and is a fact that must be taken into

consideration in sampling. This was insufficiently realised by the early workers and is perhaps still not fully realised by some workers in this field to-day. For instance, working with the total soil fauna, Thompson (1924) came to the conclusion that the animals were randomly distributed and in consequence a single spot sample of sufficient size was adequate. Jones (1937) supported this conclusion by his work on wire worms. The size of sample suggested by Thompson was a 9 inch cube. However, Glasgow (1939) showed that the Collembola in the soil are not distributed randomly and that data collected by methods such as Thompson's are inadequate when treated in the light of modern statistical analysis.

The lack of randomization in the Enchytraeid worms has recently been well demonstrated by Overgaard Nielsen (1955) and there seems no reason why his results should not apply equally to arthropods. The irregular distribution of soil arthropods is shown in results obtained in the present investigation (Table 2). Here is recorded the number of arthropods, mites and "Poduridae" in nine samples, taken on a grid system in an area of one square yard, (a) in a patch of waste land and (b) in a pineapple field. The number of arthropods obtained per sample varied from 92 to 160 and from 34 to 64 respectively. Fig. 4 (page 48 shows the variation in the number of animals within a single station ("Unique" Pinefield Station 3 series 1).

The reasons for this lack of randomization are not clear. Haarlov (1955) has endeavoured to explain it on the grounds of soil structure but does not consider his results conclusive. It is probable that both the occurrence of food and cavities in the soil are the two major factors. The possible importance of the former is illustrated by the fact that large concentrations of fauna were found in two samples containing old cow dung.

The technique of sampling will be considered first, taking into account the two points which have just been made.

<u>Sampling Techniques</u> :

Krumbein and Pettijohn (1938) give three main techniques of soil sampling for geological work :-

(1) <u>Spot sampling</u> - This method consists of taking a single sample at a particular point, and is valid only for that point and for the time of sampling. This is ruled out in faunal sampling because of the irregular distribution of the soil fauna. However, the method has been used by many workers, e.g. Thompson (1924), Ford (1935) and Watts (1951) whose findings in comparing different areas may therefore be largely invalidated.

(2) <u>Serial sampling</u> - Samples taken along a line or a grid, in accordance with some preconceived form or plan, are used.

(3) Multiple sampling - This method consists of the taking of a number of samples more or less at random over a previously marked out area, usually known as a "station". These samples may then be merged to give a mean per sample or may be tabulated individually and compared with other stations by "Analysis of Variance". In most cases both of these techniques will be used. This method of sampling seems to be the most useful for the investigation of the meso-fauna of the soil and was used in the present investigation.

Sampling Methods.

The methods of obtaining samples fall into two main categories :

(1) Direct Searching over a limited area by eye.

This method is often used, especially by entomologists and others, not concerned with exact quantitative work. It entails the collecting of the fauna on and immediately under the surface of the soil, by turning over stones, large clods of earth and by brushing away the surface layer of the soil, vegetation, litter, etc.

This method is obviously of no use for the smaller or more active animals, such as mites and Collembola, but may give a reasonable idea of the abundance of some of the larger forms, such as pterygote larvae (wire-worms, white grubs, cut-worms, etc.), isopods and myriapods (diplopods and chilopods).

A further development of this method is to sink tins into the ground so that their tops are flush with the surface and so trap animals running over the surface. This method also, cannot be used for quantitative work, even of a comparative nature, since the catch is dependent on the activity as well as on the abundance of the fauna, and the presence of one large predator such as a carabid beetle may drastically reduce the catch. However, by this method many species active at night and resting in the soil by day can be obtained. It is also useful in population studies of the larger surface animals such as Carabidae and Lycosidae, because specimens so caught can be marked and released for future catching (van der Drift 1951).

(2) Taking soil samples, counting the animals in the laboratory.

For the quantitative estimation of the fauna of the soil, it is better to use a method involving the collection of a soil sample (or samples) of a definite size and the subsequent extraction of the fauna in the laboratory.

In all sampling, it is necessary to decide on the depth from which the sample must be taken. It has been shown by many workers (Baweja, 1939; Murphy, 1955a; Haarlov, 1955; and others) that the greater part of the soil fauna is concentrated in the upper three inches of the soil, while a few ants, mites and beetle larvae may be found at depths of over 36 inches. Following the nine inch cube idea of Thompson, many workers, including Ford (1936), Watts (1951) and others, took samples to a depth of nine inches; while others took samples to a depth of one foot (Salt 1952).

For comparative work, however, it is seldom necessary to obtain the entire fauna, provided a large enough proportion of it is obtained. Therefore, a depth of six inches as used by Raw (Dobson in Lit.) and most of Salt's (1952) East African samples, seems to be sufficient. The nine inch limit seems little better, since it does not obtain the entire fauna, which may go down to over 36 inches, and since the majority of the fauna is in the upper three inches, a sample of six inches deep must be almost as good and is easier to obtain.

The number of samples to be taken must be considered in the light of the labour involved in taking samples, the apparatus used, the size of the samples, and possibly also the type of soil under study.

Methods and apparatus for taking Soil Samples.

A great diversity of methods have been used by different workers to obtain their samples. The more important of these will be briefly reviewed.

(1) Bulk Methods.

These methods are mainly used in litter sampling. Many workers including van der Drift (1951), and Carnegie (1953), merely collected the material for study into a container of given volume. Others such as McAtee (1907) and Williams (1941) collected the litter and sub-surface soil (A.O. horizon) from a given area of forest floor. Beebe (1916) collected the litter and debris from approximately four square feet of Brazilian jungle into his "war bag" and examined it on his way to New York.

In the present investigations this method was used in the collection of litter and soil for the extraction of mites other than oribatids, the litter and soil being collected from inside a marker one square foot in area. A refinement of these methods are those used by Ford (1935), Marie Hammer (1944) and Murphy (1955 b) in which a sample of required size is cut from a much larger block of soil brought into the laboratory. This has the advantage, especially for Burlese funnel extraction, that the soil is left in a natural block and not broken up. Obviously it can only be used for fairly compact soils.

Morris (1922) and Baweja (1939) used another type of bulk sampling method. They drove iron plates into the ground to form a box of required area and to the required depth. The soil in the box was removed by wire hooks. Jones (1937) used metal fans of one square foot area to remove his soil samples.

All these methods in which blocks are cut require a great deal of labour to obtain each sample, and this decreases the number of samples that can be taken at any one time. Since it is well known that in general many small samples are better than a few large ones, most modern investigators use some sort of instrument to cut a soil core, varying in diameter with the type of animal it is desired to sample. For example, wireworm samples need to be larger than those for the meso-fauna, because the animals are larger and more sparsely distributed than the meso-fauna.

Glasgow (1939) used a galvanised iron pipe, 3.2 inches in diameter, sharpened at one end, which could be driven into the soil to the desired depth by a handle. Watts (1951) used a similar instrument, 3 inches in diameter. This was tested in the present investigations and found to be unreliable since it was difficult to drive the instrument vertically into the soil, and difficult to estimate the depth to which it was driven.

Salt et al (1948) used a boring tool four inches in diameter, and six inches deep, which could be reinserted into the hole to obtain a deeper sample. Raw used a steel tube, 1 inch in diameter, to take a sample 6 inches deep in his investigations (Dobson, in lit.).

Cohen (1955) has described the tools used for wire-worm sampling, by the National Agricultural Advisory Service in Great Britain. These resemble the posthole borers used on golf courses, etc. with a device for removing the core intact.

Sampling in the present investigation :

In the present investigations, sampling was carried out as follows :
It was found that with the apparatus used, nine samples were the minimum required to give a statistically accurate comparative result, and ten samples were the maximum that could be taken in one afternoon and the fauna extracted from them in one week.

An area of about 10 yards square was selected at each site to cover as many as possible of the variations found in the field or bush. Five samples from each area to be compared were taken on a single day within the 100 square yards. Each area was sampled three times. This technique gave fifteen samples from each station which allowed for loss due to accident and also due to the fact that any sample which had obviously struck an ants' nest, could be disregarded. Where possible, ants' nests were avoided in sampling, otherwise the sampling was carried out more or less at random within the station.

All samples were taken between 2 p.m. and 4 p.m. on sunny afternoons. This removed the danger of diurnal vertical migrations. Unfortunately seasonal changes could not be allowed for, but, by testing samples taken over a short period of 3 months, the change in fauna was found to be not significant.

The instrument used in the present investigations was made to a design suggested by Professor Ewer and seems to be superior to those described in the literature for sampling micro-arthropods in the soil since its stand ensures that it is driven vertically into the soil, and prevents wobbling.

It consisted of a steel augur with a two inch internal diameter and a length of two feet. It is held upright by a support consisting of a steel tube six inches long which rests on four iron spikes that can be driven into the ground. The depth to which the augur is driven is controlled by an adjustable ring which comes to rest on the top of the tube when the required depth has been reached. (Figure 1). Using this instrument, cores of six inches deep were taken throughout this study.

The resulting counts of the fauna in a series of cores taken with this instrument have been compared with those of the fauna in a bulk sample that has been well mixed and divided into several samples. The coefficients of variance compare favourably. Those from the core samples varied from 20.9 to 38.3 and those in the bulk samples from 13.5 to 24.3 (Tables 1 and 2).

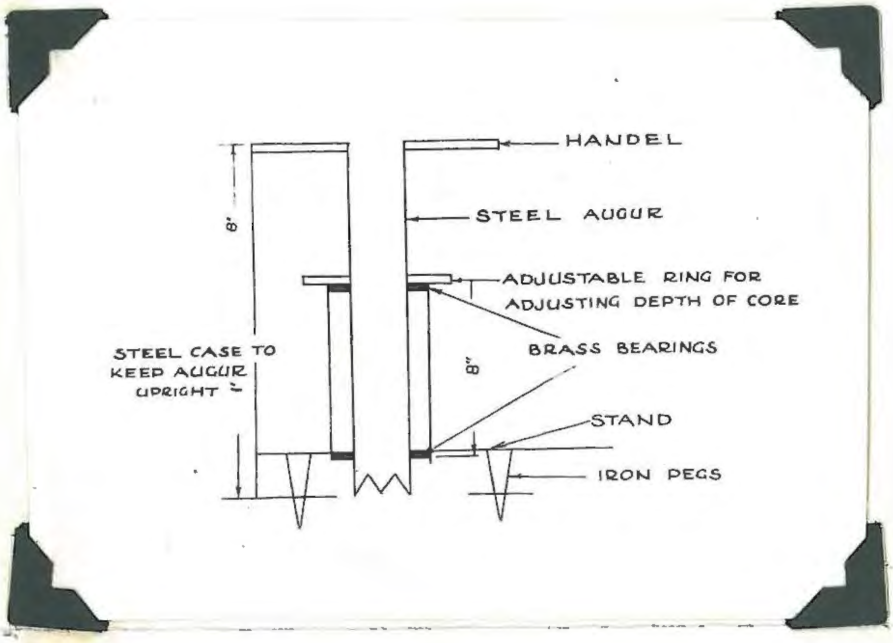


Fig. 1.

Augur For Taking Soil Samples.

Erratum. Fig. 1. For Handel read Handle.

TABLE 1.

FAUNA.	1	2	3	4	5	6	7	Co-efficient of Variation.
				EXPERIMENT 1.				
Poduridae	154	218	154	160	180	224	134	14.6
Mites	120	183	136	134	190	158	136	15.5
Poduridae & Mites	274	401	290	294	370	382	270	13.5
Total Fauna	313	451	340	336	434	447	324	16.5
				EXPERIMENT 11.				
Poduridae	251	292	353	170	307	237	-	23.7
Mites	203	193	250	120	155	216	-	24.3
Poduridae & Mites	454	485	603	290	462	453	-	21.8
Total Fauna	520	542	690	353	520	502	-	20.6

NUMBERS OF ARTHROPODS EXTRACTED FROM SAMPLES DRAWN FROM A WELL-MIXED BULK SAMPLE OF SOIL.

TABLE 2.

Fauna.	1.	2.	3.	4.	5.	6.	7.	8.	9.	Co-efficient of Variance.
A.										
Poduridae	58	21	45	30	67	36	42	36	23	38.3
Mites	69	65	61	55	80	71	71	56	58	14.4
Poduridae and Mites	127	86	126	85	147	107	113	92	81	21.5
Total Fauna	143	94	146	93	160	119	123	105	92	21.4
B.										
Poduridae	8	10	6	11	9	9	8	14	-	26.1
Mites	28	47	23	31	42	48	22	40	-	29.75
Poduridae and Mites	36	57	29	42	51	57	30	54	-	20.9
Total Fauna	40	62	36	45	53	64	34	60	-	24.5

Number of Arthropods extracted from samples of soil taken in an area of one square yard in A wasteland (same place as soil for Table 3) and B in a Pine field, to show variation.

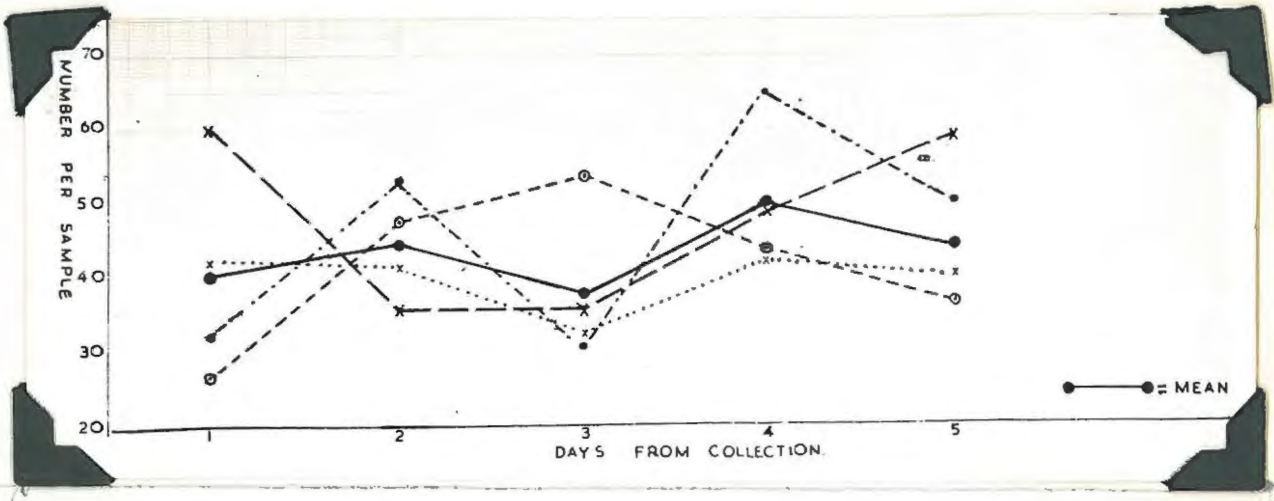


Fig. 2.

Graph Showing Number of Arthropods Per Sample Against Number of Days from Collection.

Storage of Samples :

The samples collected were brought from the field to the laboratory in bags of unbleached calico and were stored in these till sorted.

Salt (1952) considered that if samples were stored for any length of time, the composition and number of the fauna will be altered by predation. He therefore recommends the immediate freezing of the samples to immobilise the fauna. Due to lack of facilities it was impossible to freeze the samples in the present investigation. To check upon this point the fauna in the samples were plotted against the number of days from collection and found not to differ much up to five days. The composition of these samples is also much the same (Figure 2.)

Dobson (1955) states that if flotation methods are used for extraction, the samples may be preserved indefinitely in formalin.

Methods of Extracting the Fauna :

From the Soil :

The methods of extracting the fauna from the soil are very varied and almost every investigator has his own method. The principal ones will be briefly reviewed here. They fall roughly into two types : the mechanical, and those which use the reactions of the animals to extract them. The mechanical methods will be discussed first.

(1) Hand Sorting :- This method was used by most of the earlier workers such as McAtee (1907), Beebe (1916) and others. The fauna is sorted out by eye and with a hand lens or low powered microscope. Its principal disadvantages are that it is very laborious, the smaller animals are difficult to see unless they move and are thus easily overlooked, while many of the more active ones (such as Collembola) may escape. If carried out conscientiously and with small samples, it may give better catches than the Berlese funnel (Forslund 1948). The great length of time required to sort out even a small sample by this method drastically reduces the number of samples than can be dealt with at any one time.

(2) Sieving :- Many investigators such as Dammerman (1925 and 1937) and King (1939) have passed the dry soil through a series of sieves of decreasing gauge. A suitable sieve for this purpose is figured by Kuhnelt (1955 c). This method is useful when one is seeking the larger and tougher pterygote larvae, nymphal insects, grasshopper egg pods, etc., but suffers from the disadvantage that many of the more delicate arthropoda are damaged in sieving. The animals tend to get coated with dust, and become very difficult to see, so that inevitably many of the smaller forms are lost. Power-driven sifters have been developed in America for wire-worm surveys (Lange et al. 1954).

Morris (1922) devised an apparatus whereby the soil is washed through a series of graded sieves by jets of water. This apparatus, though greatly superior to the dry sieve, has many of the same disadvantages and the animals are even more likely to be damaged by the jets of water; for general survey work it has now been largely superseded by flotation processes (see below). However, this apparatus can deal with very large samples of soil; it is therefore very useful for wire-worm surveys and is still in use in this connection at Rothamstead (Strickland, 1944).

Many flotation techniques are to some extent combined with sieving.

(3) Flotation Techniques :- The idea of using flotation to separate the fauna from the soil was first thought of by Berlese (1905). In its earliest form as used by Thompson (1924), the soil was merely broken up under the water and the animals were collected off the surface. Later the idea of using a strong solution of salt to increase the specific gravity of the solution was conceived. The salt most often used for this purpose is Epsom Salts since it has a deflocculating effect on the clay fraction of the soil, but common salt is often used.

The method of merely stirring the samples up in a solution of the salt and collecting the fauna off the surface was used by many early workers, and is still useful for the extraction of fauna from mud. (Crisp and Lloyd 1954). But for soils, several complicated machines have been devised.

The first of these was made by Ladell (1936) and because this was the type of apparatus used in the present investigation, it will be described below. For wireworm extraction Salt and Hollick (1944) devised an apparatus combining washing through sieve with flotation and later applied it to micro-arthropods (Salt et al 1948). Strickland (1944) modified Ladell's apparatus by omitting the settling tank and stirrer.

Raw (1955) has further modified this process by the addition of a considerable pre-flotation treatment. The sample is first covered with an ion exchange solution containing 50 grammes Sodium Hexametaphosphate and 20 grammes Sodium Carbonate per litre of water, and the air is removed in a vacuum dessicator. The soil is thus considerably dispersed. It is then frozen for 48 hours and finally washed through a coarse sieve into a modified Ladell apparatus. This seems to be the best technique yet invented for extracting the soil fauna of cultivated lands, but Raw states that it is not designed for forest soils and has not been tested on them.

Methods which use the reactions of the fauna :

The simplest of these methods is the Baermann Funnel

(Baermann 1917) in which the soil sample is placed in a muslin bag and suspended in a funnel of water. The small animals leave the soil and congregate in the bottom of the funnel where they may be tapped off. Although invented for nematodes, this is almost the only way in which the soil dwelling tardigrades and copepods may be extracted. It also catches Collembola and small mites, but its quantitative properties for soil arthropods are doubtful and have never been tested.

It is possible to extract earthworms from the soil by means of their reaction to an electric field (Satchell 1955). This has never been tried for arthropods, but may be applicable. Strickland (1944) described methods for driving insect larvae out of the soil by means of a weak repellent solution. Again the quantitative value of this is doubtful.

Berlese Funnel :

By far the most important of these methods and still the most widely used of all methods for extracting the fauna from the soil is the Berlese funnel and its various modifications.

Originally invented by Berlese (1905) for the qualitative rather than the quantitative examination of the soil mesofauna, it has been constantly modified in attempts to make it a more accurate quantitative instrument. However, while still the most useful apparatus for qualitative work, its quantitative application seems doubtful.

In its original form it consisted of a sieve placed at the wide end of a funnel. The soil was placed in the sieve and the funnel was gently warmed with a water jacket or by the sun. As the sample dried out, the fauna migrated downward, out of the soil, through the sieve, and into a bottle of preservative at the bottom of the funnel. The unmodified Berlese Funnel has been used by Delamare Deboulteville (1950), Watts (1951) and by Lawrence (1953).

Tullgren in 1918 modified this so that the heating was applied by an element or bulb over the funnel. It was further modified by Haarlov (1947) who introduced a chimney to improve the drying of the sample and to reduce condensation.

Baring (1954) has claimed that if H.N.l. Lamps and a heating coil are used in conjunction with a thermostat to prevent overheating, very much better catches of animals are obtained.

Murphy (1955b) has recently designed a funnel capable of dealing with very small samples (two inches in diameter). Marie Hammer (1944) considered that the Berlese funnel catch was greatly increased if the soil sample was placed in the funnel as a block which had not been broken up. This has since been confirmed by Macfadyen (1955). Forslund (1948) compared handsorted samples with catches from a Tullgren funnel, and found that the count from the latter was smaller in every group, but that the difference between methods varied from group to group.

In the present investigation, the results from a Tullgren funnel, using broken soil, were compared with those from the Ladell apparatus, and the numbers from the Tullgren were much lower.

For the extraction of the fauna from forest and bush litter, the Berlese funnel (or hand sorting) is the only possible method since these cannot be treated by the flotation method. However, the Berlese funnel has been shown to be even more erratic for litter than for soil (Macfadyen 1955a) and there is probably no really suitable method available for the quantitative study of litter fauna.

A major disadvantage of the Berlese funnel is the length of time it takes to extract the fauna of the sample. It has been shown by Watts (1951) and by others that the majority of the animals fall out in the first 24 hours but the last ones may not emerge for a very long time. In one case in the present investigation animals were still being caught up to 72 hours after the sample was put into the funnel. This disadvantage can be overcome by using batteries of funnels so that many samples may be separated together.

A further disadvantage is that the sample must be placed in the funnel very soon after collection. This limits the distance from the laboratory from which samples can be collected. It also prevents any storage of samples and so limits the number that can profitably be collected at any one time.

<u>Methods of extraction used in the present Investigation:</u>

In the present investigation two methods of extracting the fauna from the soil have been tried.

(1) A battery of Tullgren funnels was tested.

These funnels were designed by Professor J. Omer-Cooper, and each was heated by a 70 watt electric light bulb. It was found that at times under 50% of the total fauna was extracted in this funnel (the soil sample being transferred to the Ladell apparatus after 72 hours in the Berlese funnel).

It has been suggested (Watts 1951) that moistening the soil sample with water prior to treatment in the funnel might result in a better catch. Three experiments were designed and carried out to test this. These gave conflicting results.

In each of these a large amount of soil was thoroughly mixed and then distributed at random over four funnels in equal quantities. Two of these funnels were moistened with the same amount of water from a flit spray and two were left as controls. After 3 days the samples were transferred to Ladell's apparatus to extract the fauna remaining in them. The two samples which had been moistened were lumped together as were the two controls.

The counts resulting from these experiments are set out in Table 3. They were tested for significance by using the χ^2 test. In experiment 1, a significantly higher proportion was extracted from the untreated sample; in experiment 2 a slightly higher (significant at 5% level) proportion was again extracted in the untreated sample, while in experiment 3 a significantly higher proportion was extracted in the treated sample.

Since the soil for experiment 1 was originally moist, that for experiment 2 was fairly dry and that for experiment 3 was very dry, these results suggest that if the soil is very dry moistening may improve the catch from it, but if it is already moist, moistening reduces the catch, possibly due to the caking of the soil trapping the animals. However, more tests are needed to support this. This work was discontinued since the Berlese funnel was not used further in investigation.

The results, however, tend to confirm the contention that the proportion of the fauna extracted by the Berlese funnel is dependent on the condition of the soil in the field, and that a fixed proportion of the fauna is not extracted every time. This makes the funnel a poor

FAUNAL GROUPS.	UNTREATED SOIL. Berlese.	UNTREATED SOIL. Ladell.	UNTREATED SOIL. Total.	TREATED SOIL. Berlese.	TREATED SOIL. Ladell.	TREATED SOIL. Total.	χ^2 For total Fauna.	% Extraction of Fauna in Berlese Funnel. Untreated.	% Extraction of Fauna in Berlese Funnel. Treated.
EXPERIMENT 1.									
Mites	51	9	63	54	8	62			
Poduridae	61	2	60	35	28	63			
Total Fauna	181	46	227	125	84	209	20.6^{xxx}	80%	59%
EXPERIMENT 11.									
Poduridae	185	139	324	145	149	294			
Mites	95	245	340	93	265	358			
Total Fauna	328	442	770	290	481	771	3.98^{x}	42.5%	37.6%
EXPERIMENT 111.									
Poduridae	153	217	370	253	301	454			
Mites	190	333	523	289	456	998			
Total Fauna	346	647	1043	590	509	1099	54.9^{xxx}	37.9%	54.6%

THE EFFECTS OF MOISTENING THE SOIL IN BERLESE FUNNELS.

xxx HIGHLY SIGNIFICANT

x SIGNIFICANT AT 5% LEVEL.

instrument for quantitative work, especially of a comparative nature and all work of this nature carried out using a Berlese funnel must be regarded with suspicion.

These remarks apply to the Tullgren funnel, using broken-up soil samples. I have not been able to test a Haarlov funnel or other types of funnel using a block of soil. These may give much more accurate results.

(2). The main apparatus used in the extraction of the fauna was Ladell's apparatus, which was found to be the most satisfactory apparatus available; all quantitative work in the present investigation was carried out by means of it for the reasons given below.

This apparatus (Figure 3) consists of a large flotation tank (A) of about 5 litres capacity the top of which is screwed onto a conical lid (N), the joint being made watertight by a rubber washer. In it is a joint stirrer and blower (E) with two grids, an upper (F) and lower (G). There is a sedimentation tank (B) with a constant level device with two half partitions (O). This is filled with a strong solution of Epsom salts to the level of an outlet (P), where a tube with a stopcock connects it to a bottle which collects the overflow. The stirrer is moved by a system of gears (K) attached to an electric motor (L). Air is blown through down the stirrer and out through holes on top of the stirrer vanes (M) by a compressor.

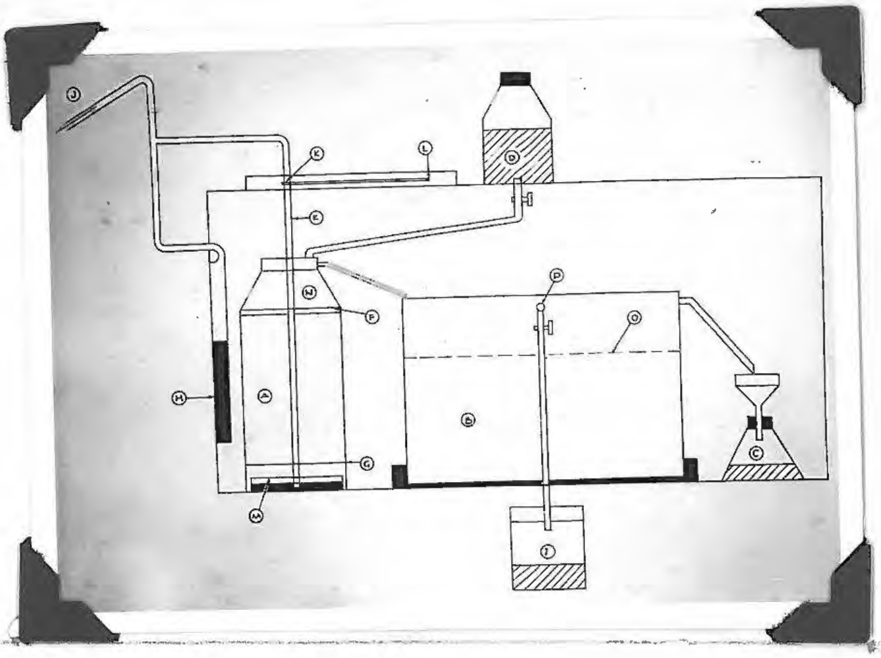


Fig. 3.

Ladell's Apparatus.

Key to lettering.

A Flotation tank.

B Sedimentation tank.

C Vacuum filter flask.

D Aspirator containing epsom salts.

E Combined stirrer and blower.

F Upper grid.

G Lower grid.

H Manometer.

I Over-flow bottle.

J Tube to air compressor.

K Gear to move stirrer.

L Connection to electric motor.

M Stirring vanes.

N. Conical top.

O Half partitions.

P Outlet for salt overflow.

The soil is placed on the lower grid, the conical top screwed on, and the tank filled with an Epsom salts solution. The tank is now placed in the frame so that the outlet is immediately over the central section of the sedimentation tank. The outlet (P) is left open. Air is driven through for about 5 minutes at 15 cms Hg. and then cut down to 10 cms Hg. the stirrer is then started and the solution run in from the aspirator (O). The scum which floats to the surface of the tank is allowed to run over into the sedimentation tank where most of the soil particles sediment out. The outlet (P) is then closed and the scum run over into the collecting funnel where it is filtered on Whatman 41 filter paper. The stirrer is run for about 10 minutes and then the apparatus is turned off. The apparatus is then run over a second time to catch those animals which may not have floated the first time. The whole process including the filling and setting up the apparatus takes under an hour, and this is a very great speeding up over all previous methods. This process is described in detail by Ladell (1936).

Unfortunately it has been impossible to test this apparatus against any other form of flotation apparatus, but two refinements were tried. It was suggested by Professor Omer-Cooper that the Ladell apparatus used in conjunction with the Berlese funnel would give a better result. This was therefore tested and the results which are set out in Table 4 show that there is no significant difference between the catches made by the two methods. Indeed, there is a considerable danger of losing some of the fauna in transferring the sample from the funnel to the Ladell.

TABLE 4.

Faunal Groups.	Ladell's Apparatus only.			Berlese Funnel, followed by Ladell's Apparatus.				F
				EXPERIMENT 1.				
Mites	154	218	154	160	180	224	134	
Poduridae	120	185	136	134	190	158	136	
Total Fauna	313	451	340	356	454	447	324	0.11
				EXPERIMENT 11.				
Mites	251	292		353	170	307	237	
Poduridae	203	193		250	120	155	216	
Total Fauna	520	542		690	353	520	502	0.02

not significant in either.

COMPARISON OF LADELL'S APPARATUS WITH JOINT USE OF BERLESE FUNNEL AND LADELL'S APPARATUS.

It was suggested by Mr. R.M. Dobson (in lit.) that even though freezing was impossible, Raw's ion exchange solution and the evacuation of the air might improve the results. This was also tested. The results are set out in Table 5, and show no significant difference between the methods, though this method might easily be of considerable use in a soil heavier than those investigated.

TABLE 5.

Sample.	1.	2.	3.	Total.
Treated	119	86	69	274
Untreated	95	114	92	301

F = 0.26 not significant.

NUMBER OF ARTHROPODS EXTRACTED FROM SAMPLE COMPARING THE EFFECT OF RAW'S ION EXCHANGE SOLUTION WITH AN UNMODIFIED LADELL TECHNIQUE.

The chief disadvantages of Ladell apparatus are :

(1) It is useless for litter since the entire litter will float and there will be no appreciable separation. Where there is a great deal of undecayed organic matter in the sample, its efficiency is also impaired.

(2) The apparatus tends to damage the large and more delicate animals in the soil, earwigs tend to be broken in half, the legs of spiders are often broken off, while some beetles are so badly broken up that identification below order is impossible.

(3) The apparatus is very bulky and uses quantities of water and salts. In addition, the filtration has to be carried out under pressure so that the apparatus can only

why?

be used in a laboratory. But since the samples for separation can be preserved for some time, this is not a serious snag.

(4) Many of the hard-shelled animals such as oribatid mites, ants and other insects, leave resistant shells in the soil after they die. These float, and great care needs to be taken to distinguish such shells from the animals which were alive when the sample was taken.

The chief advantages are that it is very speedy compared to other methods, separating out the fauna in under one hour instead of 72 hours in the Berlese funnel. It separates out the greater part of the fauna; moreover, even if it does not separate out the entire fauna, ~~and~~ it appears to yield the same proportion of the fauna from each sample regardless of the condition of the soil when collected. This is all that is required for comparative work.

Sorting the Fauna out of Ladell's Apparatus :

The scum that remains on the filter paper contains the fauna and an amount of vegetable matter. These two must be separated.

The early investigators (e.g. Baweja 1937) who used this method had to sort the animals under a binocular microscope which was a very laborious process. Salt and Hollick in 1944 introduced the benzene interface method. In this proceedure the scum and the filter paper are transferred to a beaker. Water is added and brought to the delicate animals would come off badly

boil. This drives the air out of the vegetation so that it sinks on cooling; boiling also kills the animals, leaving them in an extended state. After cooling, a quantity of benzene or paraffin is poured into the mixture which is then well stirred. The arthropods are taken up at the benzene (or paraffin) water interface and may be decanted.

Each sample needs to be stirred up several times with paraffin before all the animals are separated from the vegetation.

In the present investigation, separation at a paraffin-water interface was used. The interface was decanted into square dishes for counting.

Raw (1955) developed this method, freezing the paraffin and lifting it and the fauna off the water.

Paraffin separation is only useful for arthropods because only animals with chitinous exoskeletons are held by the benzene or paraffin-water interface. Its main disadvantage is the difficulty of removing the paraffin from the animals.

In the present investigation, they were washed in ether and filtered through a sintered glass crucible, as recommended by Raw. This proved very effective.

A QUANTITATIVE ACCOUNT OF THE MICRO-ARTHROPOD FAUNA IN SINGLE PINEAPPLE FIELD.

Introduction. Before comparing the soil fauna of pinefields with that in the soil under the natural vegetation from which the pinefields were originally cleared, it was considered desirable to obtain a quantitative picture of the fauna in different parts of the same pinefield, to see if there was any significant variation between the different parts of the field.

The Homestead Pinery on the farm "Unique", described in Section 1, was selected. Since this pinefield is growing on a fairly steep slope, it appeared that there might be considerable differences between the faunas at the top of the slope and those in the centre and lower down in the valley.

Three stations were therefore chosen in this field. Station 1 was at the top of the field; Station 2 lower down, about in the centre of the field and Station 3 was at the bottom of the field, adjoining the bush.

Since the sampling techniques used later in the investigation had not definitely been decided on at this stage of the work, each station was sampled a different number of times.

The dates of sampling and the number of samples from each station were as follows :-

Station 1 Sept. 28th and Oct. 6th, 1955. 14 samples were taken.

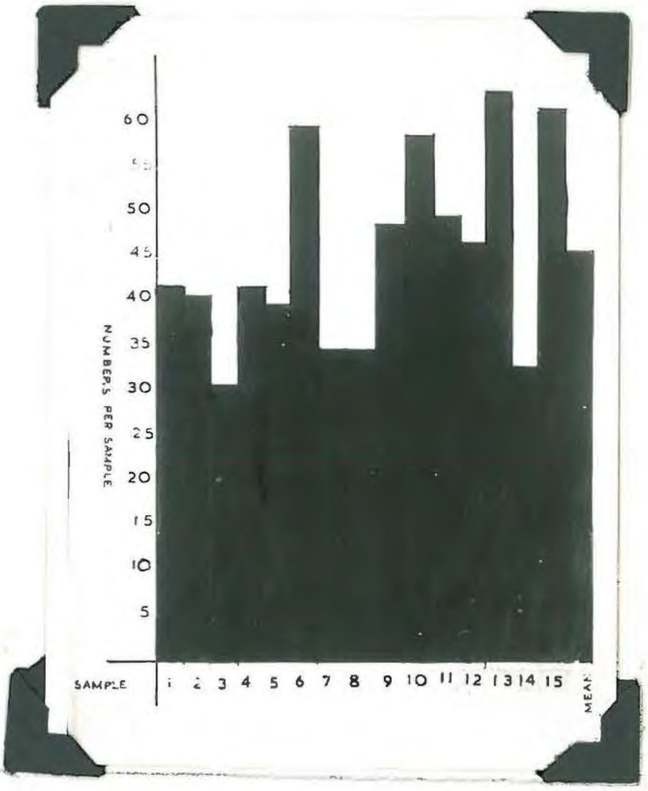
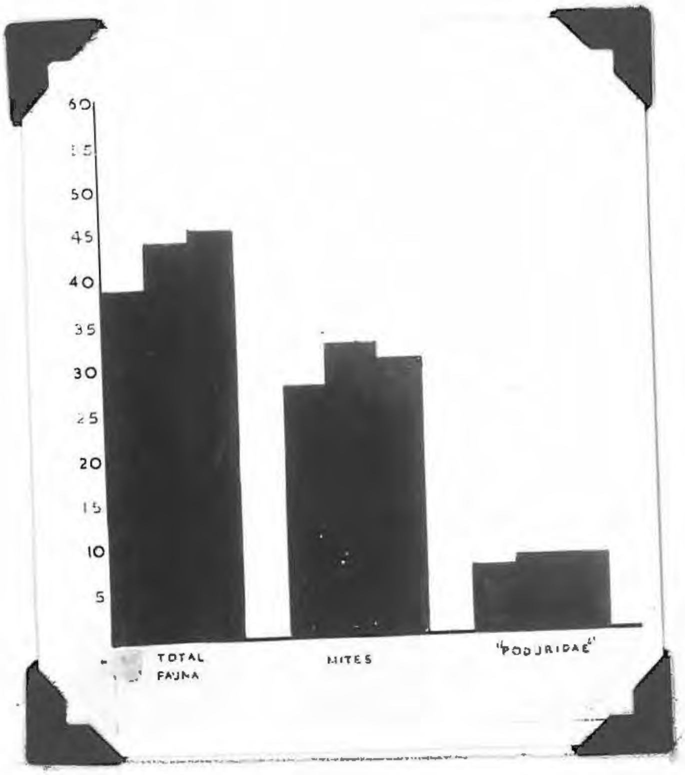


Fig. 4.

"Unique" Series 1, Station 3, No.

Arthropods per sample.



<u>Fig. 5.</u>

<u>"Unique", Series 1, Means per Sample.</u>

<u>Histogram reads, left to right, Station 1, 2 & 3.</u>

Station 2 Oct. 6th, Oct. 17th, Oct. 24th and Nov. 7th, 1955.
24 samples were taken.

Station 3 Oct. 24th, Nov. 7th, 1955, and Jan. 13th, 1956.
15 samples were taken.

These samples are designated as Series 1.

Station 3 was sampled again on May 3rd, 1956, when 9 samples were taken. These samples are referred to as Series 2.

Results. The results obtained are best considered under two sub-headings.

1) Variation in Space. The results of Series 1 from the three stations are shown in Table 5 A, B & C, for the total fauna, mites and "Poduridae" respectively.

These results show that while there is a very great variation in the numbers of animals in the different samples from within each station, the means per sample from each station are remarkably similar (Figs. 4 & 5), and show no significant differences when tested by the Analysis of Variance technique.

It may be concluded from these results, that though the micro-arthropod fauna in a pinefield shows a marked lack of randomisation in distribution and may vary considerably over a restricted area of the field, that is within a single station, the faunas from different stations do not differ significantly. This is of importance since it means that a single multiple sample, provided it consists of enough component samples, may be considered as typical of the field sampled and may be used for comparisons with other areas.

2) Variation In Time. The variation of the fauna in time was studied only at Station 3. The results were obtained incidentally during the study of the variation in space, so that for Series 1 there are only five samples from each collecting date. This is below the minimum recommended for accurate results. However, they may be regarded as giving a reasonably good pointer to the actual state of affairs. These results are set out in Table 6 and illustrated in fig. 6 where the mean numbers per sample and their standard errors are plotted against the month of collection.

The difference between the three Series 1 collections is not significant when tested by the Analysis of Variance technique. There is, however, a considerable increase in numbers between January 13, the last of Series 1 and May 3 (Series 2). Fig. 6 shows that for the Total Fauna and Mites there is probably a linear increase in numbers from October 1955 to May 1956 and that this increase is greater for the total fauna than the mites. The "Podurinae" on the other hand, remain almost constant for the Series 1 results and then show a marked increase in numbers from January 1955 to May 1956 (Series 2). These results show

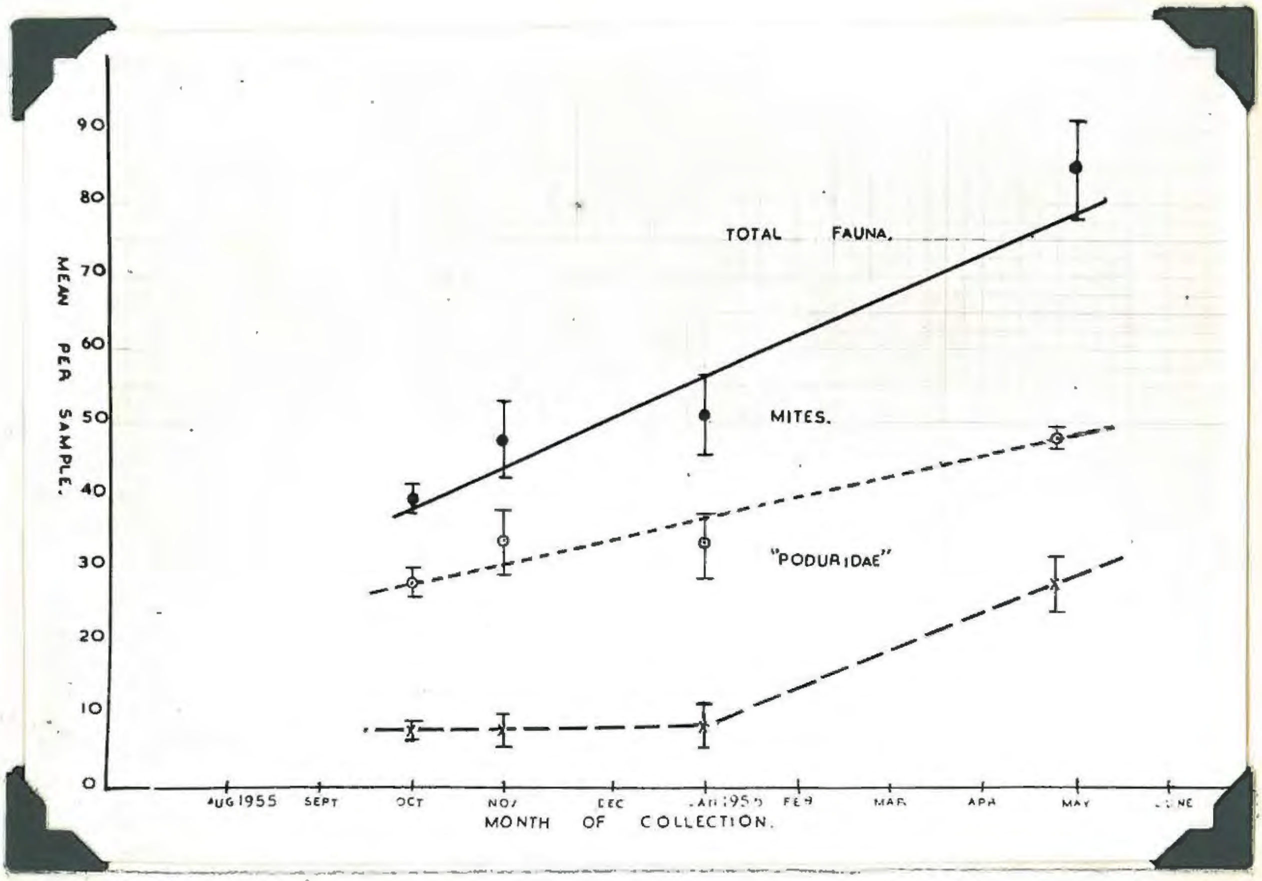


Fig. 6.

"Unique" Station 3, Means Per Sample and Standard errors

Against Month of Collection.

Showing Variation in Time.

Table 6.

UNIQUE - STATION 3.
4 COLLECTINGS. VARIATION IN TIME.
TOTAL FAUNA.
A.

Sample	1	2	3	4	5	6	7	8	9	Total	Mean	S.E.
Oct. 24th 1955	42	41	32	42	40					197	39.4	1.9
Nov. 7th 1955	60	35	35	49	59					238	47.6	5.3
Jan. 13th 1956	50	47	64	33	62					256	51.2	5.6
May 3rd 1956	65	83	88	77	95	75	136	66	62	767	85.3	6.7

B.
MITES.

Sample	1	2	3	4	5	6	7	8	9	Total	Mean	S.E.
Oct. 24th 1955	29	30	23	34	25					141	28.2	1.9
Nov. 7th 1955	43	28	28	26	45					170	34.0	4.1
Jan. 13th 1956	28	33	49	25	33					168	33.6	4.1
May 3rd 1956	30	39	58	39	46	56	77	32	58	435	48.3	1.6

C.
PODURIDAE.

Sample	1	2	3	4	5	6	7	8	9	Total	Mean	S.E.
Oct. 24th 1955	9	8	6	6	11					40	8.0	0.8
Nov. 7th 1955	14	4	5	11	7					41	8.2	1.9
Jan. 13th 1956	8	7	5	5	21					46	8.6	3.0
May 3rd 1956	19	33	24	27	39	15	49	27	18	251	27.9	3.7

NUMBER OF ARTHROPODS, MITES AND "PODURIDAE" FROM STATION 3 TO SHOW VARIATION IN TIME.

clearly that great care must be taken when it is desired to lump several sets of samples from the same station but taken on different dates. In these cases the standard errors of the means of each set of samples must be calculated and tested to see if there is a significant difference. If there is no significant difference the sets may then be safely lumped, if however there is a significant difference serious errors may arise if they are lumped together.

Whether the increases are part of an annual or longer term cycle fluctuation, or whether they are purely dependent on climatic conditions is not known.

No work was done on the long term changes of the soil fauna of a pinefield in the present investigation. Murphy (1955) has studied the long term fluctuations of the collembolan populations of English moorlands and has correlated them with changes in the plant succession.

In view of this, any long term changes in the microarthropod populations of pinefields will probably be found to be correlated with the growth of the pineapples. Both the long and the short term fluctuations of the soil fauna in pineapple fields need investigation.

A COMPARISON OF THE MAJOR CATEGORIES OF THE MICRO-ARTHROPOD FAUNA OF THREE PINEFIELDS WITH THOSE IN THE NATURAL VEGETATION.

Introduction. The investigation of the Homestead Pinery at "Unique" has shown that a single multiple sample, if it consists of enough component samples, may be regarded as typical of the fauna of a field, provided that the samples were taken within a reasonably short time of each other, and may be used to compare this fauna with that of any other type of field or vegetation.

The samples obtained at "Unique" station 3 were therefore compared with a set of samples taken from the adjacent bush. Work was then transferred to another farm "Glenhope", some 15 miles away. A set of samples was taken in a pinefield there, referred to as "Glenhope" pinefield 1, and compared with a set from adjacent bush soil. A second pinefield was then chosen on the same farm, referred to as "Glenhope" pinefield 2, and a set of samples from here was then compared with a set from the grassland from which it was originally cleared. Each of these sets consisted of 15 samples except for that from the grassland where only 14 samples were used due to one sample having hit an ants nest and therefore being discarded.

The results from these two pinefields were very similar to each other but differed considerably from those from "Unique". Therefore the Series 2 set of samples was taken from "Unique" as mentioned above, to see if the low numbers of animals at "Unique" were merely a seasonal phenomenon.

Results 1 - Quantitative (Total Fauna, Mites and "Poduridae").

The quantitative results for the total fauna, mites and the "Poduridae" are summarised in Tables 7 to 11. Tables 7, 8 & 9 compare the faunas of the natural vegetations with those in the pinefields, respectively cleared from them. It is clearly shown, that in the two pinefields cleared from bush the number of arthropods has been considerably reduced. This reduction is highly significant in both cases. In the case of the grassland and the pinefield cleared from it the picture is more complex. Here there is a significant reduction in the total fauna, but no significant difference in the mites and "Poduridae" between the two fields. Actually a few more mites were obtained in the pinefield than in the pasture. The large difference in the total fauna is due to the pterygote insects which are proportionately more important in the grassland than in the other soils studied.

Table 10 compares the three types of natural vegetation. It can be seen that two bush types do not differ significantly. In fact they differ at the 5% level for the total fauna only. This might easily be a seasonal difference since the mites and "Poduridae" do not differ significantly. However they are both significantly higher than the fauna in the grassland in all three groups. Table

TABLE 7.

VARIATION IN NUMBERS OF FAUNA BETWEEN "UNIQUE" BUSH AND PINEFIELD (STATION 3. SERIES 1).

TOTAL FAUNA.

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Mean	A
Bush	164	139	130	161	227	151	140	154	130	197	145	225	174	129	170	2436	162.4	
Pinefield	42	41	32	42	40	60	35	35	49	59	50	47	64	33	62	691	46.1	

F xxx

MITES.

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Mean	B
Bush	64	70	63	80	109	68	67	71	72	113	27	93	79	76	90	1192	79.5	
Pinefield	29	30	23	34	25	43	28	28	26	45	28	33	49	25	33	479	31.3	

F xxx

PODURIDAE.

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Mean	C
Bush	53	41	46	58	76	59	48	49	42	54	38	87	63	38	48	800	53.3	
Pinefield	9	8	6	6	11	14	4	5	11	7	8	7	5	5	21	127	8.5	

F xxx

TABLE 8.

VARIATION IN NUMBERS OF FAUNA BETWEEN "GLENHOPE" BUSH AND PINEFIELD 1.

TOTAL FAUNA.

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Mean	A
Bush	184	166	104	175	256	193	152	295	149	245	163	188	261	134	278	2462	197.3	
Pinefield	124	58	72	69	81	81	106	75	122	60	60	66	122	102	74	1272	84.8	

$F\frac{1}{28} = 48.4^{xxx}$

TOTAL MITES.

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Mean	B
Bush	80	86	56	44	101	84	77	107	70	108	71	90	101	72	110	1307	87.1	
Pinefield	53	26	44	42	52	28	68	47	51	37	36	43	79	80	46	732	48.8	

$F\frac{1}{28} = 36.7^{xxx}$

"PODURIDAE".

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Mean	C
Bush	68	41	53	38	98	51	44	133	58	82	51	58	131	33	86	1005	67.0	
Pinefield	61	24	20	19	20	30	25	17	58	16	15	17	31	16	23	382	25.5	

$F\frac{1}{28} = 63.5^{xxx}$

TABLE 9.

VARIATION IN NUMBERS OF FAUNA BETWEEN GRASSLAND AND GLENHOPE PINEFIELD 2.

TOTAL FAUNA.

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Mean	A
Grassland		60	63	67	208	94	74	96	110	94	204	136	65	99	68	1433	102.35	
Pinefield 2	69	67	89	76	110	75	91	68	91	86	116	103	78	83	70	1272	84.8	F xx

MITES.

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Mean	B
Grassland		21	35	38	95	39	45	40	42	45	35	69	68	57	39	668	47.71	
Pinefield 2	40	40	55	44	68	30	46	34	49	56	64	64	51	58	37	736	49.07	F not significant

"PODURIDAE".

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Mean	C
Grassland		15	22	20	77	14	24	24	36	71	46	29	21	22	19	440	31.4	
Pinefield 2	18	18	27	23	29	38	32	15	28	15	37	28	14	14	28	364	24.26	F not significant

TABLE 10.

VARIATION IN NUMBERS OF FAUNA BETWEEN NATURAL VEGETATION TYPES.

TOTAL FAUNA.

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Mean	A
Unique	164	139	130	161	227	151	140	154	130	197	145	225	174	129	170	2436	162.4	) signif-
Glenhope bush	184	166	134	104	175	256	193	152	295	149	245	153	188	281	278	2963	197.3	) icant at 5%
Glenhope grass	60	63	67	208	60	94	74	96	110	94	204	136	99	68		1433	102.35	xxx

MITES.

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Mean	B
Unique	64	70	63	80	109	68	67	71	72	113	77	93	79	76	90	1192	79.5	) not
Glenhope bush	80	86	72	56	94	101	84	77	107	70	108	71	90	101	110	1307	87.1	) signif- icant
Glenhope grass	21	35	38	95	39	45	40	42	45	35	69	68	57	39	-	668	47.71	xxx

"PODURIDAE".

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Mean	C
Unique	53	41	46	58	76	59	48	47	42	54	38	87	63	38	48	800	53.3	) not
Glenhope Bush	68	41	33	33	38	98	51	44	133	58	82	51	58	131	86	1005	67.0	) signif- icant
Glenhope Grass	15	22	20	77	14	22	19	24	24	36	71	45	29	21	-	440	31.4	xxx

TABLE 11.
VARIATION IN NUMBERS OF FAUNA BETWEEN PINEFIELDS.
TOTAL FAUNA.

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Mean	A
Unique Series 1	42	41	32	42	40	60	35	35	49	59	50	47	64	33	62	691	46.1 xxx	
Glenhope 1	124	58	72	69	81	81	106	75	122	60	60	66	122	102	74	1272	84.8	not
Glenhope 2	69	67	89	76	110	75	91	68	91	86	116	103	78	83	70	1272	84.8	signif-
Unique Series 2	65	83	88	77	95	75	136	66	82							767	85.2	icant

MITES.

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Mean	B
Unique Series 1	29	30	23	34	25	43	28	28	26	45	28	33	49	25	23	479	31.3 xxx	
Glenhope 1	53	26	44	42	52	28	68	47	51	37	36	43	79	80	46	732	48.8	not
Glenhope 2	40	40	55	44	68	30	46	34	49	56	64	64	51	58	37	736	49.0	signif-
Unique Series 2	30	39	58	44	46	56	76	32	57							440	48.9	icant

"PODURIDAE".

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Mean	C
Unique Series 1	9	8	6	6	11	14	4	5	11	7	8	7	5	5	31	127	8.5 xxx	
Glenhope 1	61	24	20	19	20	30	25	17	58	16	15	17	31	16	23	392	25.5	not
Glenhope 2	18	18	27	23	29	38	32	15	28	15	37	28	14	14	28	364	24.3	signif-
Unique Series 2	19	33	24	27	39	15	49	27	18							251	27.9	icant

11 compares the three pinefields. Here it may be seen that the two pinefields from "Glenhope" are remarkably similar. In fact the same number of arthropods was collected from each. Though they differ considerably from "Unique" Series 1, this was found to be a seasonal effect and Series 2 from "Unique" resembles the "Glenhope" results closely. It can also be seen that the two "Glenhope" pineries and "Unique" series 2 resemble each other much more than do the three natural vegetation types.

It seems legitimate to conclude from these results that for the total fauna and the two major groups of animals in the soil, the pinefields have similar quantitative faunas.

The ratio of mites to "poduridae" is shown in Table 12. In every case this ratio is higher in the pinefields than in the natural vegetation. It is also interesting to note that this ratio falls considerably from "Unique" series 1 to series 2. Which seems to show a proportionally larger increase for the collembola than mit es. (See 8.)

TABLE 12.

THE RATIO OF MITES/PODURIDAE.

NATURAL VEGETATION.

Locality	No. Mites	No. Poduridae	Mites/Poduridae
Unique bush	1192	800	1.49
Glenhope bush	1307	1005	1.30
Glenhope ~~bush~~ Grassland	668	440	1.51

PINEFIELD.

Locality	No. Mites	No. Poduridae	Mites/Poduridae
Unique Series 1	479	127	3.77
Unique series 2	440	250	1.75
Glenhope series 1	732	392	1.87
Glenhope series 2	736	364	2.02

2. Composition of the Fauna.

The composition of the major groups of the fauna is set out in Table 13 for the natural vegetation and Table 14 for the pinefields. It is illustrated in Figs. 7 to 24. (Figs. 7 - 14 show the means per sample and Figs. 15 - 24 show the % compositions.) It can be seen that while no major group found in the natural vegetation is absent in the pinefields the numbers of all are reduced and the composition of the faunas is very different.

Though each pinefield differs slightly from the others, as might be expected, they resemble each other more than they do the natural vegetation from which they were cleared and considerably more than the bush types do the grassland.

In the natural vegetation the two major classes of arthropods, the Arachnida and Insecta, are nearly equal in numbers. Each forming about 45% of the total fauna. In all except "Unique" bush the insects had a slight preponderance over the arachnids. At "Unique" the reverse was the case. This may possibly have been due to drought at the time of sampling.

In the pinefields, however, the insects have dropped considerably, now forming only about 40% of the population. The arachnids form nearly 60% of the population in pinefields. The composition of these classes also changes in the pinefields from the bush soils. Of the insects the Collembola are the most abundant in all soils, but tend to form a slightly larger proportion in the pinefields than the natural vegetation. The apterygote insects are relatively unimportant in all soils, while the pterygote insects are slightly more important in the bush than in the pinefields. These latter are proportionally more abundant in the grassland than in any other soil, due to the abundance of ants.

Fig. 7.

Means Per Sample. Total Fauna.

All histograms, Figs. 7 to 24, read from left to right. For Natural Vegetation, Unique Bush, Glenhope bush and grassland. For pinefields, Unique Sta. 3, series 1, Glenhope pinefield 1, Glenhope pinefield 2 and Unique Sta. 3, Series [illegible]

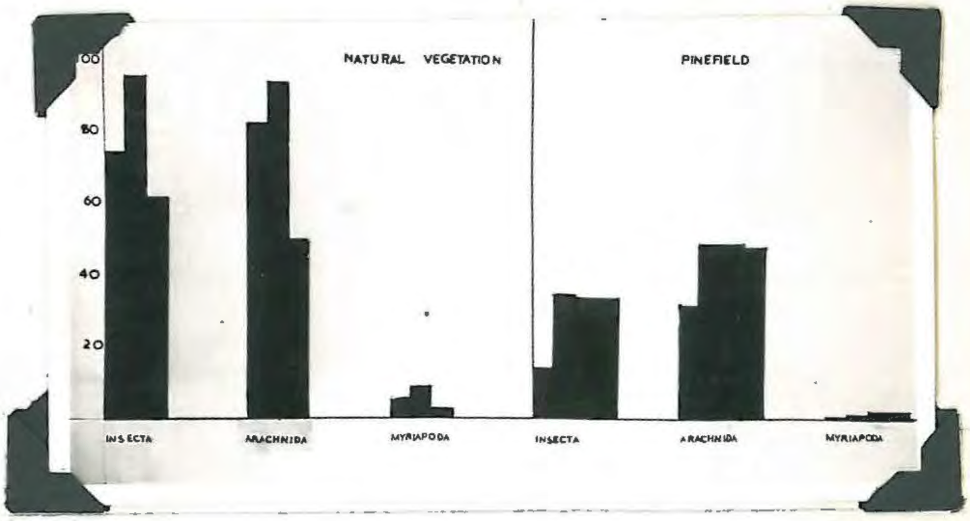


Fig. 8.

Means Per Sample. Classes of Arthropods.

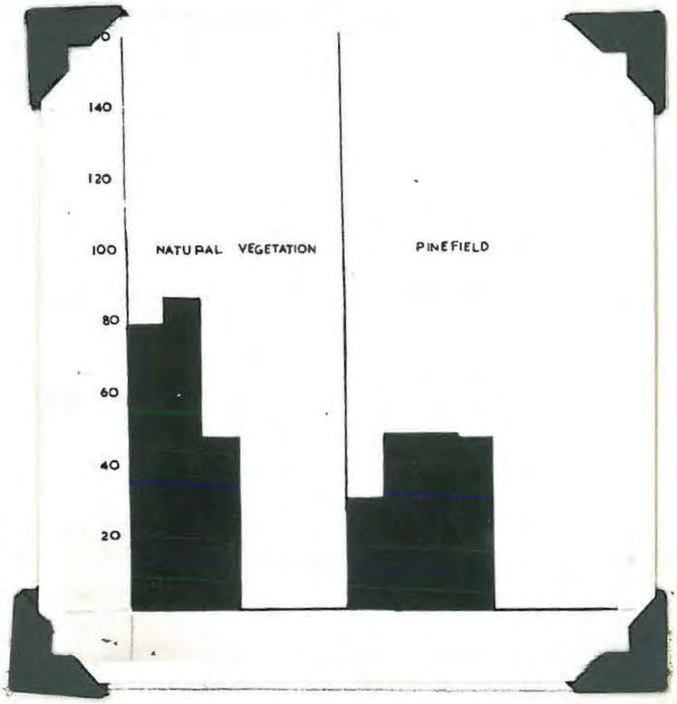


Fig. 9.

Means Per Sample. Mites.

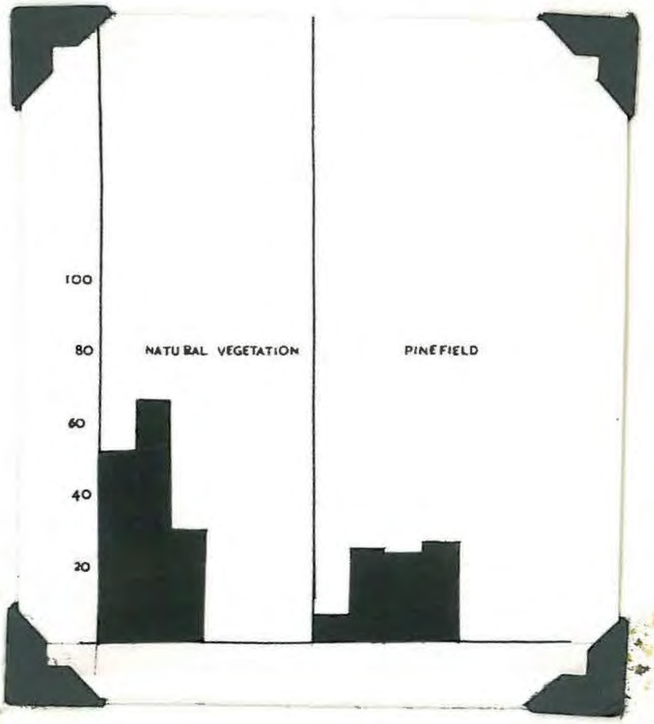


Fig. 10.

Means Per Sample. "Poduridae"

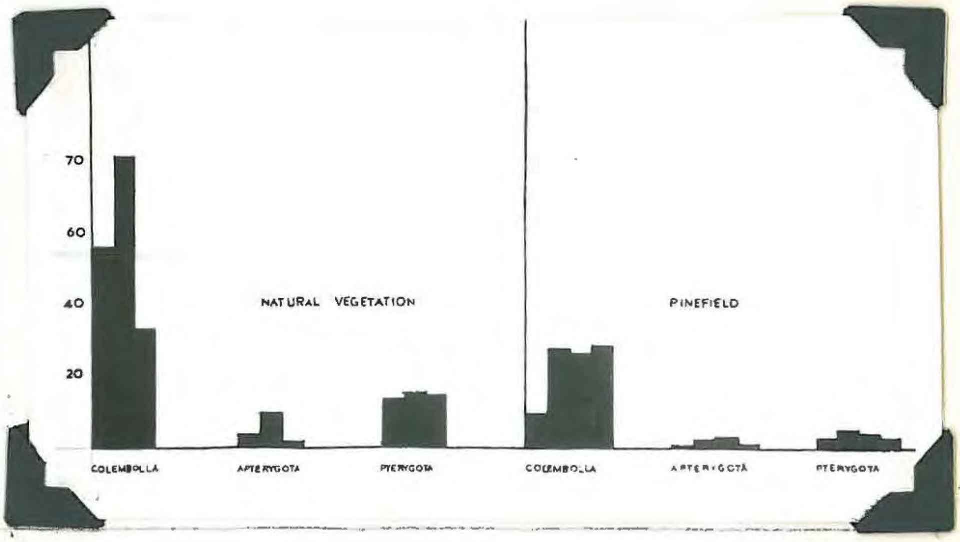


Fig. 11.

Means Per Sample. Sub-classes of Insects.

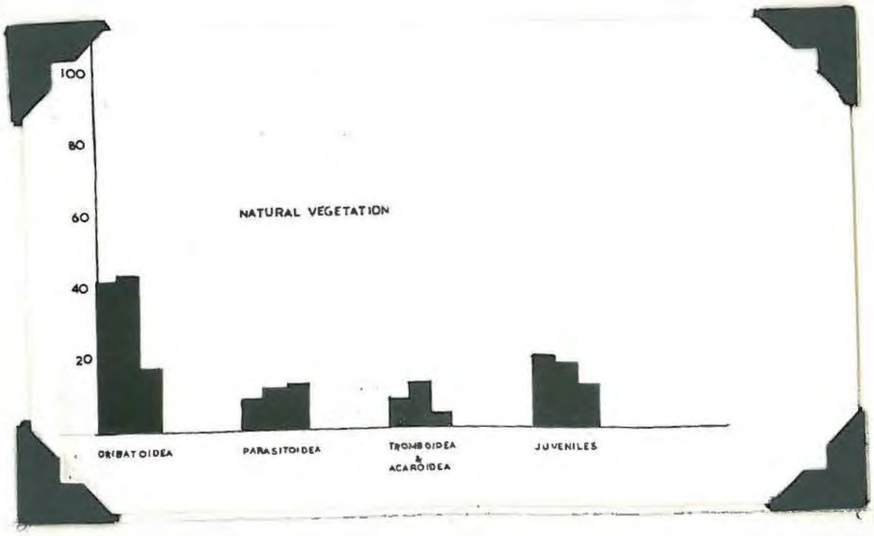


Fig. 12.

Means Per Sample. Superfamilies of Mites.

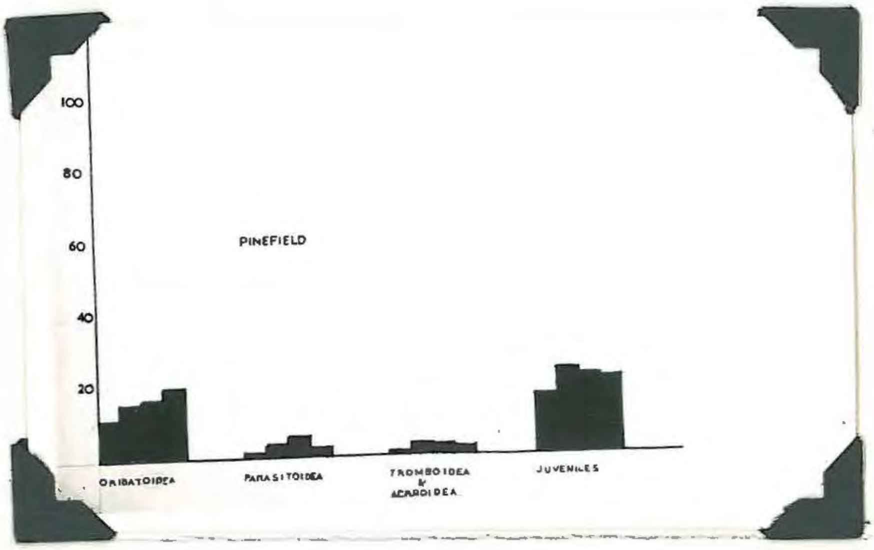


Fig. 13.

Means Per Sample. Superfamillies of Mites.

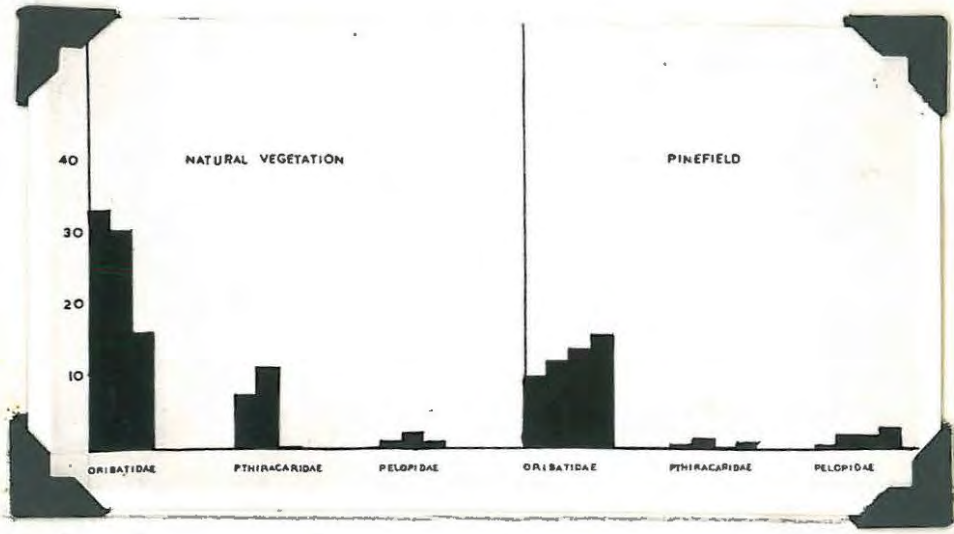


Fig. 14.

Means Per Sample. Families of Oribatoidea.

In the pinefields arachnids other than mites are virtually absent. The few that do occur being mainly spiders, though two pseudoscorpions were obtained in a single sample at "Glenhope" pinefield 1 and one palpigrade was taken in "Unique" series 2. In the natural vegetation harvest spiders also occur, Pseudoscorpions are much more common, and though no palpigrades were taken in the bush soils one was obtained in the grassland. In the pinefields and grassland the dominant arachnids other than mites are the spiders. In the bush the numbers of the spiders are exceeded by those of the pseudoscorpions, though the spiders are still more numerous than they are in the pinefields. The numbers of arachnids other than mites obtained are shown in Table 15.

Even in the bush soils the arachnids other than mites do not form more than 8% of the Arachnid population. In the grassland they form somewhat under 3% of the population, while in the pinefields they form under 1% of it.

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TABLE 15.

TOTAL NUMBERS OF ARACHNIDS OTHER THAN MITES.

Group	Unique bush	Glenhope bush	Grass-land	Unique Series 1	Unique Series 2	Pinefield Glen-hope 1	Pinefield Glen-hope 2
Spiders	17	41	12	4	4	3	1
Pseudoscorpions	20	61	4	0	0	2	0
Harvest spiders	0	2	1	0	0	0	0
Palpigrades	0	0	1	0	1	0	0

Mites are the dominant arachnids and indeed the dominant arthropods in all soils studied forming over 90% of the arachnids in all soils and about 99% in the pinefields. The mites form over 40% of the total arthropod fauna in the natural vegetation and well over 50% of it in the pinefields.

An interesting feature of the mite population in the pinefields is the relatively great number of juveniles i.e. those in the hypopus stage. These make up nearly 50% of the mite population in the pinefield as opposed to about 25% in the natural vegetation. The reasons for this large proportion of juveniles in a pinefield are not known and nothing similar appears to be recorded in the literature. It was a consistent feature of almost every sample taken in all pinefields. That it is not merely a seasonal phenomenon is shown by the fact that it is equally evident in "Unique" series 1 and 2, though the proportion is slightly less in

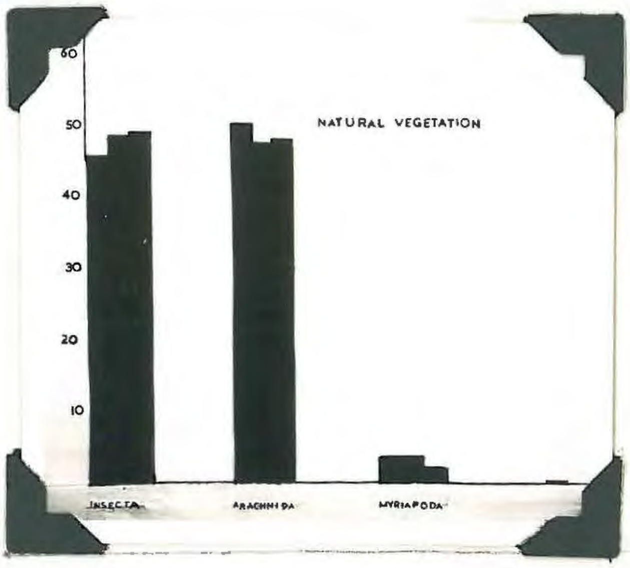


Fig. 15.

% Composition Of Classes of Arthropods.

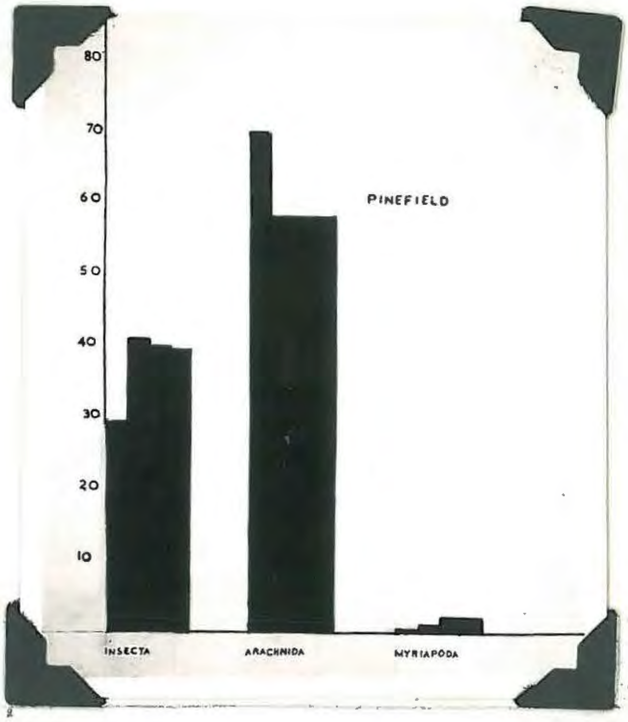


Fig. 16.

% Composition of Classes of Arthropods.

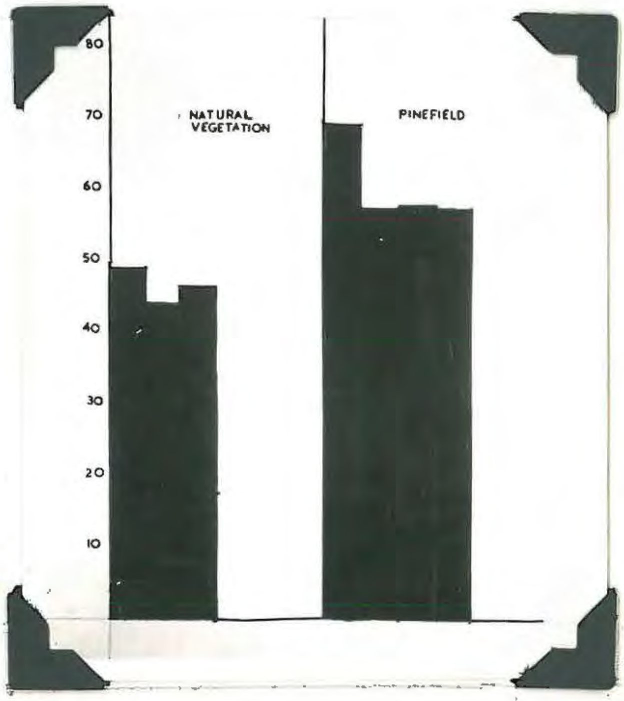


Fig. 17.

Percentage Mites of Total Fauna.

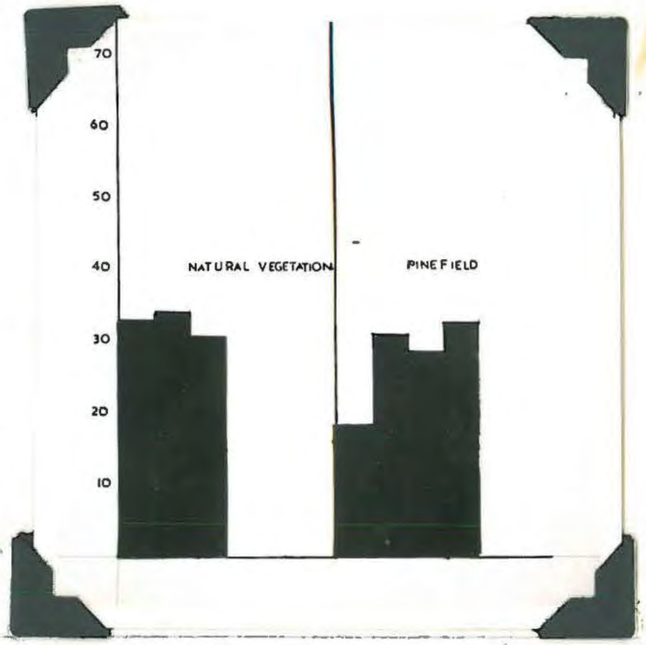


Fig. 18.

Percentage "Poduridae" of Total Fauna.

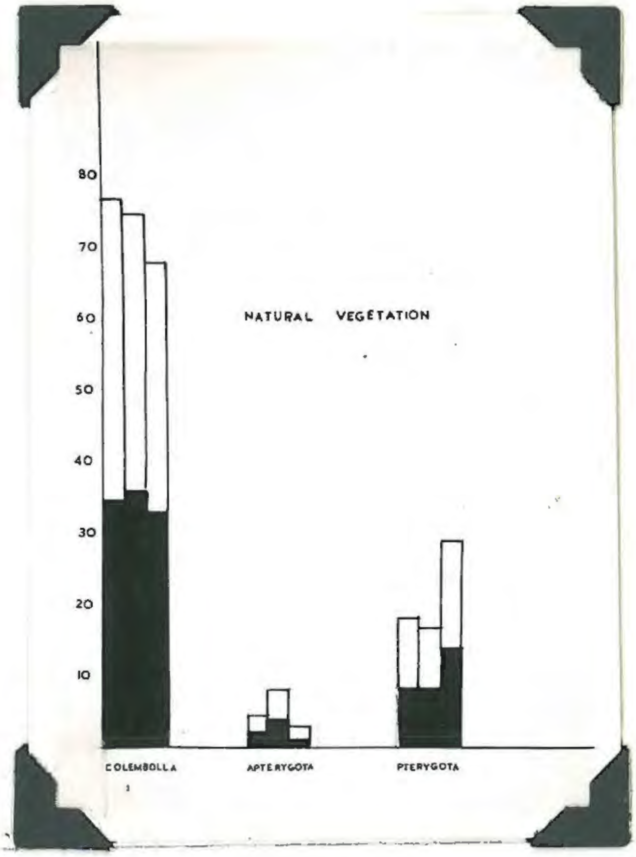


Fig. 19.

% Composition of The Sub-classes of Insects.

In Figs. 19 to 24 the shaded portion of the histogram shows the % of the total fauna and the unshaded portion the % of the group.

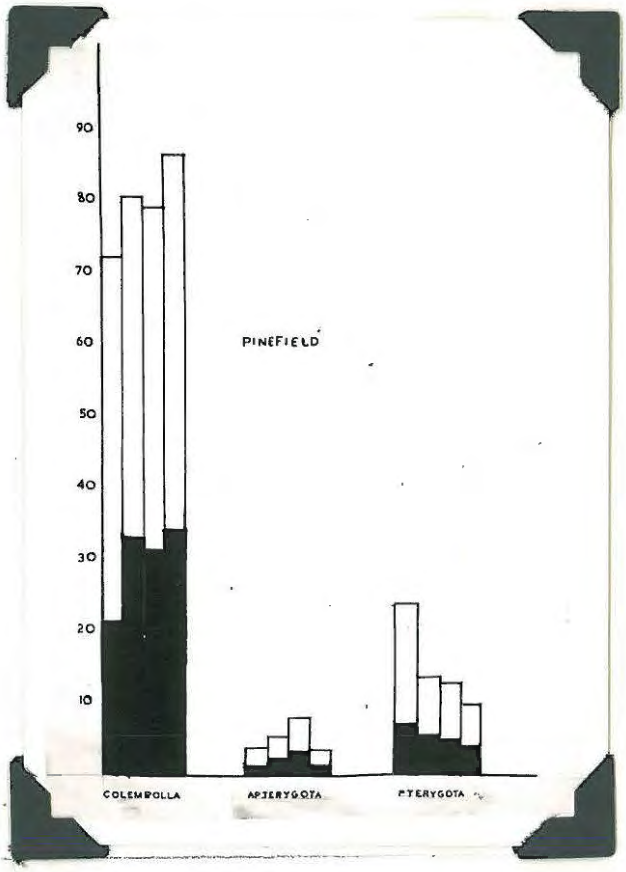


Fig. 20.

% Composition Sub-classes of Insects.

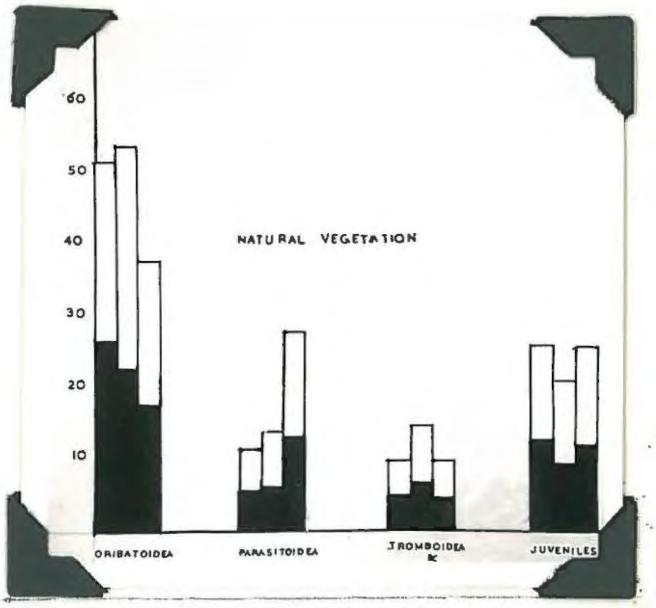


Fig. 21.

% Composition Superfamilies of Mites.

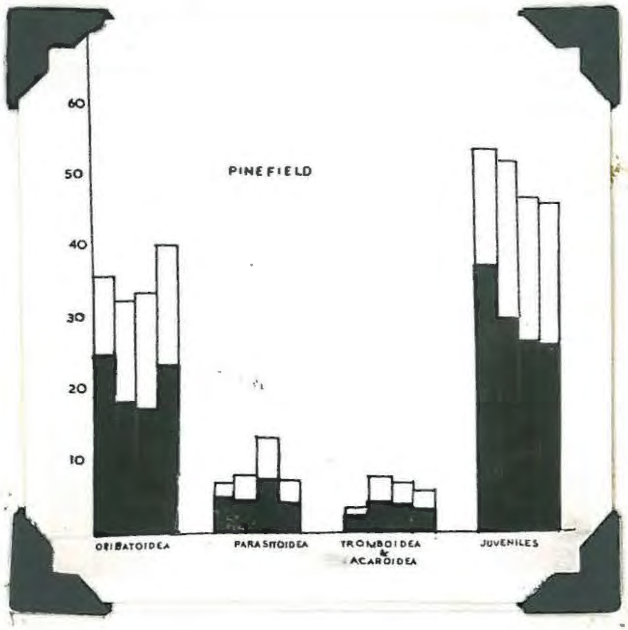


Fig. 22.

% Composition Superfamilies of Mites.

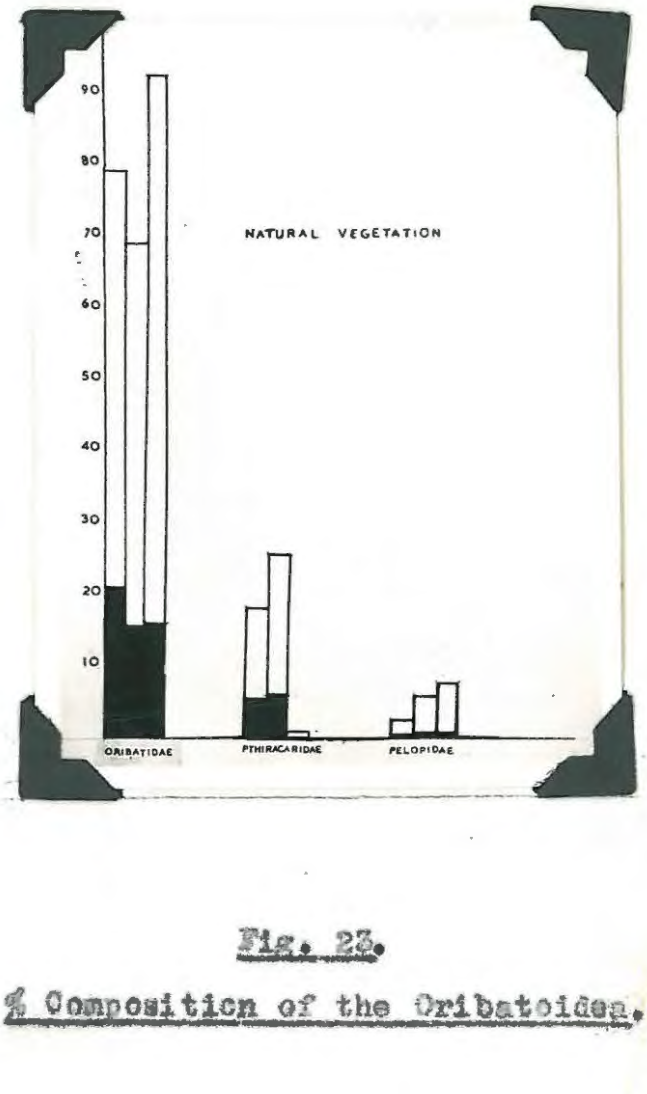


Fig. 23.

% Composition of the Oribatoidea.

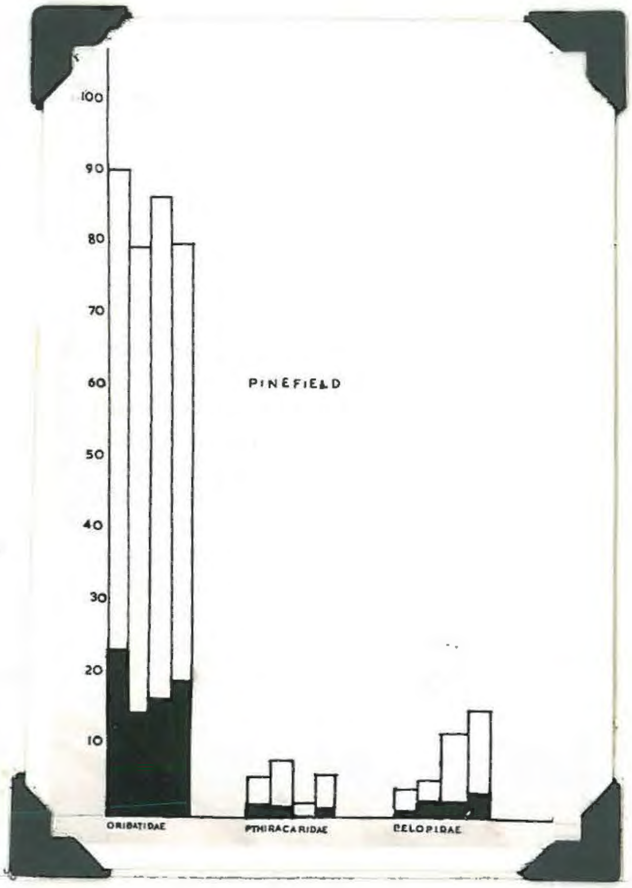


Fig. 24.

% Composition of the Oribatoidea.

Series 2 than in Series 1.

The same three families of Oribatoidea occur in all soils. However in the composition of this super-family the pinefields more closely resemble the grassland than the bush. In all soils studied the Oribatidae are the most important family. They comprise about 70% of this super-family in the bush and between 80% and 94% in the grassland and pinefields. The Pthiracaridae form about 20% of the super-family in the bush, but are much less important (under 6%) in the pinefields and almost absent in the grassland where only 2 specimens were obtained. The Pelopidae are of slightly greater importance in the pinefields than the natural vegetation, since they form over 10% in all pinefields except "Unique" series 1 where they form only 4%. In the natural vegetation they form under 3% in the bush and nearly 7% in the grassland.

The Parasitoidea form about 10% of the mites in the bush, about 7% in the pinefields and over 13% in the grassland. The large number of these mites in the latter is due to concentrations of them in two samples which contained old cow dung.

The Acaroidea and Tromboidea are not very common in any of the soils studied. They form approximately 8% of the mites obtained.

In all cases the total faunas show a considerable quantitative reduction in the pinefields from those in the natural vegetations. This reduction is greatest in "Unique" series 1, where the pinefield fauna is only 28% of that in the bush. "Glenhope" pinefield 1 has 43% of the fauna in the bush. The reduction is least in "Glenhope" pinefield 2 where there is 83% of the number of animals in the grassland. "Unique" series 2 was not compared with bush in this manner since it was sampled so much later.

A QUALITATIVE COMPARISON OF THE "PODURIDAE" AND MITES OTHER THAN ORIBATOIDEA IN THE PINEFIELDS WITH THOSE IN THE NATURAL VEGETATION.

1) "Poduridae". In order to find whether the similarity between pinefields, described in the last section, extended to categories lower than the family level, nine samples were taken during the last two weeks of May and the first two weeks of June 1956, from each of the four sampling stations at "Glenhope". The "Poduridae" in these were divided into 10 categories based on easily recognisable morphological characters.

The exact significance of these categories is doubtful and it is not known whether they represent any taxonomic grouping. At the very lowest these categories possibly represent genera, though some of them may possibly include several genera. The following discussion is therefore only tentative. Specimens of "Poduridae" from each of these four collecting stations have been sent to Dr. Delamare Deboutteville for identification and until these are received no definite conclusions can be made.

Categories of "Poduridae". As was mentioned above the "Poduridae" were divided into 10 categories. These were based on the following characters :- size, shape of the body, presence or absence of pigment, furcula and eyes, and length of the antennae. The categories were as follows :-

P1, small, unpigmented, eyeless, no furcula and antennae about the same length as the head.

P2, very similar to P1 but with eyes.

P3, stout, pigmented, no furcula, eyes present.

P4, similar to P1, but larger and more elongate.

P5, very long and slender.

P6, similar to P2 but furcula present.

P7, like P6, but pigmented.

P8, similar to P1, but antennae longer than head.

P9, large, eyes present, pigmentless, no furcula, body shape more or less cylindrical.

P10, very like P3, but furcula present.

An attempt was made to assign some of these categories to genera using the keys in Maynard (1951). These keys are for North American Collembola but many genera of these insects are widespread. From these keys P1 appears to represent the genus Onychurus; P3, Neanura; P6, Hypogastrura (Achorutes) and P10, Pseudachorutes. P7, seems assignable to the family Isotomidae, but the genus (or genera) is not known.

Results. The results are set out in table 16 and illustrated in Figs. 25 and 27 for the natural vegetation and Figs. 26 and 28 for the pinefields.

These show that there are two categories confined to the bush, P2 and P9. Only P2 is of any importance since only two specimens of P9 were obtained. P2, however, is the second most numerous "Podurid" in the bush. There are no categories confined only to the grassland, but P8 occurs in both bush and grassland but not in the pine-fields. P8 is slightly more important in the grassland, where it forms about 6% of the population, than in the bush where it forms only about 3%.

It is also noticeable that in the bush P1 is the main constituent of the "podurid" population forming nearly 60% of it. This situation occurs, also, in the pinefields, where P1 forms about 46% in pinefield 1 and about 59% in pinefield 2. In the grassland there are two major categories, each forming about 30% of the population. These are P1 which forms 31% and P4 which forms 32% of the populations.

P4 is the second largest category, numerically in the pinefields, where it composes about 20% in both fields. In the bush P4 is of little importance, since it forms just under 4% of the population. P6 is of about equal importance in all soils forming approximately 10% of the "Poduridae" in them all. P7 forms about 13% in the grassland and in pinefield 1, but only about 5% in the bush and pinefield 2. P3 and P10 are of very little importance in any soil, but are more numerous in the pinefields than in the natural vegetation.

TABLE 16.
CATEGORIES OF "PODURIDAE".

Categories.	NATURAL VEGETATION. Bush.			Grassland.			PINEFIELD. Pinefield 1.			Pinefield 2.		
	No.	Mean	%	No.	Mean	%	No.	Mean	%	No.	Mean	%
Poduridae 1	382	42.9	59.6	88	9.8	30.9	106	11.8	46.1	132	14.7	58.7
Poduridae 2	77	8.5	12.0	0	0	0	0	0	0	0	0	0
Poduridae 3	21	2.3	3.3	11	1.2	3.9	7	0.8	3.1	11	1.2	4.9
Poduridae 4	23	2.5	3.6	91	10.1	31.9	43	4.8	18.7	49	5.4	21.8
Poduridae 5	12	1.3	1.9	6	0.6	2.1	0	0	0	0	0	0
Poduridae 6.	69	7.7	10.8	28	3.1	9.8	33	3.7	14.3	14	1.5	6.2
Poduridae 7	32	3.5	5.1	39	4.3	13.7	29	3.2	12.6	9	1	4.0
Poduridae 8	22	2.4	3.4	16	1.8	5.6	0	0	0	0	0	0
Poduridae 9	2	0.2	0.3	0	0	0	0	0	0	0	0	0
Poduridae 10	1	0.1	0.2	3	0.3	1.1	12	1.3	5.2	10	1.1	4.4
	641	71.2	100	285	31.7	100	230	25.5	100	225	25.0	100

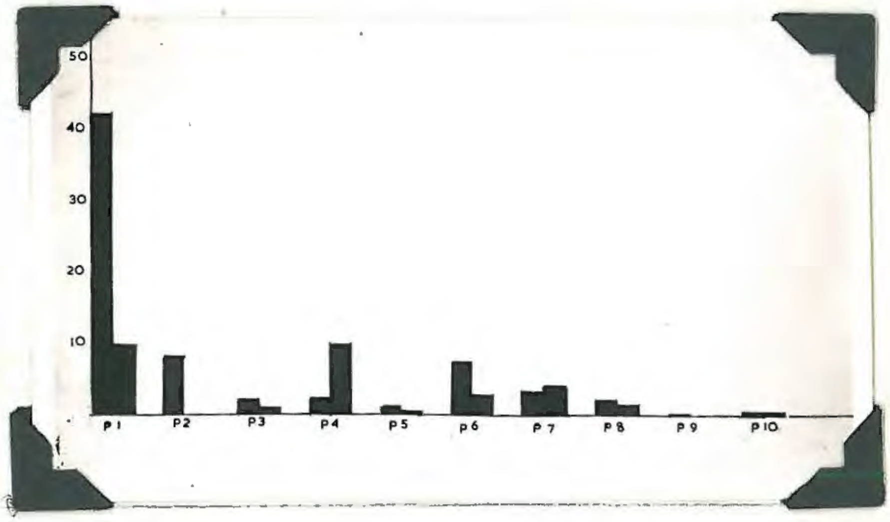
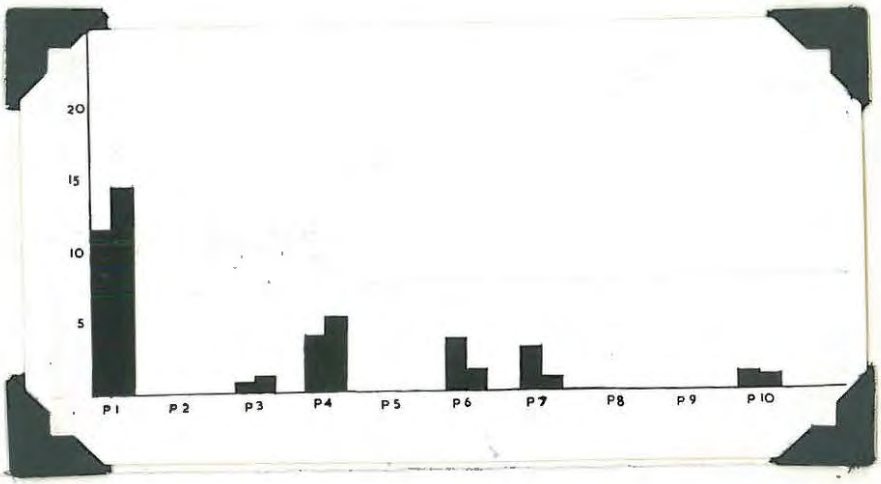


Fig. 25.

Categories of "Poduridae". Means Per Sample. Natural Vegetation

In figs. 25 to 28 the histograms read from left to right, for the Natural vegetation, Glenhope bush and grassland, and for the pinefield, Glenhope pinefield 1 and Pinefield 2.



Figs. 26.

Categories of "Poduridae". Means Per Sample. Pinefield.

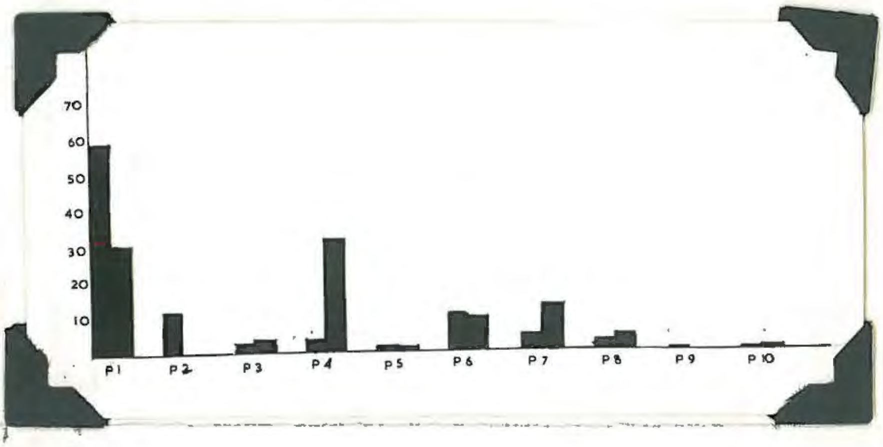


Fig. 27.

% Composition of Categories of "Poduridae". Natural Vegetation.

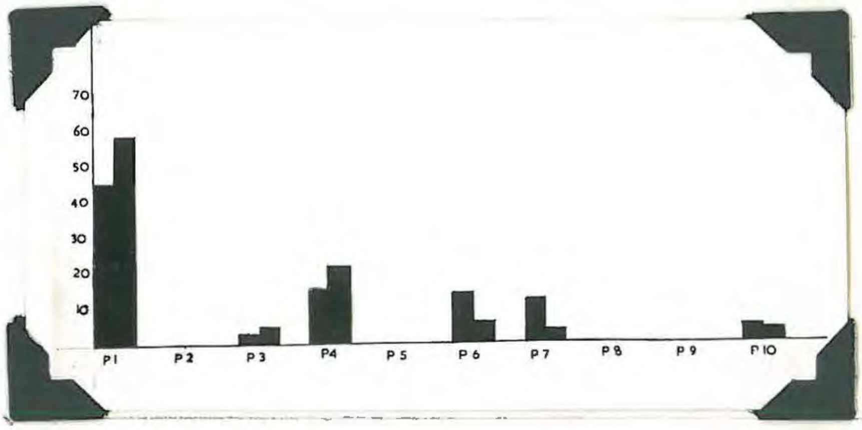


Fig. 28.

% Composition of Categories of "Poduridae". Pinefield.

These results seem to show that so far as these categories are concerned the two pinefields resemble each other in that the same four categories, P2, P5, P8 and P9, are absent from both and the two major categories in each are the same, P1 and P4, and the numbers of these obtained are much the same in both fields, these are also the major categories in the grassland. However so far as the other categories are concerned the pinefields do not resemble each other at all closely. The fact that P7 is more important in the grassland and in Pinefield 1 which was cleared from the bush, and of very little account in the bush and in Pinefield 2 which was cleared from the grassland is of interest.

It seems that the pinefields resemble each other more closely than they do the natural vegetation from which they were cleared and with the distribution of P7 this supports the conclusion that the faunas in the pinefields are not merely relict faunas.

2) Mites Other Than Oribatoidea. The Mites used in this section were collected by way of "qualitative samples". These consisted of the soil and litter over an area of about 1 sq. ft., collected with a spade, down to the depth of about 5 ins. Two of these samples were taken from each of the six sampling areas and the results from each lumped together. The Berlese Funnel was the main instrument used in the extraction of the mites from these samples. The

samples from "Unique" were taken at the end of January 1956, and those from "Glenhope" at the end of May 1956.

Identification down to genus and in a few cases, all from "Unique", down to species, was carried out by Dr. P.A.J. Ryke and his students of the University of Potchefstroom. Unfortunately they did not distinguish between the specimens from "Glenhope" pinefield 1 and pinefield 2, possibly due to the small number of specimens from these stations. This renders the identifications less valuable than they otherwise might have been.

Since the samples were not all of the same size and the method of extracting the mites was not strictly quantitative, the actual numbers of specimens of each genus is not recorded. It is felt, however, that the numbers obtained give a fair indication of the relative abundance of the genera at the stations. Therefore a scale ranging from "very abundant" to "present" and "absent" has been used. (See table 17).

Results. The result of these identifications are set out in table 17 for the Parasitoidea and table 18 for the Tromboidea and Acaroidea. These tables show the distribution and relative abundance of the families and genera over the different stations. Table 19 shows the distribution of the genera over the three main vegetational types, bush, grassland and pineapple field.

TABLE 17.

DISTRIBUTION OF FAMILIES AND GENERA OF PARASITOID MITES.

Family & Genus.	Bush Unique	Bush Glenhope	Grassland	Pines Unique	Pines Glenhope
<u>Ascaidea</u>					
Digamasellus	xxxx	xxxx	-	x	-
Asca	-	-	x	-	-
<u>Phytoseidae</u>					
Typhlodromus reticulatus	-	-	-	x	-
Amblyseius	-	-	xx	-	-
Ameroseius	-	-	xx	-	-
<u>Pachylaeleptidae</u>					
Pachylaelaps	-	xx	-	-	-
<u>Laeleptidae</u>					
Laelaspis	-	x	-	-	-
Hypoaspis	-	-	x	-	x
<u>Phaulodinychidae</u>					
GenusUnident	-	-	xxxx	-	-
Phaulodinychus	-	xxx	-	-	-
<u>Rhodacaridae</u>					
Rhodacarus	-	-	x	-	xx
<u>Parasitidae</u>					
Parasitus	-	-	xx	-	-
<u>Macrochelidae</u>					
Macrocheles	-	-	xx	-	-
Podocinum	-	xx	-	-	-
Holostaspella	-	-	-	xxx	-
Family Unident ?	x	-	-	-	-
Total Genera	2	5	8	3	2

<u>KEY</u>. xxxx very abundant   xxx common   xx rare to fairly common
x present   - absent

TABLE 18.
DISTRIBUTION OF FAMILIES AND GENERA OF TROMBOIDA AND ACAROID MITES.

Family & Genus.	Bush Unique	Bush Glenhope	Grassland	Pines Unique	Pines Glenhope.
TROMBIDIFORMES.					
Bdellidae 178					
Bdella	XXX	X	-	-	-
Odontoscirus	-	-	X	-	-
Erythraeidae 173/237					
Erythraeus	X	-	-	-	-
Leptus sp. A	XX	-	-	-	-
Leptus sp. B	XX	-	-	-	-
Cunaxidae 274					
Cunaxa setirostris	XX	-	-	-	-
Trombidiidae 254					
Camerotrobidium	XX	-	-	-	-
Microtrombidium	XX	XX	X	-	-
Allothrombium	X	-	-	-	-
Atomus	-	-	X	-	-
Enemothrobium	XX	-	-	-	-
Cryptognathidae 183					
Cryptogr athus Cucurbitae	X	-	-	-	-
Anystidae 226					
Erythracarus Parietinum	XX	-	-	-	-
Erythracarus sp. B	-	-	-	XX	-
Anystis	X	-	-	-	-
Raphignathidae 203					
Raphignathus sp. A	XX	-	-	-	-
Raphignathus sp. B	-	-	-	X	-
Homocaligus	-	-	-	X	-
Mediolata	-	-	-	-	XX
Labistommidae 184					
Labistomma	-	XX	-	-	-
Eupodidae 174					
Linopodes	-	XX	-	-	-
Rhagidiidae 181					
Rhagidia	-	-	-	-	X
ACARIFORMES					
Winterschmidtiidae 345					
Winterschmidtia S.A.	XX	-	-	X	-
Total genera	14	4	3	4	2

KEY Same as for table (17).

TABLE 19.

SUMMARY OF TABLES 17 & 18.

Genus	Bush	Grassland	Pineapples
Digmasellus	x	-	x
Asca	-	x	-
Typhlodromus	-	-	x
Amblyseius	-	x	-
Ameroseius	-	x	-
Pachylaelaps	x	-	-
Laelaspis	x	-	-
Hypoaspis	-	x	x
Phaulodinychidae gen. unident	-	x	-
Phaulodinychis	x	-	-
Rhodacarus	-	x	x
Parasitus	-	x	-
Macrocheles	-	x	-
Podocinum	x	-	-
Holostaspella	-	-	x
Parasitiod fam. & gen. unident	x	-	-
Bdella	x	-	-
Odontoscirus	-	x	-
Erythraeus	x	-	-
Leptus	x	-	-
Cunaxa	x	-	-
Gamerotrobidium	x	-	-
Microtrombidium	x	x	-
Allothrombium	x	-	-
Atomus	-	x	-
Enemothrombium	x	-	-
Erythracarus Parietinum	x	-	-
Erythracarus sp.B	-	-	x
Anystis	x	-	-
Raphignathus sp.A	x	-	-
sp.B	-	-	x
Cryptognathus	x	-	-
Homocaligus	-	-	x
Mediolata	-	-	x
Labistomma	x	-	-
Linopodes	x	-	-
Rhagidia	-	-	x
Winterschmidtia sp.A	x	-	x
Total genera	21	11	10

KEY x present

- absent

It can be seen from these tables that there is very little similarity between the areas. Only one genus, _Microtrombidium_, is common to bush, grassland and pineapple fields. Apart from _Microtrombidium_, the grassland has a distinct mite fauna from the bush.

The genus _Digamasellus_ is the dominant genus in both the bush at "Unique" and the "Glenhope" bush, otherwise these two bush types have only two genera in common, _Edella_ and _Microtrombidium_. Since _Microtrombidium_ is fairly common in both and they both have the same dominant genus, it seems possible that the difference between the two bush types may to a large extent be seasonal and to some extent due to chance in the catching of the rarer genera. It is interesting to note, though, that the Parasitoidea are very well developed at "Glenhope", while only two genera, _Digamasellus_, and one unidentified genus have been obtained at "Unique". The Tromboidea are considerably more varied at "Unique" with 14 genera as opposed to 9 at "Glenhope", while the only species of Acaroidea obtained was not found at "Glenhope".

The grassland fauna is very different with only the genus _Microtrombidium_ in common with the bush. The dominant genus here is an unidentified genus of the family Phaulodinychidae (Parasitoidea). There are 8 genera of parasitoids and three of tromboids in the grassland.

The pinefields are more difficult to evaluate due to the unfortunate lumping of the specimens from the two pinefields at "Glenhope" and the small collections of mites identified from pinefields. However some conclusions may be drawn from them.

There is no genus of mites common to both the pinefields at "Unique" and "Glenhope". This may well be due to chance because of the very small numbers of specimens identified from each pinefield.

There are four genera common to both bush and pinefields all at "Unique". In two of these cases, where species have been identified, the species in the pinefield is different from that occurring in the bush. These are Erythracarus parietinum (Berlese) in the bush and E. sp.B. in the pinefield and Raphignathus sp.A in the bush and R. sp.B in the pinefield. In only one case where the species has been identified is the same species found in both the pinefield and natural vegetation, Winterschmidtia sp.A., found in both the bush and the pinefield at "Unique".

There are two genera common to both pinefield and grassland, both at "Glenhope" (These were not identified to species).

Five genera were found only in pinefields, three at "Unique" and two at "Glenhope". One family the Rhagidiidae, Was also only found in pinefields, only at "Glenhope".

It is interesting to note that there is a different genus of Macrochelidae in each of the vegetational types, bush, grassland and pineapples.

The evidence obtained from the distribution of these mites, although unsatisfactory and of no value alone, when used in conjunction with that from the categories of "Poduridae" and the quantitative evidence given in Section 5, seems to support the conclusion that the fauna of a pinefield is not merely a depauperate relict of the original fauna of the natural vegetation, but is a distinct fauna not very closely related to the original fauna.

In evaluating the distribution of these mites solely on genera, it must be borne in mind that many of these genera are very widespread and occur in widely different climatic, vegetational and soil types. Several of the genera obtained in the present investigation have, for instance, been obtained by Macfadyen (1954) on Jan Mayen island off the north east coast of Greenland. Thus it may be that the distribution of genera shown in the tables 17 to 19 is entirely due to chance. This does not seem very likely, since in two cases, where the species are known, there are different species in the natural vegetation from the pinefield.

DISCUSSION AND CONCLUSIONS.

As stated previously, very little quantitative work has been done on the fauna of tropical and sub-tropical soils. A considerable proportion of the work that has been done concerns the fauna of the surface and litter rather than that of the soil proper. This is true of the investigations by Beebe (1916), on the litter fauna of the Brazillian forest; Williams (1941), on the floor fauna of the Panama rain forest; Dammerman (1925 and 1937), on the surface and "soil" fauna of several vegetational types in Indonesia; Wolcott (1924), on the invertebrate fauna of 3 sq. ft. of pasture in Puerto Rico and the valuable account by Lawrence (1953) on the cryptic fauna of South African relict forests.

The only quantitative works, published, on the soil fauna of tropical and sub-tropical areas are those by Van Zwaluwenberg (1931) on the soil fauna of Hawaiian sugar cane fields; Strickland (1945 & 1947) on the soil faunas of forests, grassland and cacao plantations in Trinidad and Salt (1952 and 1955) with two important recent contributions to the knowledge of the fauna in the soils of cultivated lands, pastures and elephant grass leys in East Africa. Delamare Deboutteville (1950) has published an excellent comparative account of the soil faunas in a tropical area, the Ivory Coast, and those in a temperate area, France. This work, however, is mainly systematic and ecological rather than quantitative.

It is interesting to compare the mean number of arthropods per sq. m. found in the present investigation with those found by other authors. The number of arthropods per sq. m. found by several authors are given in Table 20 and those found in the present investigation are given in Table 21. It must be borne in mind when comparing these figures that they are not strictly comparable, since the various authors used different methods of extracting the fauna and sampled to different depths. It will be seen that the earlier (before 1945) figures given are all low, probably due to inefficient extraction methods.

It can be seen from these tables that the mean number of arthropods per sq. m. found in the present investigation agrees closely with those obtained by Salt (1952 and 1955) in East Africa, though they fall well below the figure obtained by Salt et al (1948) in a meadow near Cambridge, England, where 263,658 arthropods per sq. m. were obtained. However Salt (1952) does not consider this figure to be comparable with his African samples, since a refinement in extraction, not used in Africa, was used. This gave a very large number of minute mites and other animals which escaped in the method used in Africa. The English samples were taken to a depth of 12 ins. while the African ones were only taken to 6 ins. He therefore corrects this figure, using samples in which the refined extraction technique was not used, to 90,238 arthropods per sq. m. Even this corrected figure is considerably higher than figures obtained in grassland either in East or South Africa.

TABLE 20.

NUMBERS OF ARTHROPODS PER SQUARE METRE. AFTER VARIOUS AUTHORS.

Source	Number	Author
Sugar cane field, Hawaii	17,792	Van Zwaluwenberg 1931
Tropical forest litter, Panama	9,822	Williams 1941
Forest & cacoa plantations, Trinidad	25,676	Strickland 1945
Grassland, Trinidad	33,662	Strickland 1947
Pasture, East Africa	54,565	Salt 1952
Cultivated land, East Africa	24,422	Salt 1952
Elephant grass ley, Uganda	87,147	Salt 1955
Pasture, England	90,238	Salt 1952
Beech forest, Denmark	6,200 to 19,400	Bornebusch 1930
Spruce forest, Denmark	11,900	Bornebusch 1930
Temperate forest, Sweden	1,089,600	Forslund 1945
Beech forest, Holland	336,500	Van der Drift 1951
Spruce plantation, Great Britain	154,400	Evans 1950
Natural Heathland, Great Britain	569,700	Murphy 1953

TABLE 21.

NUMBERS OF ARTHROPODS PER SQUARE METRE FOUND IN THE PRESENT INVESTIGATION.

Location	Number (nearest whole Number).
Unique bush	80,161
Glenhope bush	97,348
Glenhope grassland	50,547
Unique pinefield series 1	22,755
Unique pinefield series 2	42,104
Glenhope pinefield 1	41,857
Glenhope pinefield 2	41,857

It is comparable to the figures obtained in bush in the Bathurst District or the elephant grass leys in Uganda. From the description given by Salt (1952) and the figures he obtained it appears that the unmodified Ladell used in the present investigation and the apparatus used by Salt in East Africa give comparable catches of animals.

Large though these figures are, they fall far short of the totals obtained in temperate forests. The earlier workers, such as Bornebusch (1930) obtained very low figures. Bornebusch, for instance, obtained only between 6,300 and 19,400 arthropods per sq. m. These low results were probably due to poor extraction techniques. Most of the recent workers in temperate forests have obtained much higher figures, over 100,000 arthropods per sq. m. Van der

Drift (1951) found 336,500 arthropods per sq. m. in a Dutch beech forest and Murphy (1953) obtained 569,700 in English heathland. Evans (1950) found only 154,000 per sq. m., but this relatively low number is probably due to the fact that he worked on a plantation of a coniferous tree, the Sitka Spruce.

These figures are much lower than those found by Forslund (1945) in a Swedish deciduous forest. This author obtained the astounding figure of 1,089,600 arthropods per sq. m. There is good reason to believe that even this figure is below the true total, since in a few cases he obtained up to 2,300,000 per sq. m. Unfortunately I do not know the methods he used to obtain these results, but they must be considerably more efficient than any others in use.

Even if the exceptionally high figures obtained by Forslund are ignored, the results shown in Tables 20 and 21 show that tropical and sub-tropical soils are not so well populated by micro-arthropods as those in temperate climates. Part of this discrepancy may possibly be due to the fact that more refined extraction methods have been used in the European studies. This is probably the case in some pasture and grassland studies, but even here only a small part of the discrepancy can be accounted for by this. In the case of the temperate forests it is certainly not the case. Since the Berlese Funnel and it's modifications have been used in nearly all cases. Flotation methods are unfortunately not usable in these forests due to the amount of litter.

The fact that the figures given by Forslund (1945) are so much higher than those found by any other author seems to show that there is no really efficient quantitative method for extracting the micro-arthropods from forest soils and probably from any other soil. However if the method used gives the same proportion of the fauna at all times, as the Ladell seems to, this is all that is required for a comparitive investigation.

In nearly all soils that have been studied, the two dominant order of arthropods are the Acarina (mites) and the Collembola. The ratio of these to each other, Mites/Collembola, is interesting and perhaps informative. Margowski and Prusinkiewicz (1955) give experimental evidence showing that the mites are more resistant to desiccation than the Collembola and from their work it can be inferred that the quantitative ratio of the mites to the Collembola changes with the humidity of the environment. Thus they state that in dry biotopes the mites will greatly outnumber the Collembola and this ratio will be high, while in a wet biotope the reverse may be the case and the ratio will be lower.

This appears to be borne out by observations in the present investigation and by remarks in the literature, although this ratio has not been specifically mentioned. Thus Macfadyen (1954) observed that, in Jan Mayen, the mites were proportionally more abundant in the dry stations sampled and the Collembola were more numerous and varied in the wetter stations, though he gives no figures.

In the present investigation it was found that the Mite/"Poduridae" ratio (Table 14) at station 3 at "Unique" showed a considerable change from series 1 to series 2. In series 1 the ratio was 3.77 and the soil was very dry. In series 2 the soil was much moister and the ratio had dropped to 1.75. It was found that the highest ratio in the natural vegetation was 1.51, in the grassland, this was lower than the lowest in the pinefields 1.75. This seems to show that, although humidity may be the major factor in controlling this ratio it is by no means the only one. Since the pineapple plant has great moisture gathering powers, (pinefields are sometimes used to grow vegetables and flowers between the rows of pineapples at times when they could not be grown away from these plants without irrigation). The soil under the pineapples, at all times, appeared to be no less moist than that in the bush and sometimes seemed to be considerably moister, though no readings were taken. It therefore seems probable that other factors, such as cultivation, exposure to wind and temperature changes may also play important parts in controlling this ratio, but more work is needed on this subject.

It has been shown in Section 4 that the arthropod fauna in the soil of a pinefield undergoes a considerable increase in numbers over a short term period of eight months and that this is possibly part of an annual cyclic variation. Annual cycles in the arthropod faunas of soils have received attention from workers in Europe and North America, where there is a severe winter. Both Smith Davidson (1932) in North America and Van der Drift (1951) in Holland have shown that there is a very great fluctuation in numbers over the seasons, with a maximum in autumn and a minimum at the end of winter. This seems to be the case in the present investigation. The "Unique" Station 3 results were first taken in the spring, when there was a minimum of animals and the Series 2 results, with a large number of animals, were taken in the autumn. No samples have been taken to find out whether there was a corresponding decline in the following winter.

Van der Drift and Smith Davidson also found that there are seasonal changes in the species composition of the fauna as well as the numbers. The composition of the faunas being different in summer from that in winter and some species are only found at a particular season. Smith Davidson also found that the populations of successive years will often differ not only in regard to the population maxima and minima, but also in regard to the species composition. The dominant species will sometimes be different from the preceeding year, new species, not found previously, will appear and others will disappear.

As mentioned above, Murphy (1955) has correlated the long term changes in a collembolan population with the plant succession.

Jahn (1944) has studied the long term changes in the arthropod fauna, over 78 years, in Austrian pine plantations, by comparing plantations of different ages. He found only a slight increase in collembolan numbers but a considerable increase in mites. This seems to support the idea that humidity is only one of many factors controlling the mite/Collembola ratio.

It seems probable that the long term changes in pine-fields will be found to be correlated to the growth of the pineapples. When the land is originally cleared it is often allowed to stand fallow for about six months after ploughing before being planted out. This may considerably reduce the fauna which will build up again as the pineapples grow and provide some protection for the soil.

The fauna in pinefields possibly has several origins. Some of the animals may survive the clearing and ploughing and later increase in numbers. Some may be imported into the field on the young plants and on the clothes of workers or on animals or birds, other may immigrate in the field by their own means. In this connection it is interesting to note that Delamare Deboutteville (1950) showed that the soil fauna must have a certain amount of mobility, since the fauna of the suspended soils (i.e. the accumulations of litter in treeholes and on branches) in the West African tropical forests, often many feet above the ground, is essentially the same as that of the forest floor. These suggestions on the origin of the fauna of pinefields are purely conjectural and not based on any direct observations; more work is needed on this problem. However, Tischler (1955) has worked on a similar problem in cultivated lands, in Germany. He found that not only ploughing but also the time of year the field was ploughed affect the fauna. Ploughing always reduced the population, but the reduction was much greater if the field was ploughed in summer than in winter. The type of ploughing used also had a considerable effect, deep ploughing reducing it more than shallow ploughing, as would be expected.

The importance of the micro-arthropod fauna of the soil, apart from the undoubted pest species, is a matter of dispute, generally speaking the soil scientists (being mainly chemists or botanists) have tended to regard the soil fauna as a nuisance to be ignored if possible, though few have gone so far as Flice (1939) who claims that the soil fauna, even earth worms play no part in soil formation or fertility.

Other authors have disputed this. Jacot (1939), Murphy (1955a) and Lawrence (1953) have shown that the micro-arthropods may sometimes be effective litter reducing agents, but in general their contribution to this must be small compared to the earth worms and larger Diplopoda.

Kubiena (1955) has shown that the activity of the micro-arthropods may be very important in humus formation. In fact the humus portion of certain soils consists largely of the droppings of the Collembola and mites in that soil. Salt (1955) considers that, where the micro-arthropod fauna is large, as under elephant grass leys, the dead bodies of these animals form a very considerable reserve of nitrogen in the soil and account largely for the great fertility of these soils when later cleared for agricultural use.

It is with the use of these animals as indicators of soil fertility or otherwise that the soil zoologist is at present most concerned. Delamare Deboutteville considers that the Collembola provide the most valuable indicator species, since they are the most closely affected by the environment. The present investigation has shown that pinefields in the Bathurst district have a distinct quantitative fauna which is probably also qualitatively distinct. Work is now needed on the qualitative aspects of this fauna and its long and short term changes. These studies may show whether there are any species which can be used as indicators of the declining, or otherwise, fertility of the field. These indicator species will if found, be valuable adjuncts to the chemical and physical analyses of the soil.

In conclusion it may be said that the present investigation has shown, that three pinefields over six years old in the Bathurst District, cleared from different vegetational types and growing on different soils, have a fauna which is very similar quantitatively. This fauna is quantitatively different from that in the natural vegetation from which the field was cleared. This similarity of faunas in the pinefields is very striking in the total faunas, mites and "Poduridae"; it is also noticeable, though not so marked down to the families of the Oribatoidea.

The qualitative evidence, at the generic and specific level, is less satisfactory. The evidence from the categories of the "Poduridae" shows that the fields are alike in that the same three categories are absent and the two major categories are the same. The evidence from the distribution of the genera of mites other than Oribatoids is not very satisfactory. This shows no similarity between the pinefields, but also very little between the pinefields and the natural vegetation. It appears, however, to show that the fauna of a pinefield is not merely a relict of that in the natural vegetation. An interesting similarity between all the pinefields was the very high proportion of juvenile mites, which were proportionally much more abundant than in the natural vegetations.

To sum up, the evidence obtained shows that the fauna in a pinefield is not merely a depauperate relict of that in the natural vegetation from which it was originally cleared. Whether this fauna is qualitatively the same in all fields or whether each field develops a separate climax fauna, which resembles the other field quantitatively, but differs in the genera and species present is not known.

This fauna is shown to undergo a great increase in numbers between October 1955, spring, and May 1956, autumn. This increase is shown to be approximately linear in the total fauna and the mites, but not in the "Poduridae".

Whether the results will be found to apply to a wider area differing greatly in climatic conditions is not known. This investigation must, therefore, be regarded only as a preliminary investigation and more work is needed on this subject.

Acknowledgement. I am indebted to the Council for Scientific and Industrial Research, Messrs. African Explosives and Chemical Industries Ltd. and to the Pineapple Research Station, East London, for the provision of grants which have enabled this work to be carried out. I am also indebted to Dr. R.F. Lawrence who has identified Polygonarea oligopus, to Dr. P.A.J. Ryke of the University of Potchefstroom who identified the mites other than oribatoids and to Prof. P. Remy of the

University of Nancy who identified the Pauropods.

I should also like to express my thanks to Prof. D.W. Ewer and Dr. E. McC. Callan for much help and encouragement and to Messrs. A.W. Staples and A.W. Legg who have allowed me to work on their farms.

SUMMARY.

1) The methods of sampling and extracting the micro-arthropod fauna of the soil are discussed in relation to the methods used in the present investigation.

2) Soil samples from 3 pinefields, each of over 6 years growth, in the Bathurst District of the Eastern Cape Province, are compared with soil samples from the natural vegetation from which the pinefields were cleared. Only the top 6 inches of soil were sampled.

3) It was found that :-

i) the fauna in these fields was a characteristic fauna, quantitatively the same, at the higher levels of classification, in all three fields regardless of the natural vegetation from which they were cleared.

ii) The evidence at generic and specific level is less satisfactory but supports the conclusion that this fauna is not merely an impoverished relict of the previous fauna before the field was cleared.

iii) The fauna in a pinefield is shown to undergo a considerable numerical increase over a period of 8 months. This change is approximately linear for the total fauna and the mites, but not for the Collembola.

iv) This fauna is shown to be very irregular in distribution over a small area, i.e. 1 sq. m., but if series of samples from widely scattered stations in the same field are compared there is no significant difference between the means for sample.

APPENDIX.

Tables showing the major groups of arthropods obtained and the number of samples they were obtained in, from all sampling stations.

Table 22.

"Unique" Station 1. 14 Samples Taken.

Fauna	Number Obtained	Number of Samples.	Fauna	Number Obtained	Number of samples.
Myriapoda			Ants	12	6
			Hymenoptera	0	0
Chilopoda	0	0	Coleoptera	1	1
Diplopoda	0	0	Coleoptera larvae	3	3
Pauropoda	4	4	Unident insect larvae	0	0
Symphyla	2	2			
Insecta			Arachnida		
Collembola			Palpigrades	0	0
			Pseudoscorpions	0	0
"Poduridae"	106	14	Harvest spiders	0	0
Entomobryidae	8	6	Spiders	2	2
Sminthuridae	1	1	Mites		
Neelidae	0	0			
Apterygota			Oribatidae	90	14
			Pthiracaridae	0	0
Japygidae	0	0	Pelopidae	5	4
Campodeidae	0	0	Parasitiodea	40	14
Protura	5	5	Tromboidea and Acaroidea	14	9
Pterygota			Juveniles	256	14
Blattaria	0	0			
Orthoptera	0	0			
Dermaptera	0	0			
Isoptera	0	0			
Psocotera	1	1			
Thysanoptera	1	1			
Homoptera	2	2			
Lepidoptera larvae	0	0			
Diptera	0	0			
Diptera larvae	0	0			
Hemiptera	0	0			

TABLE 23.

"UNIQUE" STATION 2. 24 SAMPLES TAKEN.

Fauna	Number Obtained	Number of Samples
Myriapoda		
Chilopoda	1	1
Diplopoda	0	0
Pauropoda	5	5
Symphyla	0	0
Insecta		
Collembola		
"Poduridae"	194	24
Entmobryidae	11	8
Sminthuridae	8	8
Neelidae	0	0
Apterygota		
Japygidae	0	0
Campodeidae	0	0
Protura	10	9
Pterygota		
Blattaria	0	0
Orthoptera	0	0
Dermaptera	2	2
Isoptera	0	0
Lepidoptera Larvae	0	0
Psocoptera	4	4
Thysanoptera	3	3
Homoptera	2	2
Hemiptera	9	6
Diptera	1	1
Diptera Larvae	3	2
Ants	8	7
Hymenoptera	0	0
Coleoptera	2	2
Coleoptera Larvae	4	4
Unident insect Larvae	0	0

Fauna	Number Obtained	No. of samples
Arachnida		
Palpigradi	0	0
Pseudoscorpions	0	0
Harvest spiders	0	0
Spiders	3	3
Mites		
Oribatidae	228	24
Phiracaridae	2	2
Pelopidae	9	7
Parasitoidea	53	21
Tromboidea and Acaroidea	21	17
Juveniles	419	24

TABLE 24.

"UNIQUE" STATION 3. SERIES 1.
15 SAMPLES TAKEN.

Fauna	Number Obtained	Number of Samples	Fauna	Number Obtained	No. of Samples
Myriapoda			Arachnida		
Chilopoda	0	0	Palpigradi	0	0
Diplopoda	0	0	Pseudoscorpions	0	0
Pauropoda	3	3	Harvest Spiders	0	0
Symphyla	0	0	Spiders	4	4
Insecta			Mites		
Collembola			Oribatidae	155	15
"Poduridae"	127	15	Phiracaridae	10	5
Entomobryidae	16	9	Pelopidae	7	7
Sminthuridae	7	5	Parasitoidea	34	12
Neelidae	0	0	Tromboidea & Acaroidea	18	9
Apterygota			Juveniles	255	15
Japygidae	2	1			
Campodeidae	0	0			
Protura	6	5			
Pterygota					
Blattaria	0	0			
Orthoptera	0	0			
Dermaptera	1	1			
Isoptera	0	0			
Psocoptera	8	4			
Thysanoptera	3	3			
Homoptera	1	1			
Hemiptera	6	6			
Lepidoptera Larvae	0	0			
Diptera	0	0			
Diptera larvae	1	1			
Ants	6	3			
Hymenoptera	4	4			
Coleoptera	6	4			
Coleoptera larvae	5	4			
Unident insect larvae	0	0			

TABLE 25.

"UNIQUE" STATION 3. SERIES 2. 9 SAMPLES TAKEN.

Fauna	Number Obtained	Number of samples
Myriapoda		
Chilopoda	0	0
Diploda	6	2
Pauropoda	10	6
Symphyla	2	2
Insecta		
Collembola		
"Poduridae"	251	9
Entomobryidae	9	6
Sminthuridae	3	2
Neelidae	0	0
Apterygota		
Japygidae	2	2
Campodeidae	0	0
Protura	9	7
Pterygota		
Blattaria	0	0
Orthoptera	0	0
Dermaptera	1	1
Isoptera	0	0
Psocoptera	3	3
Thysanoptera	3	3
Homoptera	2	1
Hemiptera	5	5
Lepidoptera larvae	0	0
Diptera	1	1
Diptera larvae	0	0
Ants	10	5
Hymenoptera	0	0
Coleoptera	0	0
Coleoptera larvae	6	5
Unident insect larvae	0	0

Fauna	Number Obtained	Number of Samples
Arachnida		
Palpigradi	1	1
Pseudoscorpions	0	0
Harvest Spiders	0	0
Spiders	4	4
Mites		
Oribatidae	145	9
Phiracaridae	9	3
Pelopidae	23	9
Parasitoidea	32	9
Tromboidea & Acaroidea	26	7
Juveniles	200	9

TABLE 26.

"GLENHOPE" PINEFIELD 1. 15 SAMPLES TAKEN.

Fauna	Number Obtained	Number of samples
Myriapoda		
Chilopoda	0	0
Diplopoda	1	1
Pauropoda	10	7
Symphyla	3	3
Insecta		
Collembola		
"Poduridae"	392	15
Entomobryidae	22	12
Sminthuridae	6	5
Neelidae	0	0
Apterygota		
Japygidae	11	8
Campodeidae	0	0
Protura	18	12
Pterygota		
Blattaria	0	0
Orthoptera	1	1
Dermaptera	0	0
Isoptera	1	1
Psocoptera	12	7
Thysanoptera	7	7
Homoptera	2	2
Hemiptera	15	6
Lepidoptera Larvae	0	0
Diptera	2	2
Diptera larvae	1	1
Ants	17	8
Hymenoptera	2	2
Coleoptera	2	2
Coleoptera Larvae	6	5
Unident insect Larvae	2	2

Fauna	Number Obtained	No. of samples
Arachnida		
Palpigradi	0	0
Pseudoscorpions	2	1
Harvest spiders	0	0
Spiders	3	2
Mites		
Oribatidae	188	15
Phiracaridae	19	12
Pelopidae	30	13
Parasitiodea	59	15
Tromboidea & Acaroidea	58	15
Juveniles	376	15

TABLE 27.

"GLENHOPE" PINEFIELD 2 - 15 SAMPLES TAKEN.

Fauna	Number obtained	Number of Samples
Myriapoda		
Chilopoda	2	2
Diplopoda	5	4
Pauropoda	20	10
Symphyla	1	1
Insecta		
Collembola		
"Poduridae"	364	15
Entomobryidae	28	15
Sminthuridae	7	5
Neelidae	2	2
Apterygota		
Japygidae	21	12
Campodeidae	1	1
Protura	20	12
Pterygota		
Blattaria	0	0
Orthoptera	0	0
Demaptera	0	0
Isoptera	0	0
Psocoptera	7	6
Thysanoptera	8	5
Homoptera	4	4
Hemiptera	9	7
Lepidoptera Larvae	0	0
Diptera	0	0
Diptera larvae	2	2
Ants	8	5
Hymenoptera	7	6
Coleoptera	6	2
Coleoptera larvae	13	7
Unident. Insect Larvae	0	0

Fauna	Number obtained	No. of Samples.
Arachnida		
Palpigradi	0	0
Pseudoscorpions	0	0
Harvest spiders	0	0
Spiders	1	1
Mites		
Oribatidae	213	15
Phiracaridae	5	4
Pelopidae	29	14
Parasitoidea	96	15
Tromboidea & Acaroidea	52	15
Juveniles	341	15

TABLE 28.

"UNIQUE" BUSH - 15 SAMPLES TAKEN.

Fauna	Number Obtained	Number of samples
Myriapoda		
Chilopoda	3	3
Diplopoda	5	3
Pauropoda	24	15
Symphyla	55	15
Insecta		
Collembola		
"Poduridae"	800	15
Entomobryidae	55	15
Sminthuridae	6	6
Neelidae	0	0
Apterygota		
Japygidae	27	12
Campodeidae	5	4
Protura	20	14
Pterygota		
Blattaria	1	1
Orthoptera	1	1
Dermaptera	5	3
Isoptera	2	2
Psocoptera	43	13
Thysanoptera	9	8
Homoptera	14	8
Hemiptera	13	8
Lepidoptera Larvae	2	2
Diptera	2	2
Diptera larvae	24	12
Ants	18	10
Hymenoptera	10	5
Coleoptera	8	7
Coleoptera larvae	30	13
Unident. Insect larvae	6	4

Fauna	Number Obtained	No. of samples
Arachnida		
Palpigradi	0	0
Pseudoscorpions	20	12
Harvest Spiders	0	0
Spiders	17	8
Mites		
Oribatidae	504	15
Phiracaridae	115	15
Pelopidae	18	11
Parasitoidea	134	15
Tromboidea & Acaroidea	116	15
Juveniles	305	15

TABLE 29.

"GLENHOPE" BUSH - 15 SAMPLES TAKEN.

Fauna	Number obtained	Number of samples
Myriapoda		
Chilopoda	6	5
Diplopoda	14	7
Pauropoda	54	14
Symphyla	32	14
Insecta		
Collembola		
"Poduridae"	1005	15
Entomobryidae	64	15
Sminthuridae	7	6
Neelidae	5	4
Apterygota		
Japygidae	41	13
Campodeidae	8	7
Protura	70	14
Pterygota		
Blattaria	0	0
Orthoptera	1	1
Dermaptera	1	1
Isoptera	1	1
Psocoptera	40	14
Thysanoptera	16	9
Homoptera	15	7
Hemiptera	6	3
Lepidoptera Larvae	8	5
Diptera	8	6
Diptera larvae	15	11
Ants	77	14
Hymenoptera	5	4
Coleoptera	19	10
Coleoptera larvae	34	11
Unident. Insect larvae	1	1

Fauna	Number obtained	No. of samples
Arachnida		
Palpigradi	0	0
Pseudoscorpions	61	13
Harvest Spiders	2	2
Spiders	41	13
Mites		
Oribatidae	463	15
Phiracaridae	172	15
Palopidae	34	10
Parasitoidea	179	15
Tromboidea & Acaroidea	188	15
Juveniles	271	15
Crustacea		
Isopoda	1	1

TABLE 30.

"GLENHOPE" GRASSLAND 14 SAMPLES TAKEN.

Fauna	Number obtained	Number of samples
Myriapoda		
Chilopoda	0	0
Diplopoda	4.	1
Pauropoda	30	7
Symphyla	8	5
Insecta		
Collembola		
"Poduridae"	440	14
Entomobryidae	30	9
Sminthuridae	10	6
Neelidae	2	2
Apterygota		
Japygidae	4	1
Campodeidae	0	0
Protura	15	7
Pterygota		
Blattaria	0	0
Orthoptera	0	0
Dermaptera	2	2
Isoptera	0	0
Psocoptera	7	4
Thysanoptera	10	4
Homoptera	5	3
Hemiptera	7	7
Lepidoptera Larvae	0	0
Diptera	11	3
Diptera larvae	13	2
Ants	91	9
Hymenoptera	2	2
Coleoptera	17	8
Coleoptera larvae	39	11
Unident. Insect larvae	0	0

Fauna	Number obtained	No. of samples
Arachnida		
Palpigradi	1	1
Pseudoscorpions	4	3
Harvest spiders	1	1
Spiders	12	9
Mites		
Oribatidae	231	14
Pthiracaridae	2	2
Pelopidae	17	9
Parasitoides	185	13
Tromboidea & Acaroidea	64	13
Juveniles	169	14

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